SH20-6168-2

Program Offering

Pascal/VS

Language Reference Manual

Program Number: 5796-PNQ

Pascal/VS is a Pascal compiler operating in VS1, MVS and VM/CMS. Originally designed as a high level programming language to teach computer programming by Professor Niklaus Wirth (circa 1968), Pascal has emerged as an influential and well accepted user language in today's data processing environment. Pascal provides the user with the ability to produce very reliable code by performing many error detection checks automatically.

The compiler adheres to the currently ANSI and ISO (Level 0) standard (with minor deviations) and includes many important extensions. The language extensions include: separate compilation, dynamic character strings and extended I/O capabilities. The implementation features include: fast compilation, optimization and a symbolic terminal oriented debugger that allows the user to debug a program quickly and efficiently.

This manual describes the implementation of the language by this compiler, and is intended as a reference guide for the Pascal programmer.

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Third Edition (February, 1985)

This document is the reference manual to the Pascal/VS programming language. The Pascal/VS Programmer's Guide, SH20-6162, is also available from IBM to help write programs in Pascal/VS.

It is assumed that you are already familiar with Pascal and programming in a high level programming language. There are many text books available on Pascal; the following list of books was taken from the Pascal User's Group Pascal News, December 1978 NUMBER 13 and September 1979 NUMBER 15. You may wish to check later editions of Pascal News and your library for more recent books.

- The Design of Well-Structured and Correct Programs by S. Alagic and M.A. Arbib, Springer-Verlag, New York, 1978, 292 pp.
- Microcomputer Problem Solving by K.L. Bowles, Springer-Verlag, New York, 1977, 563 pp.
- A Structured Programming Approach to Data by D. Coleman, MacMillan Press Ltd, London, 1978, 222 pp.
- A Primer on Pascal by R.W. Conway, D. Gries and E.C. Zimmerman, Winthrop Publishers Inc., Cambridge Mass., 1976, 433 pp.
- PASCAL: An Introduction to Methodical Programming by W. Findlay and D. Watt, Computer Science Press, 1978, 306 pp.; UK Edition by Pitman International Text, 1978.
- Programming in PASCAL by Peter Grogono, Addison-Wesley, Reading Mass., 1978, 357pp.
- Pascal Users Manual and Report by K. Jensen and N. Wirth, Springer-Verlag, New York, 1978, 170 pp.
- Structured Programming and Problem-Solving with Pascal by R.B. Kieburtz, Prentice-Hall Inc., 1978, 365 pp.
- Programming via Pascal by J.S. Rohl and Barrett, Cambridge University Press.
- An Introduction to Programming and Problem-Solving with Pascal by G.M. Schneider, S.W. Weingart and D.M. Perlman, Wiley & Sons Inc., New York, 394 pp.
- Introduction to Pascal by C.A.G. Webster, Heyden, 1976, 129 pp.
- Introduction to Pascal by J. Welsh and J. Elder, Prentice-Hall Inc., Englewood Cliffs, 220 pp.
- A Practical Introduction to Pascal by I.P. Wilson and A.M. Addyman, Springer-Verlag New York, 1978, 145pp; MacMillan, London, 1978.
- Systematic Programming: An Introduction by N. Wirth, Prentice-Hall Inc., Englewood Cliffs, 1973 169 pp.
- Algorithms + Data Structures = Programs by N. Wirth, Prentice-Hall Inc., Englewood Cliffs, 1976 366 pp.

This reference manual considers ANSI/IEEE770X3.97-1983 as the Pascal Standard.

STRUCTURE OF THIS MANUAL

This manual is divided into the following major topics

Chapter 1 is a summary of the language.

Chapter 2 is a description of the basic units (lexical) of Pascal/VS.

Chapters 3 through 9 are a top-down presentation of the language.

Chapter 10 describes the I/O procedures and functions.

Chapter 11 describes the predefined procedures and functions.

Chapter 12 describes the compiler directives.

Appendices provide supplemental information about Pascal/VS.

PASCAL/VS SYNTAX DIAGRAMS

The syntax of Pascal/VS will be described with the aid of syntax diagrams. These diagrams are essentially "road maps"; by traversing the diagram in the direction of the arrows you can identify every possible legal Pascal/VS program.

Within the syntax diagram, the names of other diagrams are printed in lower case and surrounded by braces ("{}"). When you traverse the name of another diagram you can consider it a subroutine call (or more precisely a "subdiagram call"). The names of reserved words are always in lower case. Special symbols (i.e. semicolons, commas, operators, etc.) appear as they appear in a Pascal/VS program.

The diagram traversal starts at the upper left and completes with the arrow on the right. Every horizontal line has an arrowhead to show the direction of the traversal on that line. The direction of traversal on the vertical lines can be deduced by looking at the horizontal lines to which it connects. Dashed lines (i.e. "----") indicate constructs which are unique to Pascal/VS and are not found in standard Pascal.

Identifiers may be classified according to how they are declared. For the sake of clarity, a reference in the syntax diagram for {id} is further specified with a one or two word description indicating how the identifier was declared. The form of the reference is "{id:description}". For example {id:type} references an identifier declared as a type; {id:function} references an identifier declared as a function name.

REVISION CODES

The convention used in this document is that all changes in the current version from the previous edition are flagged with a vertical bar in the left margin.

Extensions to Pascal are marked with a plus sign in the margin.

RELEASE 2.2

The following is a list of the functional changes that were made to Pascal/VS for Release 2.2.

- The interactive debugger now supports 32 breakpoints.
- Two new predefined constants have been added to the compiler: MINREAL and MAXREAL.
- The LANGLVL(STDRES) compiler option has been added to allow the user to use the non-standard Pascal/VS reserved words as identifiers.
- A new predefined function, ADDR, accepts a variable name and returns the location of that variable in storage.
- Structured array constants may now be passed as the source arrays to PACK and UNPACK.

RELEASE 2.1

The following is a list of the functional changes that were made to Pascal/VS for Release 2.1.

- A procedure (or function) at any nesting level may now be passed as a routine parameter. The previous restriction which required such procedures to be at the outermost nesting level of a module has been removed.
- Two new options may be applied to files when they are opened: UCASE and NOCC.
- Rules have been relaxed in passing fields of packed records by **var** to a routine.
- The "STACK" and "HEAP" run time options have been added to control the amount by which the stack and heap are extended when an overflow occurs.
- The syntax of a "structured constant" which contains non-simple constituents has been simplified.

RELEASE 2.0

The following is a list of the functional changes that were made to Pascal/VS for Release 2.0.

- Pascal/VS now supports single precision floating point (32 bit) as well as double precision floating point (64 bit).
- Files may be opened for updating with the UPDATE procedure.
- Files may be opened for terminal input (TERMIN) and terminal output (TERMOUT) so that I/O may take place directly to the user's terminal without going through the DDNAME interface.
- The MAIN directive permits you to define a procedure that may be invoked from a non-Pascal environment. A procedure that uses this directive is not reentrant.
- The REENTRANT directive permits you to define a procedure that may be invoked from a non-Pascal environment. A procedure that uses this directive is reentrant.
- A new predefined type, STRINGPTR, has been added that permits you to allocate strings with the NEW procedure whose maximum size is not defined until the invocation of NEW.

A new parameter passing mechanism is provided that allows strings to be passed into a procedure or function without requiring you to specify the maximum size of the string on the formal parameter.

The maximum size of a string has been increased to 32767 characters.

The Pascal/VS compiler is now fully reentrant.

Code produced from the compiler will be reentrant if static storage is not modified.

Pascal/VS programs may contain source lines up to 100 characters in length.

Files may be accessed based on relative record number (random access).

Run time errors may be intercepted by the user's program.

Run time diagnostics have been improved.

Pascal/VS will flag extensions when the option "LANGLVL(STD)" is used.

A mechanism has been provided so that Pascal/VS routines may be called from other languages.

All record formats acceptable to QSAM are now supported by the Pascal/VS I/O facilities.

A procedure or function may now be exited by means of the **goto** statement.

You may now declare an array variable where each element of the array is a file.

You may define a file to be a field of a record structure.

Files may now be allocated in the heap (as a dynamic variable) and accessed via a pointer.

You may now define a subrange of INTEGER which is allocated to 3 bytes of storage. Control over signed or unsigned values is determined by the subrange.

- Variables may be declared in the outermost scope of a SEGMENT. These variables are defined to overlay the variables in the outermost scope of the main program.
- The PDSIN procedure opens a member of a library file (partitioned dataset) for input.
- The PDSOUT procedure opens a member of a library file (partitioned dataset) for output.
- A procedure or function that is declared as EXTERNAL may have its body defined later on in the same module. Such a routine becomes an entry point.
- The CPAGE percent (%) statement conditionally does a page eject if less than a specified number of lines remain on the current listing page.
- The MAXLENGTH function returns the maximum length that a string variable can assume.
- The %CHECK TRUNCATE option enables (or disables) the checking for truncation of strings.
- The PASCALVS exec for invoking the compiler under CMS has been modified so that the specification of the operands allows greater flexability.
- New compiler options have been added, namely: LINECOUNT, PXREF, PAGEWIDTH, and LANGLVL.
- The catalogued procedures for invoking Pascal/VS in OS Batch have been simplified.
- The format of the output listing has been modified so that longer source lines may be accomodated.
- Multiple debugger commands may be entered on a single line by using a semicolon (;) as a separator.

- The format of the Pascal File Control Block has been modified.
- Support is now provided for ANSI and machine control characters on output files.
- Execution of a Pascal/VS program will terminate after a user determined number of non-fatal run time errors.
- The debugger now supports breakpoints at the end of a procedure or function.
- The Trace mode in the debugger provides information on when procedures are being exited.
- The TRACE procedure now permits you to specify the file on which the traceback is to be written.
- The Equate command of the debugger has been enhanced.
- The debugger will print "uninitialized" when displaying a variable that has not been assigned.
- New run time options are provided: SETMEM, ERRCOUNT, and ERRFILE.

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"The language Pascal was designed by Professor Niklaus Wirth to satisfy two principal aims:

- to make available a language suitable for teaching programming as a systematic discipline based on certain fundamental concepts clearly and naturally reflected by the language.
- to define a language whose implementations could be both reliable and efficient on then available computers."

(Pascal Draft Proposal ISO/TC 97/SC 5 N595, January, 1981)

Pascal/VS is an extension to standard Pascal. The purpose of extending Pascal is to facilitate application programming requirements. Among the extensions are such features as separately compilable external routines, internal and external static data, and varying length character strings.

Pascal is of interest as a high level programming language for the following reasons:

- It provides constructs for defining data structures in a clear manner.
- It is suitable for applying structured programming techniques.
- The language is relatively machine-independent.
- Its syntax and semantics allow extensive error diagnostics during compilation.
- A program written in the language can have extensive execution time checks.
- Its semantics allow efficient object code to be generated.
- Its syntax allows relatively easy compilation.
- The language is relatively well known and is growing in popularity.

1.1 PASCAL LANGUAGE SUMMARY

This section of the manual is meant to be a capsule summary of Pascal/VS. It should serve as a brief outline of the language. The details are explained in the remainder of this document.

1.1.1 Syntax

The syntax is described with an example-like format that summarizes the important features of the item. The following rules are the conventions used.

...	indicates that the item preceding this symbol may be repeated an arbitrary number of times.
<u>[ ]</u>	encloses items which are optional.
[ ]	denote the standard square brackets of Pascal.
item-comma-list	indicates that the item may be repeated, separating each occurrence with a comma.
digit-list	refers to a sequence of one or more digits ("0".."9").
binary-digits	refers to a sequence of one or more binary digits ("0" or "1").
hex-digits	refers to a sequence of one or more hexadecimal digits ("0".."9" or "A".."F").
id	refers to an identifier.
label	refers to either an identifier or an integer number in the range 0..9999.

directive refers to any one of: FORWARD, EXTERNAL, FORTRAN, MAIN, or REENTRANT.

field-list refers to the list of fields that compose the body of a record data type.

1.1.2 Modules

program is a self-contained and independently executable unit of code.

```
program id [ ( id-comma-list ) ] ;
  declaration...
  compound-statement .
```

SEGMENT is a shell in which procedures and functions may be separately compiled.

```
SEGMENT id ;
  declaration... .
```

1.1.3 Declarations

label is used to declare a label in a program, procedure or function.

```
label
  label-comma-list ;
```

const declares an identifier that becomes synonymous with a compile time computable value.

```
const
  id = constant-expression ;
[ id = constant-expression ; ]...
```

type declares an identifier which is a user-defined data type.

```
type
  id = data-type ;
[ id = data-type ; ]...
```

var declares a local variable.

```
var
  id-comma-list : data-type ;
[ id-comma-list : data-type ; ]...
```

def declares a variable which is defined in one module and may be referenced in other modules.

```
def
  id-comma-list : data-type ;
[ id-comma-list : data-type ; ]...
```

ref declares a variable which is defined in another module.

```
ref
  id-comma-list : data-type ;
[ id-comma-list : data-type ; ]...
```

static declares a variable which persists for the entire execution of the program.

```
static
  id-comma-list : data-type ;
[ id-comma-list : data-type ; ]...
```

value assigns a value to a **def** or **static** variable at compile time.

```
value
  variable := constant-assignment-statement ;
[ variable := constant-assignment-statement ; ]...
```

procedure defines a unit of a module which may be invoked as a statement.

```
procedure id [ ( parameter [; parameter]... ) ] ;
  directive ;
          or
procedure id [ ( parameter [; parameter]... ) ] ;
  declaration...
  compound-statement ;
```

function defines a unit of a module which may be invoked and returns a value.

```
function id [ ( parameter [; parameter]... ) ] : id ;
  directive ;
          or
function id [ ( parameter [; parameter]... ) ] : id ;
  declaration...
  compound-statement ;
```

1.1.4 Data-Types

id is an identifier that was previously declared as a type.

enumeration is a list of constants of a user-defined scalar data type.

```
( id-comma-list )
```

subrange is a continuous range of a scalar type.

```
[ packed ] constant .. constant-expression
```

array is a data structure composed of a list of homogeneous elements.

```
[ packed ] array [ data-type ] of data-type
```

record is a data structure composed of a list of heterogeneous fields.

```
[ packed ] record
  [ id-comma-list : data-type ; ]...
  [ case [id :] id of
      constant-comma-list : ( field-list ) ;
  [ constant-comma-list : ( field-list ) ; ]... ]
end
```

set is a collection of zero or more scalar values.

```
[ packed ] set of data-type
```

file is a sequence of data to be read or written by a Pascal program.

```
file of data-type
```

pointer is a reference to a variable that is created by the programmer.

```
@ id
```

1.1.5 Parameters

value designates a pass-by-value parameter.

```
id-comma-list : id
```

var designates a pass-by-reference (read/write) parameter.

```
var id-comma-list : id
```

const designates a pass-by-reference (read-only) parameter.

```
const id-comma-list : id
```

procedure is the mechanism whereby a procedure may be passed to the called procedure (function) and executed from there.

```
procedure id [ ( parameter [; parameter]... ) ] ;
```

function is the mechanism whereby a function may be passed to the called procedure (function) and executed from there.

```
function id [ ( parameter [; parameter]... ) ] : id ;
```

1.1.6 Statements

Every statement may be preceded with one label:

```
[ label: ] statement
```

assert tests a condition that should be true and if not causes a runtime error to be produced.

```
assert bool-expression
```

assignment assigns a value to a variable.

```
variable := expression
```

case causes any one of a list of statements to be executed based upon the value of an expression.

```
case expression of
  [ constant-comma-list : statement ; ]...
  [ otherwise
    statement [ ; statement ]... ]
end
```

compound is a series of statements enclosed within **begin/end** brackets.

```
begin
  statement [ ; statement ]...
end
```

continue resumes execution of the next iteration of the innermost loop. The termination condition is tested to determine if the loop should continue.

```
continue
```

empty contains no executable code.

for is a loop statement that modifies a control variable for each iteration of the loop.

```
for variable := expression to expression do
  statement
            or
for variable := expression downto expression do
  statement
```

goto changes the flow of your program.

```
goto label
```

if causes one of two statements to be executed based on the evaluation of an expression.

```
if bool-expression then
    statement
[ else
    statement ]
```

leave terminates the execution of the innermost loop. Execution resumes as if the loop termination condition were true.

```
leave
```

call invokes a procedure. At the conclusion of the procedure, execution continues at the next statement.

```
id [ ( expression-comma-list ) ]
```

repeat is a loop statement with the termination test occurring at the end of the loop.

```
repeat
  statement [ ; statement ]...
until bool-expression
```

return terminates the executing procedure (function) and returns control to the caller.

```
return
```

while is a loop statement with the termination test occurring at the beginning of the loop.

```
while bool-expression do
  statement
```

with permits complicated references to fields within a record to be treated as simple variables within a statement.

```
with variable-comma-list do
  statement
```

1.1.7 Expressions

An expression is composed of operands combined with operators. The operators have the following precedence:

```
not operator (highest)
multiplying operators
adding operators
relational operators (lowest)
```

1.1.8 Operands

variable represents a unit of storage which may be referenced and altered.

```
simple variable: id
array:           variable [ expression ]
field:           variable . id
pointer:         variable @
```

constant represents a literal value.

```
INTEGER          digit-list
                  ' hex-digits 'X
                  ' binary-digits 'B
REAL             digit-list . digit-list [E+/- digit-list]
                  ' hex-digits 'XR
BOOLEAN          FALSE/TRUE
CHAR             EBCDIC character in single quotes
string           EBCDIC characters in single quotes
                  ' hex-digits 'XC
array            id ( expression [: expression]
                      [ , expression [: expression] ]... )
record           id ( expression [, expression]... )
```

set-constructor refers to an operand that describes the values of a set.

[expression [.. expression]
[, expression [.. expression]]...]

function-call refers to the invocation of a function.

id [(expression-comma-list)]

parenthesized-expression is used to override the normal precedence of operators.

(expression)

1.1.9 Special Symbols

symbol	meaning
+	addition and set union operator
-	subtraction and set difference operator
*	multiplication and set intersection operator
/	division operator, REAL results only
¬	BOOLEAN not, one's complement on INTEGER or set complement
|	BOOLEAN or, logical or on INTEGER
&	BOOLEAN and, logical and on INTEGER
&&	BOOLEAN xor operator, logical xor on INTEGER and set exclusive union
=	equality operator
<	less than operator
<=	less than or equal operator
>=	greater than or equal operator
>	greater than operator
<> or ¬=	not equal operator
>>	right logical shift on INTEGER
<<	left logical shift on INTEGER
||	catenation operator
:=	assignment symbol
.	period to end a module
.	field separator in a record
,	comma, used as a list separator
:	colon, used to specify a definition
;	semicolon, used as a statement separator
..	subrange notation
'	quote, used to begin and end string constants
@ or ->	pointer symbol
(	left parenthesis
)	right parenthesis
[or (.	left square bracket
] or .)	right square bracket
{ or (*	comment left brace (standard)
} or *)	comment right brace (standard)
/*	comment left brace (alternate form)
*/	comment right brace (alternate form)

1.1.10 Identifiers

Identifiers are composed of the letters "a" through "z", the digits "0" through "9" and the special characters "_" and "$". An identifier must begin with a letter or "$" and must be unique in the first 16 positions. There is no distinction between the an upper case letter and its lower case equivalent.

1.1.11 The Not Operator

operator	operation	operands	result
¬ (**not**)	boolean not	BOOLEAN	BOOLEAN
¬ (**not**)	logical one's complement	INTEGER	INTEGER
¬ (**not**)	complement	**set of** t	**set of** t

1.1.12 Multiplying Operators

operator	operation	operands	result
*	multiplication	INTEGER	INTEGER
		SHORTREAL	SHORTREAL
		REAL	REAL
		mixed	REAL
/	real division	INTEGER	REAL
		SHORTREAL	SHORTREAL
		REAL	REAL
		mixed	REAL
div	integer division	INTEGER	INTEGER
mod	modulo	INTEGER	INTEGER
& (**and**)	boolean and	BOOLEAN	BOOLEAN
& (**and**)	logical and	INTEGER	INTEGER
*	set intersection	**set of** t	**set of** t
||	string catenation	STRING	STRING
<<	logical left shift	INTEGER	INTEGER
>>	logical right shift	INTEGER	INTEGER

1.1.13 Adding Operators

operator	operation	operands	result
+	addition	INTEGER	INTEGER
		SHORTREAL	SHORTREAL
		REAL	REAL
		mixed	REAL
+	set union	**set of** t	**set of** t
-	subtraction	INTEGER	INTEGER
		SHORTREAL	SHORTREAL
		REAL	REAL
		mixed	REAL
-	set difference	**set of** t	**set of** t
| (**or**)	boolean or	BOOLEAN	BOOLEAN
| (**or**)	logical or	INTEGER	INTEGER
&& (**xor**)	boolean xor	BOOLEAN	BOOLEAN
&& (**xor**)	logical xor	INTEGER	INTEGER
&& (**xor**)	exclusive union	**set of** t	**set of** t

1.1.14 Relational Operators

operator	operation	operands	result
=	compare equal	any set, scalar, pointer or string	BOOLEAN
<> (¬=)	not equal	any set, scalar, pointer or string	BOOLEAN
<	less than	scalar type or string	BOOLEAN
<=	compare < or =	scalar type or string	BOOLEAN
<=	subset	**set of** t	BOOLEAN
>	compare greater	scalar type or string	BOOLEAN
>=	compare > or =	scalar type or string	BOOLEAN
>=	superset	**set of** t	BOOLEAN
in	set membership	t and **set of** t	BOOLEAN

1.1.15 Reserved Words

and	**end**	**of**	**space**
array	**file**	**or**	**static**
assert	**for**	**otherwise**	**then**
begin	**function**	**packed**	**to**
case	**goto**	**procedure**	**type**
const	**if**	**program**	**until**
continue	**in**	**range**	**value**
def	**label**	**record**	**var**
div	**leave**	**ref**	**while**
do	**mod**	**repeat**	**with**
downto	**nil**	**return**	**xor**
else	**not**	**set**	

1.1.16 Predefined Constants

ALFALEN	length of type ALFA, value is 8
ALPHALEN	length of type ALPHA, value is 16
FALSE	constant of type BOOLEAN, FALSE < TRUE
MAXINT	maximum value of type INTEGER: 2147483647
MAXREAL	maximum value of type REAL: '7FFFFFFFFFFFFFFF'XR
MININT	minimum value of type INTEGER: -2147483648
MINREAL	minimum non-zero value of type REAL: '0010000000000000'XR
TRUE	constant of type BOOLEAN, TRUE > FALSE

1.1.17 Predefined Types

ALFA	**packed array[** 1..ALFALEN **]** **of** CHAR
ALPHA	**packed array[** 1..ALPHALEN **]** **of** CHAR
BOOLEAN	data type composed of the values FALSE and TRUE
CHAR	character data type

INTEGER	integer data type
REAL	floating point represented in a 64 bit value
SHORTREAL	floating point represented in a 32 bit value
STRING	an array of CHAR whose length varies during execution up to a specified maximum
STRINGPTR	is a predefined type that points to a STRING whose maximum length is determined when the STRING is allocated with NEW
TEXT	file of CHAR

1.1.18 Predefined Variables

INPUT	default input file
OUTPUT	default output file

1.1.19 Predefined Functions

The following symbols represent parameters in the descriptions of the predefined functions and procedures.

```
a = an array variable
e = any expression
f = a file variable
n = a positive integer expression
p = pointer valued variable
s = a string expression
t = a type name or variable name
v = a variable
x = any arithmetic expression
```

ABS(x)	computes the absolute value "x"
ADDR(v)	returns the address of variable "v"
ARCTAN(x)	returns the arctangent of "x"
CHR(n)	returns the EBCDIC character whose ordinal value is "n"
CLOCK	returns the number of micro-seconds of execution
COLS(f)	returns current column of file "f"
COMPRESS(s)	replaces multiple blanks in "s" with one blank
COS(x)	returns the cosine of "x"
DELETE(s,n1[,n2])	returns "s" with the "n2" characters starting at position "n1" removed
EOF(f)	tests file "f" for end-of-file condition
EOLN(f)	tests file "f" for end-of-line condition
EXP(x)	computes the base of the natural log (e) raised to to the power "x"
FLOAT(n)	converts "n" to a floating point value
HBOUND(a[,n])	determines the upper bound of array "a"
HIGHEST(t)	determines the maximum value the type of a scalar "t"
INDEX(s1,s2)	returns the location, if present, of "s2" in "s1"
LBOUND(a[,n])	determines the lower bound of array "a"

LENGTH(s)	determines the current length of string "s"
LN(x)	returns the natural logarithm of the "x"
LOWEST(t)	determines the minimum value the type of a scalar "t"
LTRIM(s)	returns "s" with leading blanks removed
MAX(x[,x]...)	determines the maximum value of a list of scalar expressions
MAXLENGTH(s)	determines the maximum length of string "s"
MIN(x[,x]...)	determines the minimum value of a list of scalar expressions
ODD(n)	returns TRUE if integer "n" is odd
ORD(x)	converts a scalar value "x" to an integer
PARMS	returns the system dependent invocation parameters
PRED(x)	obtains the predecessor of scalar expression "x"
RANDOM(n)	returns a pseudo-random number, "n" is the seed value or zero
ROUND(x)	converts a floating point value to an integer value by rounding
SIN(x)	returns the sine of "x"
SIZEOF(t)	determines the memory size of a variable or type "t"
SQRT(x)	returns the square root of "x"
SQR(x)	returns the square of "x"
STR(a)	converts array of characters "a" to a string
SUBSTR(s,n1[,n2])	returns the substring of "s" starting at "n1" with length "n2"
SUCC(x)	obtains the successor of scalar "x"
TRIM(s)	returns "s" with trailing blanks removed
TRUNC(x)	converts floating point expression "x" to an integer by truncating

1.1.20 Predefined Procedures

CLOSE(f)	closes a file
DATETIME(a1,a2)	returns the current date in "a1" and time of day in "a2"
DISPOSE(p)	deallocates a dynamic variable
GET(f)	advances file pointer to the next element of input file "f"
HALT	halts the programs execution
MARK(p)	creates a new heap, "p" designates the heap
NEW(p,[,x]...)	allocates a dynamic variable from the most recent heap
PACK(a1,x,a2)	copies array "a1" starting at index "n" to packed array "a2"
PAGE[(f)]	skips to the top of the next page
PDSIN(f,s)	opens file "f" for input, where "s" designates the open options which must specify the member name
PDSOUT(f,s)	opens file "f" for output, where "s" designates the open options which must specify the member name
PUT(f)	advances the file pointer to the next element of output file "f"

READ([f,]v[,v]...) reads data from file "f" into variable "v"

READLN([f,]v[,v]...) reads variable "v" and then skips to end-of-line of TEXT file "f"

READSTR(s,v[,v]...) reads data from string "s" into variable "v"

RELEASE(p)	destroys one or more heaps, "p" designates the last heap to be destroyed
RESET(f[,s])	opens file "f" for input, "s" designates the optional open options
RETCODE(n)	sets the system return code
REWRITE(f[,s])	opens file "f" for output, "s" designates the optional open options
SEEK(f,n)	modifies the current position of file "f' so that next GET (or PUT) reads (or writes) record number "n", where record 1 is the first record of the file
TERMIN(f[,s])	opens file "f" for input from the users terminal, "s" designates the optional open options
TERMOUT(f[,s])	opens file "f" for output from the users terminal, "s" designates the optional open options
TOKEN(s,v)	extracts tokens from string "s" updating starting position "v"
TRACE(f)	writes the procedure and function invocation history to file "f"
UNPACK(a1,a2,n)	copies packed array "a1" to array "a2" beginning at index "n"
UPDATE(f[,s])	opens file "f" for update -- a PUT immediately following a GET of a record of the file replaces that record; "s" designates the optional open options

WRITE([f,]e[,e]...) writes the value of "x" to file "f"

WRITELN([f,]e[,e]...) writes the value of "x" and then writes an end-of-line to TEXT file "f"

WRITESTR(s,e[,e]...) writes the value of "e" to string "s"

1.1.21 % Statements

%CHECK	enables or disables execution time checking features.
%CPAGE n	skips to the next page if less than "n" lines remain on the current page
%INCLUDE	includes source code from a library.
%LIST ON/OFF	enables or disables the pseudo-assembler listing.
%MARGINS m n	resets the left margin of the source program to "m" and the right margin to "n".
%PAGE	forces the source listing to start on a new page.
%PRINT ON/OFF	enables or disables the source listing.
%SKIP n	inserts "n" blank lines into the source listing.
%TITLE	specifies a title for the listing.

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2.1 IDENTIFIERS

Syntax:

```
id:
                     ┌───────────────────────────────────────────>
                     │
──>{letter}──┬───────┼──>{digit}──────>┐
             │       ├──>{letter}─────>┼────>┐
             │       └--->{underscore}-->┘    │
             │                               │
             └<──────────────────────────────┘

where:
   {letter} is 'A', 'B', ..., 'Z','a','b', .... 'z' or '$'
   {digit} is '0', '1', ..., '9'
   underscore is '_'
```

Identifiers are names given to variables, data types, procedures, functions, named constants and modules.

correct:	incorrect:
I	5K
K9	NEW JERSEY
New_York	
AMOUNT$	

Valid and Invalid Identifiers

Pascal/VS permits identifiers of up to 16 characters in length. You may use longer names but Pascal/VS will ignore the portion of the name longer than 16 characters. You must assure identifiers are unique within the first 16 positions.

There is no distinction between lower and upper case letters within an identifier name. For example, the names 'ALPHA', 'alpha', and 'Alpha' are equivalent.

There is an implementation restrictions on the naming of external variables and external routines. You must make sure that identifiers used as external names are unique in the first 8 characters.

2.2 LEXICAL SCOPE OF IDENTIFIERS

The area of the module where a particular identifier can be referenced is called the lexical scope of the identifier (or simply scope).

In general, scopes are dependent on the structure of routine declarations. Since routines may be nested within other routines, a lexical level is associated with each routine. In addition, record definitions define a lexical scope for the fields of the record. Within a lexical level, each identifier can be defined only once. A program module is at level 0, routines defined within the module are at level 1; in general, a routine defined in level i would be at level (i+1). The following diagram illustrates a nesting structure.

```
program M (level 0)
  procedure A (level 1)
    procedure B (level 2)
    type
         R =
          record
            R1:...
            R2:...
          end;

      function C
            (level 3)

    procedure D (level 2)

  function X (level 1)
    procedure Y (level 2)

    procedure Z (level 2)
```

The scope of an identifier is the entire routine (or module) in which it was declared; this includes all routines defined within the routine. The following table references the preceding diagram.

identifiers declared in:	are accessible in:
Module M	M,A,B,C,D,X,Y,Z
procedure A	A,B,C,D
procedure B	B,C
type R	B,C
function C	C
procedure D	D
function X	X,Y,Z
procedure Y	Y
procedure Z	Z

If an identifier is declared in a routine which is nested in the scope of another identifier with the same name, then the new identifier will be the one recognized when its name appears in the routine. The first identifier becomes inaccessible in the routine. In other words, the identifier declared at the innermost level is the one accessible.

The scope of a field identifier defined within a record definition is limited to the record itself. The scope of a record may be accessed by either field referencing (see "Field Referencing" on page 70) or with the with-statement (see "The With Statement" on page 102).

The Pascal/VS compiler effectively inserts a prelude of declarations at the beginning of every module it compiles. These declarations consist of the predefined types, constants, and routines. The scope of the prelude encompasses the entire module. You may re-declare any identifier that is predefined if you would like to use the name for another purpose.

2.3 RESERVED WORDS

Reserved Words			
and	end	of	+ space
array	file	or	+ static
+ assert	for	+ otherwise	then
begin	function	packed	to
case	goto	procedure	type
const	if	program	until
+ continue	in	+ range	+ value
+ def	label	record	var
div	+ leave	+ ref	while
do	mod	repeat	with
downto	nil	+ return	+ xor
else	not	set	

Note: Those words marked by '+' are not reserved in standard Pascal and may be used as identifiers when using LANGLVL(STDRES).

Pascal/VS reserves the identifiers shown above for expressing the syntax of the language. These reserved words may never be declared by you. Reserved words must be separated from other reserved words and identifiers by a special symbol, a comment, or at least one blank.

A lower case letter is treated as equivalent to the corresponding upper case letter in a reserved word.

2.4 SPECIAL SYMBOLS

Special Symbols	
symbol	meaning
+	addition and set union operator
-	subtraction and set difference operator
*	multiplication and set intersection operator
/	division operator, REAL result only
¬	BOOLEAN not, one's complement on INTEGER or set complement
|	BOOLEAN or, logical or on INTEGER
&	BOOLEAN and, logical and on INTEGER
&&	BOOLEAN xor operator, logical xor on INTEGER and set exclusive union
=	equality operator
<	less than operator
<=	less than or equal operator
>=	greater than or equal operator
>	greater than operator
<> or ¬=	not equal operator
>>	right logical shift on INTEGER
<<	left logical shift on INTEGER
||	catenation operator
:=	assignment symbol
.	period to end a module
.	field separator in a record
,	comma, used as a list separator
:	colon, used to specify a definition
;	semicolon, used as a statement separator
..	subrange notation
'	quote, used to begin and end string constants
@ or ->	pointer symbol
(	left parenthesis
)	right parenthesis
[or (.	left square bracket
] or .)	right square bracket
{ or (*	comment left brace (standard)
} or *)	comment right brace (standard)
/*	comment left brace (alternate form)
*/	comment right brace (alternate form)

Special symbols used by Pascal/VS are listed above. Several special symbols may also be written as a reserved word. These symbols are shown in the following table.

Symbol	Reserved Word
¬	**not**
|	**or**
&	**and**
&&	**xor**

2.5 COMMENTS

Pascal/VS supports two forms of comments: '{ ... }' and '/*...*/'. The curved braces are the standard comment symbol in Pascal. The symbols '(*' and '*)' are considered by the compiler to identical to left and right braces. The form of comment using '/*' and '*/' is considered to be distinct from the form using braces.

When the compiler encounters the symbol '{', it will bypass all characters, including end-of-line, until the symbol '}' is encountered. Likewise, all characters following '/*' will be bypassed until the symbol '*/' is detected. As a result, either form may be used to enclose the other; for example /*...{...}...*/ is one comment. One use of these two forms of comments is to use one for ordinary comments and use the other to block out temporary sections of code: a '/*...*/' comment could be used to indicate a temporary piece of code, or perhaps debugging statements.

A comment may be placed anywhere in a module where a blank would be acceptable.

```
/*
if A = 10 then { this statement is
                 for program
                 debugging       }
  WRITE('A IS EQUAL TO TEN');
*/
```

Example of a nested Comment

2.6 CONSTANTS

Syntax:

```
unsigned-integer:

 ──────┬──────┬──>{digit}───┐
       │      └<────────────┘
       ├───> ' ───┬───>{binary digit}───┬───> 'B ───>┤
       │          └<────────────────────┘            │
       └───> ' ───┬───>{hex-digit}───┬───> 'X ──────>┘
                  └<─────────────────┘

real-number:

 ──────┬───> ' ───┬───>{hex-digit}───┬───> 'XR ────────────────────>┐
       │          └<─────────────────┘                              │
       └──────┬──>{digit}───┬──────────> . ──┬──────┬──>{digit}──┬──┼──────>
              └<────────────┘                │      └<───────────┘  │
              ┌<────────────────┘            │                 │    │
              ├<─────────────────────────────┘                 │    │
              ├<───────────────────────────────────────────────┘    │
              │                                                     │
              └───> E ──────┬────────────>┬─────┬──>{digit}───┬────>┘
                            ├───> + ─────>┤     └<────────────┘
                            └───> - ─────>┘

unsigned-number:

 ──────┬───>{unsigned-integer}───>┬───────────────────────────────>
       └───>{real-number}────────>┘

string:

 ──────┬───> ' ──┬──────────────────────┬───> ' ──────┬──────────────>
       │         └<───{character}<──────┘             │
       └───> ' ───┬───>{hex-digit}───┬───> 'XC ──────>┘
                  └<─────────────────┘

unsigned-constant:

 ──────┬───>{unsigned-number}──────┬──────────────────────────────>
       │                           │
       ├───>{string}──────────────>┤
       │                           │
       ├───>{id:constant}─────────>┤
       │                           │
       └───> nil ─────────────────>┘

constant:

 ──────┬───>{unsigned-constant}──────────────────────────┬────────>
       └──┬───> + ──┬──>{unsigned-number}───────────────>┘
          └───> - ─>┘

where:
   {binary-digit} is '0' or '1'.
   {digit} is '0' through '9';
   {hex-digit} is '0' through '9' and 'A' through 'F';
   {character} is any EBCDIC character.
```

Constants can be divided into several categories according to the predefined type to which they belong. An unsigned number will conform to either a REAL or an INTEGER. Strings will conform to the type STRING or **packed array**[1..n] **of** CHAR. In addition, if the string is one character in length, it will conform to the type CHAR.

If a single quote is to be used within a string, then the quote must be written twice. Lower case and upper case letters are distinct within string constants. String literals are not permitted to extend past the end of line of a source line. Longer strings can be formed by catenating shorter strings.

Nil is of a special type which will conform to any pointer type. It represents a unique pointer value which is not a valid address.

The constants TRUE and FALSE are predefined in the language and are of the standard type BOOLEAN.

Integer hexadecimal constants are enclosed in quotes and suffixed with an 'X' or 'x'. Integer binary constants are enclosed in quotes and suffixed with a 'B' or 'b'.

Hexadecimal constants may be used in any context where an integer constant is appropriate. If you do not specify 8 hexadecimal digits (i.e. 4 bytes), Pascal/VS assumes that the digits not supplied are zeros on the left. For example, 'F'x is the value 15.

Floating point hexadecimal constants are enclosed in quotes and suffixed with an 'XR' or 'xr'. Such constants may be used in any context where a real constant is appropriate. If you do not specify 16 hexadecimal digits (i.e. 8 bytes), Pascal/VS assumes that the digits not supplied are zeros on the right. For example, '4110'xr is the same as '4110000000000000'xr.

String hexadecimal constants are enclosed in quotes and suffixed with an 'XC' or 'xc'. Such constants may be used in any context where a string constant is appropriate. There must be an even number of digits within a hexadecimal string constant; that is, you must specify each character fully that is to be in the string.

The symbol 'E' or 'e' when used in a real-number expresses 'ten to the power of'.

Pascal/VS permits <u>constant expressions</u> in places where the Pascal standard only permits constants. Constant expressions are evaluated and replaced by a single result at compile time. See "Constant Expressions" on page 78 for a description of constant expressions.

constant matches	standard type
`0`	INTEGER
`-500`	INTEGER
`1.0`	REAL
`314159E-5`	REAL
`0E0`	REAL
`1.0E10`	REAL
`TRUE`	BOOLEAN
`'FF'X`	INTEGER
`'A'`	CHAR
`'ABC'`	STRING
`'C1C2C2'xc`	STRING
`'4E800000FFFFFFFF'xr`	REAL
`'abc'`	STRING
`''`	STRING
`''''`	CHAR
`' '`	CHAR
`'  '`	STRING
`'Thats''s all '`	STRING

Examples of Constants

2.7 STRUCTURED CONSTANTS

```
 Syntax:

 structured-constant:

  ---┬--->{record-structure}---┬----------------------------------------------->
     └--->{array-structure}--->┘

 record-structure:

  --->{id:type}---> ( ---┬---┬--->{constant-expr}---┬---┬---> ) ------------->
                         │   └--------------------->┘   │
                         └<------------ , <-------------┘

 array-structure:

  --->{id:type}---> ( --->┐
     ┌<-------------------┘
     └---┬---┬--->{constant-expr}--┬--> : {repetition}--┬---┬---┬---> ) ---------->
         │   │                     └------------------->┘   │   │
         │   └--------------------------------------------->┘   │
         └<------------------ , <---------------------------────┘

 repetition:

  --->{constant-expr}---------------------------------------------------------->

  Note: the repetition must evaluate to a positive integer.
```

Structured constants are constants which are of a structured type. The type of the constant is determined by the type identifier which is used in its definition. These constants may be used in constant declarations, value declarations or in executable statements.

There are two kinds of structured constants: one is used for arrays and the second is used to specify records.

Array constants are specified by a list of constant expressions where each expression defines one element of the array. See "Constant Expressions" on page 78 for a description of constant expressions. You may omit an element of the array within the list in which case the value of that element is not defined. Elements may be omitted at the end of the array in which case the value of those elements are also not defined. You may follow the constant expression with a colon and a repetition expression; this is used to specify that the first constant expression is to be repeated.

The second kind of structured constant is used to specify records. Record constants are specified by a list of constant expressions where each expression defines one field of the record in the order declared. You may omit a field of the record within the list by specifying nothing between two commas, in which case the value of that field is not defined.

Values within the list may correspond to fields of a record's variant part. In order for the compiler to know which variant is being referenced, the tag field value must be specified immediately prior to those values which are to be assigned to the variant fields. (See the examples below.) The tag field must be specified even if it does not exist as a field. (This occurs when only a tag type is specified.)[1]

The type identifier that begins a structured constant may be omitted if the structured constant is imbedded within another structured constant. This simplifies the syntax for structured constants which are multidimensional arrays or records with structured fields.

---

[1] If the tag field is a "refer-back" type (see "Variant Part" on page 47) then it will need to be specified twice in the list: once to be assigned a value, and again to identify the variant being referenced.

```
type
  COMPLEX = record
              RE,IM: REAL
            end;
  VECTOR  = array[1..7] of INTEGER;
  CARRAY  = array[0..9] of COMPLEX;
  TETRA   = array[1..3,1..2,1..4]
                 of INTEGER;

const
  { Structured Constants    }
  THREEFOUR = COMPLEX(3.0,4.0);
  VECTOR_1  = VECTOR(7,0:5,1);
  VECTOR_2  = VECTOR(2,3,,4);
  ZEROTETRA =
        TETRA(
          ( (0:4):2 ),
          ( (0:4),(0:4) ),
          ( (0,0,0,0),(0,0,0,0) ) );

  {the following two declarations
    are equivalent                    }
  VECTOR_3  = CARRAY(
                  COMPLEX(1.0,0.0),
                  COMPLEX(1.0,1.0):8,
                  COMPLEX(0.0,1.0));
  VECTOR_4  = CARRAY(
                   (1.0,0.0),
                   (1.0,1.0):8,
                   (0.0,1.0));
```

Examples of Structured Constants

```
type
  FORM = (FCHAR,FINTEGER,FREAL,
          FSTRING);
  KONST =
   record
     SIZE: INTEGER;
     case F: FORM of
       FCHAR:    (C: CHAR);
       FINTEGER: (I: INTEGER);
       FREAL:    (R: REAL);
       FSTRING:  (
          case BOOLEAN of
              TRUE: (
                 LEN: packed 0..32767;
                 A   : ALPHA);
              FALSE:(S: STRING(16)));
   end

const
  A      = KONST(1,FCHAR,'A');
  PI     = KONST(8,FREAL,3.14159);
  BLANK  =
      KONST(1,FSTRING,FALSE,' ');
  STARS  =
      KONST(4,FSTRING,TRUE,4,'****');
```

Structured constants with variant record fields

This page intentionally left blank

Syntax:

module:

```
───┬────>{program-module}──────┬──────────────────────────────────────────────────────>
   └───>{segment-module}--->───┘
```

program-module:

```
──> program ──>{id}────┬────> ( ──┬──>{id}──┬───> ) ───┬──>┐
                       │          └<── , <──┘          │   │
                       └─────────────────────────────>─┘   │
    ┌<──────────────────────────── ; <─────────────────────┘
    │
    ├<────────────────────────┐
    ├───>{declaration}───>────┘
    │
    └───>{compound-statement}───┬───> . ──┬─────────────────────────────────────>
                                └────────>┘
```

declaration:

```
─────┬───>{label-dcl}──────────>┐
     │                          │
     ├───>{constant-dcl}───────>┤
     │                          │
     ├───>{type-dcl}───────────>┤
     │                          │
     ├───>{var-dcl}────────────>┤
     │                          │
     ├--->{def-dcl}----------->┤
     │                          │
     ├--->{static-dcl}-------->┤
     │                          │
     ├--->{value-dcl}--------->┤
     │                          │
     └───>{routine-dcl}───────>┴──────────────────────────────────────────────>
```

segment-module:

```
---> SEGMENT --->{id}---> ; --->┐
    ┌<--------------------------┬------┘
    │                          │
    ├--->{constant-dcl}----->┤
    │                          │
    ├--->{type-dcl}--------->┤
    │                          │
    ├--->{var-dcl}---------->┤
    │                          │
    ├--->{def-dcl}---------->┤
    │                          │
    ├--->{static-dcl}------->┤
    │                          │
    ├--->{value-dcl}-------->┤
    │                          │
    ├--->{routine-dcl}------>┘
    │
    └---┬---> . ---┬---------------------------------------------------------->
        └--------->┘
```

A module is an independently compilable unit of code. There are two types of modules in Pascal/VS: the program module and the segment module.

The program is the module which gains initial control when the compiled program is invoked from the system loader. It is effectively a procedure that the loader invokes. The body of a program module is identical to the body of a procedure.

A segment module may be compiled as a unit independent of the program module. It consists of routines that are to be linked into the final program prior to execution. Data is passed to routines through parameters and external variables. Segments are useful in breaking up large Pascal/VS programs into smaller units.

The global automatic variables of the program module may be accessed in a segment module. See "The Var Declaration" on page 28 for an explanation.

The identifier following the reserved word "**program**" must be a unique external name. The identifier following the word "SEGMENT" may be the same as one of the EXTERNAL routines in the segment or may be a unique external name. Thus, a function called SIN could be in a segment called SIN. An external name is an identifier for a program, segment, def or ref variable, EXTERNAL routine, MAIN procedure or a REENTRANT procedure.

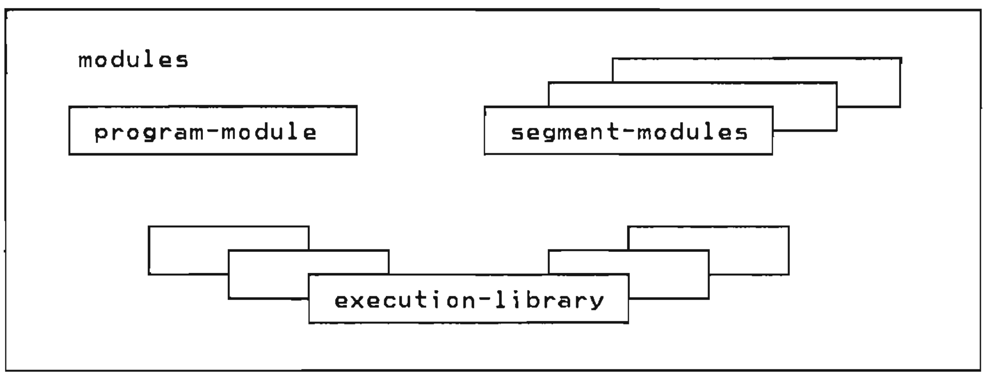
The optional identifier list following the program identifier is not used by Pascal/VS. The identifiers will be ignored.

A program is formed by linking a program module with segment modules (if any) and with the Pascal/VS execution library and libraries that you may supply.

Pascal/VS allows declarations to be given in any order. This is an extension to Pascal and is provided primarily to permit source that is INCLUDEd during compilation to be independent of any ordering already established in the module. The standard ordering for declarations is shown in the diagram for declarations. (For a description of the INCLUDE facility see "The %INCLUDE Statement" on page 150.)

Every identifier must be predefined or declared by you before it is used. There is one exception to this rule: a definition of a pointer may refer to an identifier before it is declared. The identifier must be declared later or a compile-time' diagnostic will be produced.

Pascal/VS program




```
program EXAMPLE;
  var
     I : INTEGER;
  begin
    for I:=0 to 1000 do
      if I mod 7 = 0 then
        WRITELN( I:5,
           ' IS DIVISIBLE BY SEVEN')
  end.
```

Example of a Program Module

```
SEGMENT COSINE;
  function COSINE
       (X : REAL ) : REAL; EXTERNAL;
  function COSINE;
  var S: REAL;
  begin
    S := SIN(X);
    COSINE := SQRT(1.0 - S*S)
  end; .
```

Example of a Segment Module

Pascal/VS provides you with 10 types of declarations:

- label
- const
- type
- var
- def
- ref
- static
- value
- procedure
- function

4.1 THE LABEL DECLARATION

Syntax:

label-dcl:

```
 ---> label ----+--->{label}----+-----> ; ---------------------------------->
                └<------- , <---┘
```

label:

```
 -----+--->{unsigned-integer}---+------------------------------------------->
      └--->{id}---------------->┘
```

Note: the values of the unsigned integer must be in the subrange 0..9999.

A label declaration is used to declare labels which will appear in the routine and will be referenced by a goto statement within the routine. All labels defined within a routine must be declared in a label declaration within the routine.

A label may be either an unsigned integer or an identifier. If the value is an unsigned integer it must be in the range 0 to 9999.

```
label
  10,
  Label_A,
  1,
  2,
  Error_exit;
```

A Label Declaration

4.2 THE CONST DECLARATION

Syntax:

<u>constant-dcl:</u>

```
——> const ——┬——>{id}——> = ——>{constant-expr}——> ; ——┬——————————————————>
            └<——————————————————————————————————————┘
```

A constant declaration allows you to assign identifiers that are to be used as synonyms for constant expressions. The type of a constant identifier is determined by the type of the expression in the declaration.

```
const
  BLANK     = ' ';
  BLANKS    = '  ';
  FIFTY     = 50;
  A         = FIFTY;
  B         = FIFTY * 10/(3+2);
  C_SQUARED = A*A + B*B;
  ORD_OF_A  = ORD('A');
  PI        = 3.14159265358;
  MASK      = '8000'X | '0400'X;
  ALFALEN   = 8;
  ALPHALEN  = 16;
  LETTERS   = [ 'A'..'Z','a'..'z' ]
  MAXREAL   = '7FFFFFFFFFFFFFFF'xr;
```

Constant Declarations

4.3 THE TYPE DECLARATION

Syntax:

type-dcl:

```
——> type ——┬——>{id}——> = ——>{type}——> ; ——┬————————————————————>
           └<—————————————————————————————┘
```

A type declaration allows you to define a data type and associate a name to that type. Once declared, such a name may be used in the same way as a predefined type name.

```
type

  { all of the following types  }
  { are predefined in Pascal/VS }

  INTEGER = MININT..MAXINT;
  BOOLEAN = (FALSE,TRUE);
  ALFA    = packed array[1..ALFALEN]
              of CHAR;
  ALPHA   = packed array[1..ALPHALEN]
              of CHAR;
  TEXT    = file of CHAR;
```

Type Declarations

4.4 THE VAR DECLARATION

Syntax:

var-dcl:

```
──> var ──┬──┬──>{id}──┬──> : ──>{type}──> ; ──┬──────────────>
          │  └<── , ───┘                       │
          └<───────────────────────────────────┘
```

The var declaration is used to declare automatic variables. Automatic variables are allocated when the routine is invoked, and are de-allocated when the corresponding return is made. If the routine is invoked a second time, before an initial invocation completes (a recursive call), the local automatic variables will be allocated again in a stack-like manner. The variables allocated for the first invocation become inaccessible until the recursive call completes.

Commas are used in the declaration to separate two or more identifiers that are being declared of the same type. This is a shorthand notation for two separate declarations.

```
var
  I     : INTEGER;
  SYSIN : TEXT;
  X,
  Y,
  Z     : REAL;
  CARD  :
     record
       RANK : 1..13;
       SUIT : (SPADE,HEART,DIAMOND,CLUB)
     end;
```

Example of a Var Declaration

Variables which are to be accessed across modules should be declared as **def** variables (see "The Def/Ref Declaration" on page 30), but if reentrancy is required, then a mechanism is required that does not rely on static storage.

The global automatic variables of the main program[2] may be accessed from a segment module. The storage for automatic variables declared in the outermost level of a segment are mapped directly on top of the main program global variables. Therefore, to access the main program globals, a segment module must have an identical copy of the main program's variable declarations. This mechanism is not as safe[3] and as convenient as using **def** variables.

If the variables of the main program are to be accessable across modules then the %INCLUDE facility should be incorporated so that identical copies of the variable's declarations can be included in all modules. (See "The %INCLUDE Statement" on page 150).

```
program MAIN;
var
 I      : INTEGER;
 X,
 Y      : REAL;
 J      : INTEGER;
 ...    {remainder of program module}

SEGMENT SEG;
var
 I      : INTEGER;
 X,
 Y      : REAL;
 J      : INTEGER;
 ...    {remainder of segment module}
```

Example of a Var Declarations
Shared between Programs and Segments

---

2 That is, those variables declared with the **var** construct in the outermost nesting level of the main program.

3 That is, unpredictable errors can occur when the variables declared in a segment do not match those in the associated main program. The compiler has no way of checking the integrity.

4.5 THE STATIC DECLARATION

Syntax:

static-dcl:

```
---> static ---T-----T--->{id}---T---> : --->{type}---> ; ---T----------------->
               |     L<--- , ----J                           |
               |                                             |
               L<--------------------------------------------J
```

The static declaration is used to declare static variables. The variables declared in this way are allocated prior to program execution and exist for the life of the program's execution.

Static variables can be referenced according to the lexical scoping rules. Two static variables in different scopes are different variables even though they have the same name.

Data in static variables that are local to a routine will be preserved over separate invocations of the routine. Such a routine called recursively will access the same instance of each static variable.

Static variables may be initialized at compile-time by the use of a value declaration.

Programs which modify static variables are not reentrant.

```
static
    SYSPRINT : TEXT;
    X,Y:       REAL;
```

Example of a Static Declaration

4.6 THE DEF/REF DECLARATION

Syntax:

def-dcl:

```
---┬---> def ---┬----┬---┬--->{id}---┬---> : --->{type}---> ; ---┬---------->
   └---> ref --->┘    |   └<--- , ----┘                           |
                      |                                           |
                      └<------------------------------------------┘
```

The def/ref declarations are used to declare external variables. External variables are allocated prior to execution and can be accessed from more than one module. All identifiers that are to be used as external names must be unique in the first eight characters.

If an external variable with a particular name is declared in several modules, a single common storage location will be associated with each such variable. An external variable must be declared with identical types in each module; the programmer is responsible for assuring that the types are the same.

The def declaration specifies that the program loader is responsible for generating the common storage for the variable. The ref declaration specifies that storage for the variable is defined in another module (or in the runtime environment). Ref declared variables will remain unresolved until the encompassing module is compiled and linked with a module in which the variable is declared as a def variable or defined in a non-Pascal CSECT or in an assembly language COM. The expected use of ref variables is to access external data declared in non-Pascal/VS programs such as those written in assembly language.

A def or ref variable may be declared local to a routine; the same scope rules apply as for any other declared identifier. However, if the name of the variable is declared in another scope (even in another module) as a def or ref variable, both occurrences of the variable will reference the same storage.

In the following example, the variable X in procedures A, B, and C references the same storage; however, the variables X declared in segment P and procedure D each refer to storage that is separate from the external variable X.

Def variables may be initialized at compile-time by the use of a value declaration.

Programs which modify def, ref, or static variables are not reentrant.

```
SEGMENT M;
procedure A;
  def X: REAL; { same as X in B    }
  begin
    ...
  end;

procedure B;
  def X: REAL; { same as X in A    }
  begin
    ...
  end;.


 SEGMENT P;
 static X: REAL;{ local to P       }
 procedure C;

   ref X: REAL; { same as X in A,B}
   begin
     ...
   end;

 procedure D;
   var X: REAL; { local to D       }
   begin
     ...
   end;.
```

Examples of Def and Ref Declarations

4.7 THE VALUE DECLARATION

```
Syntax:

value-dcl:

 ---> value ---┬---{value-assignment}---> ; ---┬--------------------------->
               └<------------------------------┘

value-assignment:

 --->{variable}---> := ---┬--->{constant-expression}----┬------------------->
                          └--->{structured-constant}--->┘

note: If the variable contains subscripts, the subscripts are limited
      to constant expressions.
```

The value declaration is used to specify an initial value for static and def variables. The declaration is composed of a list of value-assignment statements separated by semicolons. The assignment statements in a value declaration are of the same form as the assignment statements in the body of a routine except that all subscripts and expressions must be able to be evaluated at compile time.

```
type
  COMPLEX = record
              RE,IM: REAL
            end;
  VECTOR  = array[1..7] of INTEGER;

static
  C: COMPLEX;
  V: VECTOR;
  V1: VECTOR;

def
  I : INTEGER;
  Q : array[1..10] of COMPLEX;

{ the following assignments will }
{ take place at compile time     }
value
  C       := COMPLEX(3.0,4.0);
  V       := VECTOR(1,0:5,7);
  V1      := VECTOR(,,,4);
  V[2]    := 2;
  V[3]    := 3*4-1;
  I       := 0;
  Q[1].RE := 3.1415926 / 2;
  Q[1].IM := 1.414;
```

Example of a Value Declaration

If a def variable is initialized with a value declaration in one module, you may not use a value declaration on that variable in another module. The compiler will not check this violation, however a diagnostic will be generated when you combine the modules into a single load module by the system loader.

```
type
  CUBE = array[1..10,1..10,1..10]
           of REAL;

static
  BLOCK   : CUBE:

{ the following assignments will }
{ take place at compile time     }
value
  BLOCK   :=
    CUBE( ( (0.0:10):10 ):10 );
```

Example of Intializing a 3 Dimensional Array

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Syntax:

```
type:

─────┬──>{id:type}─────────────────────────────────────────>┐
     ├──>{enumerated-scalar-type}───────────────────────────>┤
     ├──>{subrange-scalar-type}─────────────────────────────>┤
     ├──>{array-type}───────────────────────────────────────>┤
     ├──>{record-type}──────────────────────────────────────>┤
     ├──>{set-type}─────────────────────────────────────────>┤
     ├──>{file-type}────────────────────────────────────────>┤
     ├──>{pointer-type}─────────────────────────────────────>┤
     └--->{string-type}------------------------------------->┴────>
```

A data type determines the kind of values that a variable of that type can assume. Pascal/VS allows you to define new data types with the type declaration. The data type mechanism is a very important part of Pascal/VS. With it you can describe your data with great clarity.

There are several mechanisms that can be used to define a type; each mechanism allows the new data type to have certain properties. All data types can be classified as either scalar, pointer, or structured.

You define the data type of a variable when the variable is declared. A previous type declaration allows an identifier to be associated with that type. Such an identifier can be used wherever a type definition is needed: in a variable declaration (var, static, def, or ref), as a parameter, in a procedure or function, in a field declaration within a record definition, or in another type declaration.

5.1 A NOTE ABOUT STRINGS

Standard Pascal defines the term "string" as a variable or constant which has an associated type of "**packed array**[1..n] **of** CHAR," where n is a positive integer constant.

Pascal/VS supports varying length strings; that is, strings which have lengths that vary at execution time. A variable may be declared as a varying length string with the predefined type STRING (see "The Type STRING" on page 53).

Throughout this manual the term "string" shall refer to an object of the predefined type STRING.

5.2 TYPE COMPATIBILITY

Pascal/VS supports _strong typing_ of data. The strong typing permits Pascal/VS to check the validity of many operations at compile time; this helps to produce reliable programs at execution time. Strong typing puts strict rules on what data types are considered to be the same. These rules, called _type compatibility,_ requires you to carefully declare data.

5.2.1 Implicit Type Conversion

In general, Pascal/VS does not perform implicit type conversions on data. The only implicit conversions that Pascal/VS permits are:

1. An INTEGER will be converted to a REAL (SHORTREAL) when one operand of a binary operation is an INTEGER and the other is a REAL (SHORTREAL).

2. An INTEGER will be converted to a REAL (SHORTREAL) when assigning an INTEGER to a REAL (SHORTREAL) variable.

3. An INTEGER will be converted to a REAL (SHORTREAL) if it is used in a floating point divide operation ('/').

4. An INTEGER will be converted to a REAL (SHORTREAL) if it is passed by value or passed by const to a parameter requiring a REAL (SHORTREAL) value.

5. A SHORTREAL will be converted to a REAL when one operand of a binary operation is a SHORTREAL and the other is a REAL.

6. A SHORTREAL will be converted to a REAL when assigning a SHORTREAL to a REAL variable.

7. A SHORTREAL will be converted to a REAL if it is passed by value or passed by const to a parameter requiring a REAL value.

8. A string will be converted to a '**packed array**[1..n] **of** CHAR' on assignment. The string will be padded with blanks on the right if it is shorter than the array to which it is being assigned. Truncation will raise a runtime error if checking is enabled.

9. A string being passed by value or passed by const to a formal parameter that requires a '**packed array**[1..n] **of** CHAR' will be converted. The string will be padded with blanks on the right if it is shorter than the array to which it is being passed. Truncation will raise a runtime error if checking is enabled.

5.2.2 Same Types

Two variables are said to be of the <u>same type</u> if the declaration of the variables:

- refer to the same type identifier;
- or, refer to different type identifiers which have been defined as equivalent by a type definition of the form:

  type T1 = T2

5.2.3 Compatible Types

Operations can be performed between two values that are of <u>compatible types.</u> Two types are said to be compatible if:

- the types are the same;
- one type is a subrange of the other or they are both subranges of the same type;
- both types are strings;
- one value is a string literal and the other is a '**packed array**[1..n] **of** CHAR';
- one value is a string literal of one character and the other is a CHAR;
- they are set types with compatible base types;
- or, they are both '**packed array**[1..n] **of** CHAR' with the same number of elements.

Furthermore, any object which is of a set type is compatible with the empty set. And, any object which is a pointer type is compatible with the value **nil**.

5.2.4 Assignment Compatible Types

A value may be assigned to a variable if the types are <u>assignment compatible.</u> An expression E is said to be assignment compatible with variable V if:

- the types are same type and neither is a file type;
- V is of type REAL and E is compatible with type INTEGER;
- V is a compatible subrange of E and the value to be assigned is within the allowable subrange of V;
- V and E have compatible set types and all members of E are permissible members of V; or,
- V is a '**packed array**[1..n] **of** CHAR' and E is a string.

```
type

  X       = array[ 1..10 ] of
               INTEGER;
  DAYS    = (MON, TUES, WED, THURS,
             FRI, SAT,  SUN);
  WEEKDAY = MON .. FRI;

var

  A : array[ 1..10 ] of
         INTEGER;
  B : array[ 1..10 ] of
         INTEGER;
  C,
  D : array[ 1..10 ] of
         CHAR;
  E : X;
  F : X;
  W1: DAYS;
  W2: WEEKDAY


  is  compatible
         with
 ----- -------------
   A      A
   B      B
   C      C, D
   D      D, C
   E      E, F
   F      F, E
   W1     W1, W2
   W2     W2, W1
```

Examples of Compatibility

5.3 THE ENUMERATED SCALAR

Syntax:

enumerated-scalar-type:

```
——> ( ——┬——>{id}——┬——> ) ————————————————————————————————————>
        └<——— , <——┘
```

An enumerated scalar is formed by listing each value that is permitted for a variable of this type. Each value is an identifier which is treated as a self-defining constant. This allows a meaningful name to be associated with each value of a variable of the type.

```
type
  DAYS      = (MON, TUES, WED, THURS,
               FRI, SAT,  SUN);

  MONTHS    = (JAN, FEB,  MAR, APR,
               MAY, JUN,  JUL, AUG,
               SEP, OCT,  NOV, DEC);

var
  SHAPE     : (TRIANGLE, RECTANGLE,
               SQUARE,   CIRCLE);

  REC       : record
               SUIT: (SPADE, HEART,
                      DIAMOND, CLUB);
               WEEK: DAYS
              end;

  MONTH     : MONTHS;
```

Enumerated Scalars

An enumerated scalar type definition declares the identifiers in the enumeration list as constants of the scalar type being defined. The lexical scope of the newly defined constants is the same as that of any other identifier declared explicitly at the same lexical level.

These constants are ordered such that the first value is less than the second, the second less than the third and so forth. In the first example, MON < TUES < WED < ... < SUN. There is no value less than the first or greater than the last.

The following predefined functions operate on expressions of a scalar type (see the indicated section for more details):

	Function	Page
	ORD	128
+	MAX	132
+	MIN	132
	PRED	133
	SUCC	133
+	LOWEST	125
+	HIGHEST	125

Notes:

1. Two enumerated scalar type definitions must not have any elements of the same name in the same lexical scope.
2. The standard type BOOLEAN is defined as (FALSE, TRUE).

5.4 THE SUBRANGE SCALAR

```
Syntax:

subrange-scalar-type:

+  ──┬──> packed ───>┐
     ├<──────────────┘
     │
     └────┬──>{constant}──> .. ──>{constant-expr}─────────────────┬──>
          │                                                       │
+         └───> range ───>{constant-expr}───> .. ───>{constant-expr}───>┘
```

The subrange type is a subset of consecutive values of a previously defined scalar type. Any operation which is permissible on a scalar type is also permissible on any subrange of it.

A subrange is defined by specifying the minimum and maximum values that will be permitted for data declared with that type. For subranges that are packed, Pascal/VS will assign the smallest number of bytes required to represent a value of that type.

If the reserved word **range** is used in the subrange definition, then both the minimum and maximum values may be any expression that can be computed at compile time. If the range prefix is not employed then the minimum value of the range must be a simple constant.

The following predefined functions operate on expressions of a scalar type (see the indicated section for more details):

	Function	Page
	ORD	128
+	MAX	132
+	MIN	132
	PRED	133
	SUCC	133
+	LOWEST	125
+	HIGHEST	125

Notes:

1. A subrange of the standard type REAL is not permitted.

2. The number of values in a subrange of type CHAR is determined by the collating sequence of the EBCDIC character set.

3. The lower bound of a subrange definition that is not prefixed with 'range' must be a simple constant instead of a generalized constant expression.

```
const
  SIZE          = 1000;

type
  DAYS          = (SU,  MO,  TU,  WE,
                   TH,  FR,  SA);
  MONTHS        = (JAN, FEB, MAR, APR,
                   MAY, JUN, JUL, AUG,
                   SEP, OCT, NOV, DEC);
  UPPER_CASE    = 'A' .. 'Z';
  ONE_HUNDRED   =  0 .. 99;
  CODES         = range
                   CHR(0)..CHR(255);
  INDEX         = packed 1 .. SIZE+1;

var
  WORK_DAY      : MO .. FR;
  SUMMER        : JUN .. AUG;
  SMALLINT      : packed 0..255;
  YEAR          : 1900 .. 2000;
```

Subrange Scalars

The following example illustrates that two subrange types may be defined over the same base type. Operations are permitted between these two variables because they have the same base type.

```
var
  NEG           : MININT .. -1;
  POS           : 1 .. MAXINIT;
```

Subranges with the Same Base Type

5.5 PREDEFINED SCALAR TYPES

5.5.1 The Type INTEGER

The following table describes the operations and predefined functions that apply to values which are the standard type INTEGER.

INTEGER		
operation	form	description
+	unary	returns the unchanged result of the operand
+	binary	forms the sum of the operands
-	unary	negates the operand
-	binary	forms the difference of the operands
*	binary	forms the product of the operands
/	binary	converts the operands to REAL and produces the REAL quotient
div	binary	forms the integer quotient of the operands
mod	binary	forms the integer modulus of the operands (same as remainder if the arguments are positive)
=	binary	compares for equality
<> or ¬=	binary	compares for inequality
<	binary	compares for less than
<=	binary	compares for less than or equal to
>=	binary	compares for greater than or equal to
>	binary	compares for greater than
¬	unary	returns one's complement on the operand
|	binary	returns 'logical or' on the operands
&	binary	returns 'logical and' on the operands
&&	binary	returns 'logical xor' on the operands
<<	binary	returns the left operand value shifted left by the right operand value
>>	binary	returns the left operand value shifted right by the right operand value
CHR(x)	function	returns a CHAR whose EBCDIC representation is x
PRED(x)	function	returns x-1
SUCC(x)	function	returns x+1
ODD(x)	function	returns TRUE if x is odd and FALSE otherwise
ABS(x)	function	returns the absolute value of x
SQR(x)	function	returns the square of x
FLOAT(x)	function	returns a REAL whose value is x
MIN( )	function	returns the minimum value of two or more operands
MAX( )	function	returns the maximum value of two or more operands
LOWEST(x)	function	returns MININT or the minimum value of the range if x is a subrange of INTEGER
HIGHEST(x)	function	returns MAXINT or the maximum value of the range if x is a subrange of INTEGER
ADDR(x)	function	returns the location in memory of INTEGER variable x
SIZEOF(x)	function	returns the number of bytes required for a value of the type of x, which is always 1, 2, 3, or 4

The type INTEGER is provided as a pre-defined type in Pascal/VS. This type represents the subset of whole numbers as defined below:

```
type
  INTEGER = MININT..MAXINT;
```

where MININT is a predefined INTEGER constant whose value is -2147483648 and MAXINT is a predefined INTEGER constant whose value is 2147483647. That is, the predefined type INTEGER represents 32-bit values in 2's complement notation.

Type definitions representing integer subranges may be prefixed with the reserved word "packed". For variables declared with such a type, Pascal/VS will assign the smallest number of bytes required to represent a value of that type. The following table defines the number of bytes required for different ranges of integers. For ranges other than those listed, use the first range that encloses the desired range. Given a type definition T as:

```
type    T = packed i..j;
```

Range of i .. j	Size in bytes	Alignment
0..255	1	BYTE
-128..127	1	BYTE
-32768..32767	2	HALFWORD
0..65535	2	HALFWORD
-8388608..8388607	3	BYTE
0..16777215	3	BYTE
otherwise	4	FULLWORD

Notes:

1. The operations of **div** and **mod** are defined as:

   A **div** B = TRUNC(A/B), B<>0

   A **mod** B = A-B*(A **div** B), A>=0,B>0
   A **mod** B = B-abs(A) **mod** B, A<0,B>0

   B=0 when doing a **div** operation or B<=0 when doing a **mod** operation is defined as an error and will cause a runtime error message to be produced.

2. The following operators perform logical operations:

<<	shift left logical
>>	shift right logical
¬	1's complement
|	logical inclusive or
&	logical and
&&	logical exclusive or

The operands are treated as unsigned strings of binary digits. See "Logical Expressions" on page 80 for more details on logical expressions.

5.5.2 The Type CHAR

The following table describes the operations and predefined functions that apply to the standard type CHAR.

CHAR		
operation	form	description
=	binary	compares for equality
<> or ¬=	binary	compares for inequality
<	binary	compares for left less than right
<=	binary	compares for left less than or equal to right
>=	binary	compares for left greater than or equal to right
>	binary	compares for left greater than right
ORD(x)	function	converts operand to an INTEGER based on ordering sequence of underlying character set.
PRED(x)	function	returns the preceding character in collating sequence
SUCC(x)	function	returns the succeeding character in collating sequence
STR(x)	function	converts the operand to a STRING
MIN( )	function	returns the minimum value of two or more operands
MAX( )	function	returns the maximum value of two or more operands
LOWEST(x)	function	returns the minimum value of the range of the character x
HIGHEST(x)	function	returns the maximum value of the range of the character x
ADDR(x)	function	returns the location in memory of CHAR variable x
SIZEOF(x)	function	returns the number of bytes required for a value of the type of a CHAR, which is always 1

CHAR is a scalar type that consists of all of the values of the EBCDIC character set. Variables of this type occupy one byte of memory and will be aligned on a byte boundary.

A single-character string constant will be regarded as a CHAR constant if the context so dictates. For example, the assignment statement shown below sets variable C to the EBCDIC code for the letter A.

```
var C: CHAR;
begin
  ...
  C := 'A';
  ...
end
```

5.5.3 The Type BOOLEAN

The following table describes the operations and predefined functions that apply to the standard type BOOLEAN.

BOOLEAN		
operation	form	description
¬	unary	returns TRUE if the operand is FALSE, otherwise it returns FALSE
&	binary	returns TRUE if both operands are TRUE
|	binary	returns TRUE if either operand is TRUE
&&	binary	returns TRUE if either, but not both operands are TRUE
=	binary	compares for equality
<> or ¬=	binary	compares for inequality
<	binary	compares for left less than right
<=	binary	compares for left less than or equal to right
>=	binary	compares for left greater than or equal to right
>	binary	compares for left greater than right
ORD(x)	function	returns 0 if x is FALSE and 1 if x is TRUE
MIN( )	function	returns TRUE if all operands are TRUE
MAX( )	function	returns FALSE if all operands are FALSE
LOWEST(x)	function	returns FALSE by definition
HIGHEST(x)	function	returns TRUE by definition
ADDR(x)	function	returns the location in memory of BOOLEAN variable x
SIZEOF(x)	function	returns the number of bytes required for a value of the type of a BOOLEAN, which is always 1

Binary Operations on BOOLEAN					
	FALSE FALSE	FALSE TRUE	TRUE FALSE	TRUE TRUE	Name
=	TRUE	FALSE	FALSE	TRUE	Equivalence
<>	FALSE	TRUE	TRUE	FALSE	Exclusive Or
<	FALSE	TRUE	FALSE	FALSE	
<=	TRUE	TRUE	FALSE	TRUE	Implication
>=	TRUE	FALSE	TRUE	TRUE	
>	FALSE	FALSE	TRUE	FALSE	
&	FALSE	FALSE	FALSE	TRUE	And
|	FALSE	TRUE	TRUE	TRUE	Inclusive Or
&&	FALSE	TRUE	TRUE	FALSE	Exclusive Or

The type BOOLEAN is defined as a scalar whose values are FALSE and TRUE as though declared with the following type declaration:

```
type
  BOOLEAN=(FALSE,TRUE);
```

Variables of this type will occupy one byte of memory and will aligned on a byte boundary. The relational operators form valid boolean functions as shown in the table of binary operations.

Pascal/VS will optimize the evaluation of BOOLEAN expressions involving '&' (and) and '|' (or) such that the right operand expression will not be evaluated if the result of the operation can be determined by evaluating the left operand. For more details see "Boolean Expressions" on page 79.

5.5.4 The Type REAL

The following table describes the operations and predefined functions that apply to the standard type REAL.

REAL		
operation	form	description
+	unary	returns the value of the operand
+	binary	forms the sum of the operands
-	unary	negates the operand
-	binary	forms the difference of the operands
*	binary	forms the product of the operands
/	binary	forms the REAL quotient of the operands
=	binary	compares for equality
<> or ¬=	binary	compares for inequality
<	binary	compares for left less than right
<=	binary	compares for left less than or equal to right
>=	binary	compares for left greater than or equal to right
>	binary	compares for left greater than right
TRUNC(x)	function	returns the operand value truncated to an INTEGER
ROUND(x)	function	returns the operand value rounded to an INTEGER
ABS(x)	function	returns the absolute value of the operand
SIN(x)	function	returns the trigonometric sine of x (in radians)
COS(x)	function	returns the trigonometric cosine of x (in radians)
ARCTAN(x)	function	returns (in radians) the arc tangent of x
LN(x)	function	returns the natural logarithm of x
EXP(x)	function	returns natural log base raised to the x power
SQRT(x)	function	returns square root of x
SQR(x)	function	returns the square of x
MIN( )	function	returns the minimum value of the operands
MAX( )	function	returns the maximum value of the operands
ADDR(x)	function	returns the location in memory of REAL variable x
SIZEOF(x)	function	returns the number of bytes required for a value of the type of a REAL, which is always 8

The type REAL represents floating point data. Variables of this type will occupy eight bytes of memory and will be aligned on a double word boundary. All REAL arithmetic is done using double precision floating point. See "Implicit Type Conversion" on page 33.

The type REAL has restrictions that other scalar types do not have. You may not take a subrange of REAL nor index an array by REAL. The predefined functions SUCC, PRED, ORD, HIGHEST and LOWEST are not defined for type REAL.

MAXREAL is a predefined constant whose value is the value of the largest floating point number representable on the machine, and MINREAL is a predefined constant whose value is the value of the smallest non-zero floating point number representable on the machine.

5.5.5 The Type SHORTREAL

The following table describes the operations and predefined functions that apply to the standard type SHORTREAL.

SHORTREAL		
operation	form	description
+	unary	returns the value of the operand
+	binary	forms the sum of the operands
-	unary	negates the operand
-	binary	forms the difference of the operands
*	binary	forms the product of the operands
/	binary	forms the SHORTREAL quotient of the operands
=	binary	compares for equality
<> or ¬=	binary	compares for inequality
<	binary	compares for left less than right
<=	binary	compares for left less than or equal to right
>=	binary	compares for left greater than or equal to right
>	binary	compares for left greater than right
TRUNC(x)	function	returns the operand value truncated to an INTEGER
ROUND(x)	function	returns the operand value rounded to an INTEGER
ABS(x)	function	returns the absolute value of the operand
SIN(x)	function	returns the trigonometric sine of x (in radians)
COS(x)	function	returns the trigonometric cosine of x (in radians)
ARCTAN(x)	function	returns (in radians) the arc tangent of x
LN(x)	function	returns the natural logarithm of x
EXP(x)	function	returns natural log base raised to the x power
SQRT(x)	function	returns square root of x
SQR(x)	function	returns the square of x
MIN( )	function	returns the minimum value of the operands
MAX( )	function	returns the maximum value of the operands
ADDR(x)	function	returns the location in memory of SHORTREAL variable x
SIZEOF(x)	function	returns the number of bytes required for a value of the type of a SHORTREAL, which is always 4

The type SHORTREAL represents floating point data. Variables of this type will occupy four bytes of memory and will be aligned on a word boundary. All SHORTREAL arithmetic is done using single precision floating point instructions.

Operations between data of type REAL and SHORTREAL will be performed using double precision floating point instructions. The SHORTREAL operand will be implicitly converted to a value of type REAL. A SHORTREAL may be passed as an operand to a function or procedure that expects its parameter to be of type REAL if the parameter passing mechanism for that parameter is value or const. See "Implicit Type Conversion" on page 33.

The type SHORTREAL has restrictions that other scalar types do not have. You may not take a subrange of SHORTREAL nor index an array by SHORTREAL. The predefined functions SUCC, PRED, ORD, HIGHEST and LOWEST are not defined for type SHORTREAL.

5.6 THE ARRAY TYPE

Syntax:

array-type:

```
          ┌──> packed ───┐
          │<─────────────┘
          └──────> array [ ──┬──>{index-type}──┬──> ] of ──>{type} ────────>
                             └<──────── , <────┘
```

index-type:

```
        ┌──>{enumerated-scalar-type}──>┐
 ───────┼──>{id:scalar-type}──────────>┼──────────────────────────────────>
        └──>{subrange-scalar-type}────>┘
```

The array type defines a list of homogeneous elements; each element is paired with one value of the index. An element of the array is selected by a subscript. The number of elements in the array is the number of values potentially assumable by the index. Each element of the array is of the same type, which is called the element type of the array. Entire arrays may be assigned if they are of the same type.

Pascal/VS uses square brackets, '[' and ']', in the declaration of arrays. Because these symbols are not directly available on many I/O devices, the symbols '(.' and '.)' may be used as an equivalent to square brackets.

Pascal/VS will align each element of the array, if necessary, to make each element fall on an appropriate boundary. A packed array will not observe the boundary requirements of its elements. Elements of packed arrays may not be passed as var parameters to routines.

An array which is defined with more than one index is said to be a multi-dimensional array. A multi-dimensional array is exactly equivalent to an array of arrays. In short, an array definition of the form

```
array[i,j,... ] of T
```

is an abbreviated form of

```
array[i] of
   array[j] of
     ... T
```

where i and j are scalar type definitions. Thus, the first and second type declarations in the example below are alternatives to the same structure.

```
type

  MATRIX = array[ 1..10, 1..10 ] of
              REAL;

  MATRIX0 = array[ 1..10 ] of
              array[ 1..10 ] of
                REAL;

  ABLE = array[BOOLEAN] of INTEGER;

  COLOR     = (RED, YELLOW, BLUE);

  INTENSITY = packed array[COLOR]
                of REAL;

  ALFA = packed array[ 1..ALFALEN] of
            CHAR;
```

Examples of Array Declarations

There are two procedures available for conversion between a packed array and a similar but unpacked array. The predefined procedures PACK (see "PACK Procedure" on page 124) and UNPACK (see "UNPACK Procedure" on page 124) are provided for this purpose.

5.6.1 Array Subscripting

Array subscripting is performed by placing an expression in square brackets following an array variable. The expression must be of a type that is compatible with the index type and evaluate to one of the values of the index. See "Compatible Types" on page 34. The index may be any scalar type except REAL or SHORTREAL.

```
var
  M       : MATRIX;
  HUE     : INTENSITY;

begin

  { assign ten element array }
  M[1]          := M[2];

  { assign one element of a two }
  { dimensional array two ways  }
  M[1,1]        := 3.14159;
  M[1][1]       := 3.14159;

  { this is a reddish orange    }
  HUE[RED]      := 0.7;
  HUE[YELLOW]   := 0.3;
  HUE[BLUE]     := 0.0;
end
```

Examples of Array Indexing

5.7 THE RECORD TYPE

```
 Syntax:

record-type:

 ──────┬──────────────────────┬──> record ──>{field-list}──> end ──────────────────>
       └──> packed ───>───────┘

field-list:

 ───┬──>{fixed-part}───┬──────> ; ───┬──>{variant-part}──┬──┬──> ; ──┬──>
    │                  └─────────────┼───────────────────>┘  └───────>┘
    └───────────────────────────────>┘

fixed-part:

 ────┬───┬───┬──>{field}──┬──┬──> : ──>{type}──┬──────────────────>
     │   │   └<──── , <───┘  │                 │
     │   └-------------------->┘               │
     └<──────────────── ; <────────────────────┘

variant-part:
                            ┌------------------>┐
 ──> case ────┬──>{id}──> : ┴──┬─>{id:type}─────┴──> of ──>┐
              └────────────────>┘                           │
    ┌<──────────────────────────────────────────────────────┘
    │
    └───┬──┬──>{range}──┬──> : ( ─┬──>{field-list}──┬──> ) ──┬──────>
        │  └<─── , <────┘         └─────────────────>┘       │
        └<───────────────────── ; <──────────────────────────┘

field:

 ──>{id}──┬─────────────────────────────────────────────────┬──────>
+         └---> ( --->{constant-expr}---> ) --->┘

range:

+ ──>{constant-expr}──┬─────────────────────────────────────┬──────>
+                     └---> .. --->{constant-expr}--->┘
```

A record is a data structure which is composed of heterogeneous components; each element may be of a different type. Components of a record are called _fields._

5.7.1 Naming of a Field

A field is referred to by the name of the field. The scope of the identifiers used as names is the record type itself. That is, every field name within a record must be unique, even if that name appears in a variant part.

+ A field of a record need not be named;
+ that is, the field identifier may be
+ missing. In such a case, the field only
+ serves as padding; it can not be refer-
+ enced.

```
type
   REC =   record
           A,
           B   : INTEGER;
               : CHAR;       {unnamed}
           C   : CHAR
           end;

   DATE =  record
           DAY    : 1..31;
           MONTH  : 1..12;
           YEAR   : 1900..2100
           end;

   PERSON = record
           LAST_NAME,
           FIRST_NAME      : ALFA;
           MIDDLE_INITIAL  : CHAR;
           AGE             : 0..99;
           EMPLOYED        : BOOLEAN
           end;
```

Simple Record Declarations

5.7.2 Fixed Part

The fixed part of a record is a series of fields that exist in every variable that is declared to be of that record type. The fixed part, if present, is always before the variant part.

5.7.3 Variant Part

The variant part of a record permits the defining of an alternative structure to the record. The record structure adopts one of the variants at a time.

The variant part of a record is denoted with the **case** symbol. A tag field identifier may follow. This field is a scalar value that indicates which variant is intended to be active.

The tag field is a field in the fixed part of the record. When the tag field is followed by a type identifier, then the tag field defines a new field within the record.

\+ If the type identifier is missing, then
\+ the tag field name must be one which was
\+ previously defined within the record.
\+ This allows you to place the tag field
\+ anywhere in the fixed part of the
\+ record.

A variant part of a record need not have a tag field at all. In this case, only a type identifier is specified in the case construct. You still refer to the variant fields by their names but it is your responsibility to keep track of which variant is 'active' (i.e. contains valid data) during execution.

In short, tag fields may be defined in the following ways:

- "**case** I : INTEGER **of**" results in I being a tag field of type INTEGER.
- "**case** INTEGER **of**" means no tag field is present, the variants are denoted by integer values in the variant declaration.
- "**case** I: **of**" means that I is the tag field and it must have been declared in the fixed part, the type of I is as given in the field definition of I.

The following examples illustrate the three tag fields in complete record definitions.

```
type

   SHAPE = (TRIANGLE, RECTANGLE,
            SQUARE,   CIRCLE);

   COORDINATES =
                  { fixed part:   }
     record
       X,Y     : REAL;
       AREA    : REAL;
       case S  : SHAPE of
                  { variant part: }
       TRIANGLE:
          (SIDE : REAL;
           BASE : REAL);

       RECTANGLE:
          (SIDEA,SIDEB : REAL);

       SQUARE:
          (EDGE : REAL);

       CIRCLE:
          (RADIUS : REAL)
     end;
```

A Record With a Variant Part

The record defined as COORDINATES in the example above contains a variant part. The tag field is S, its type is SHAPE, and its value (whether TRIANGLE, RECTANGLE, SQUARE, or CIRCLE) indicates which variant is in effect. The fields SIDE, SIDEA, EDGE, and RADIUS would all occupy the same offset within the record. The following diagram illustrates how the record would look in storage.

fixed part:

X
Y
AREA

tag field:

S

variant part:

SIDE	SIDEA	EDGE	RADIUS
BASE	SIDEB		

Each column in the variant represents one alternative for the variant.

If you preferred the tag field to be the first field instead of the fourth, you could define it as follows:

```
COORDINATES =
  record
    S       : SHAPE;
    X,Y     : REAL;
    AREA    : REAL;
    case S : of
               { variant part: }
    TRIANGLE:
       (SIDE : REAL;
        BASE : REAL);

    RECTANGLE:
       (SIDEA,SIDEB : REAL);

    SQUARE:
       (EDGE : REAL);

    CIRCLE:
       (RADIUS : REAL)
  end;
```

Record with Back Reference Tag Field

If you preferred the tag field to be absent altogether you could define the record as follows:

```
COORDINATES =
  record
    X,Y     : REAL;
    AREA    : REAL;
    case SHAPE of
               { variant part: }
    TRIANGLE:
       (SIDE : REAL;
        BASE : REAL);

    RECTANGLE:
       (SIDEA,SIDEB : REAL);

    SQUARE:
       (EDGE : REAL);

    CIRCLE:
       (RADIUS : REAL)
  end;
```

Record Variant with No Tag Field

5.7.4 Packed Records

The fields in a record are normally assigned offsets sequentially, padding where necessary for boundary alignment. In packed records, however, no such padding is done. This may save storage within the record, but may degrade performance of the program. Fields of packed records may not be passed as var parameters to a routine.

5.7.5 Offset Qualification of Fields

Pascal/VS provides you a method of forcing the fields of a record to begin at a specified byte offset in the record. A field name may be followed by an integer constant expression enclosed in parentheses which represents the byte offset within the record that the field is to represent. All fields so specified must be in consecutive order according to offsets. If the offset is not specified, the field will be assigned the next offset that is required for boundary alignment. If an offset specification attempts to assign an incorrect boundary for a field and the record is not packed, a compile time error will be raised.

As an example of offset qualified fields within a record, consider a large control block of 100 bytes, in which four fields at various offsets need to be referenced.

```
    byte
displacement     information
------------   -----------------
     0         field A (integer)
    36         field B (8 chars)
    80         field C (4 flags)
    92         field D (integer)
```

The control block might be represented in Pascal/VS as follows:

```
type
  FLAGS = set of
            (F1,F2,F3,F4);
  PADDING = packed array[1..4] of
              CHAR;
  CB    = packed record
            A      : INTEGER;
            B(36)  : ALFA;
            C(80)  : FLAGS;
            D(92)  : INTEGER;
                   : PADDING
          end;
var
  BLOCK : CB;
```

A Record with Offset Qualified Fields

Note: You cannot use an offset qualifier on the variant part tag field. If you wish the tag field to be at a certain offset, make the tag field a back reference and have the last identifier of the fixed part have the same name as the tag field and put the offset qualifier on this last identifier. The example below give an illustration of this.

```
type
  TAG =
    packed record
      A    : BOOLEAN;
      B(2): BOOLEAN;

      case B : of
      TRUE:
         (C : CHAR);

      FALSE:
         (D : REAL)
    end;
var
  BLOCK : TAG;
```

Putting an Offset Qualifier on a Tag Field

5.8 THE SET TYPE

```
Syntax:

set-type:

  ──┬──────────────────┬──> set of ──>{base-scalar-type}──────────────>
    └──> packed ──>────┘

base-scalar-type:

      ┌──>{enumerated-scalar-type}──>┐
  ────┼──>{id:scalar-type}──────────>┼─────────────────────────────────>
      └──>{subrange-scalar-type}────>┘
```

A variable whose type is a set may contain any combination of values taken from the base scalar type. A value is either in the set or it is not in.

Note: Pascal/VS sets can be used in many of the same ways as bit strings (which often tend to be machine dependent). Each bit corresponds to one element of the base type and is set to a binary one when that element is a member of the set. For example, a set operation such as intersection (the operator is '*') is the same as taking the 'boolean and' of two bit strings.

```
type
  CHARS       = set of CHAR;
  DAYSOFMON   = packed set of 1..31;
  DAYSOFWEEK  = set of MONDAY..FRIDAY;
  FLAGS       = set of
                   (A,B,C,D,E,F,G,H);
```

Set Declarations

The following table describes the operations that apply to the variables of a set type.

Set Operators

operation	form	description
¬	unary	returns the complement of the operand
=	binary	compares for equality
<> or ¬=	binary	compares for inequality
<=	binary	returns TRUE if first operand is subset of second operand
>=	binary	returns TRUE if first operand is superset of second operand
in	binary	TRUE if first operand (a scalar) is a member in the set represented by the second operand
+	binary	forms the union of two sets
*	binary	forms the intersection of two sets
-	binary	forms the difference between two sets
&&	binary	forms an 'exclusive' union of two sets
ADDR(x)	function	returns the location in memory of a set variable x
SIZEOF(x)	function	returns the number of bytes required for a value of the type of x

Set complement produces a set that has all of the elements which are not in the set being complemented. Set union produces a set which contains all of the elements which are members of the two operands. Set intersection produces the set that contains only the elements common to both sets. Set difference produces the set which includes all elements from the left operand except those elements which are members of the right operand. Set exclusive union produces the set which contains all elements from the two operands except the elements which are common to both operands. The in operator tests for membership of a scalar within a set; if the scalar is not a permissible value of the set, then FALSE will be returned.

The storage and alignment required for a set variable is dependent on the scalar type on which the set is based. The amount of storage required for a packed set will be the minimum number of bytes needed so that every member of the set may be assigned to a unique bit. Given a set definition:

```
  type    S = set of BASE;
```

where BASE is a scalar type which is not a subrange

the ordinal value of the last member M which can be contained on the set is:

```
    M := ORD(HIGHEST(BASE))
```

The following table indicates the mapping of a set variable as a function of M.

Range of M	Size in Bytes	Alignment
0 <= M <= 7	1	BYTE
8 <= M <= 15	2	HALFWORD
16 <= M <= 23	3	BYTE
24 <= M <= 31	4	FULLWORD
32 <= M <= 255	(M+7) div 8	BYTE

Unpacked sets based upon integer (or subranges of integers) will occupy 32 bytes. The maximum value of a member of a set of integer may not exceed 255.

The storage is the same for all unpacked sets of subranges of a base scalar type. The following illustrates this point.

Given:

```
  type
    T   =  set of t;
    S   =  set of s;
```

Where:
  t is a subrange of s.

The types T and S have identical storage mappings.

5.9 THE FILE TYPE

Syntax:

file-type:

```
──┬──────────────┬──> file of ──>{type}──────────────────>
  └──> packed ──>┘
```

All input and output in Pascal/VS use the file type. A file is a structure consisting of a sequence of components where each component is of the same type. Variables of this type reference the components with pointers called file pointers. A file pointer could be thought of as a pointer into an input/output buffer.

The association of a file variable to an actual file of the system is implementation dependent and will not be described in this manual. Refer to the Programmer's Guide for this information.

Note: Declaring a file to be packed is legal, but has no effect on the file's storage requirements.

```
type
  TEXT = file of CHAR;
  LINE = file of
           packed array[1..80] of
             CHAR;
  PFILE = file of
            record
              NAME: packed
                array[1..25] of
                  CHAR;
              PERSON_NO:INTEGER;
              DATE_EMPLOYED:DATE;
              WEEKLY_SALARY : INTEGER
            end;
```

File Declarations

You access the file through predefined procedures and functions (see "I/O Facilities" on page 105). They are:

- GET (see "GET Procedure" on page 109)
- PUT (see "PUT Procedure" on page 110)
- EOF (see "EOF Function" on page 111)
- EOLN (see "EOLN function" on page 117)
- RESET (see "RESET Procedure" on page 105)
- REWRITE (see "REWRITE Procedure" on page 106)
- READ (see "READ and READLN (TEXT Files)" on page 111)
- WRITE (see "WRITE and WRITELN (TEXT Files)" on page 114)
- TERMIN (see "TERMIN Procedure" on page 106)
- TERMOUT (see "TERMOUT Procedure" on page 107)
- PDSIN (see "PDSIN Procedure" on page 107)
- PDSOUT (see "PDSOUT Procedure" on page 108)
- UPDATE (see "UPDATE Procedure" on page 108)
- SEEK (see "SEEK Procedure" on page 110)
- COLS (see "COLS Function" on page 118)
- PAGE (see "PAGE Procedure" on page 117)
- CLOSE (see "CLOSE Procedure" on page 109)

OUTPUT and INPUT are predefined TEXT files. Pascal/VS enforces the following restrictions on the file type:

1. A file may be passed by var or passed by const, but never by value to a procedure or function.
2. A file may not be contained within a file.

5.10 PREDEFINED STRUCTURE TYPES

5.10.1 The Type STRING

Syntax:

string-type:

```
---> STRING ---┬---> ( --->{constant-expr}---> ) ---┬----------------------->
               └------------------------------------>┘
```

The type STRING is defined as a '**packed array**[1..n] **of** CHAR' whose length varies at execution time up to a compile time specified maximum. The length of the array is obtained during execution by the LENGTH function (see "LENGTH Function" on page 139). The length is managed implicitly by the operators and functions which apply to STRINGs. The maximum length of the array is obtained during execution by the MAXLENGTH function (see "MAXLENGTH Function" on page 139). The length of a STRING variable is determined when the variable is assigned. By definition, string constants belong to the type STRING.

A STRING variable may be subscripted with an integer expression to reference individual characters. A subscript of 1 will reference the first character. The subscript value must not be less than 1 nor exceed the string's length.

The constant expression which follows the STRING qualifier in the type definition is the maximum length that the string may obtain and must be in the range of '1 .. 32767'.

Any variable of a STRING type is compatible with any other variable of a STRING type; that is, the maximum length field of a type definition has no bearing in type compatibility tests.

Implicit conversion is performed when assigning a STRING to a variable whose type is '**packed array**[1..n] **of** CHAR'. All other conversion must be done explicitly.

The assignment of one string to another may cause a run time error if the actual length of the source string is greater then the maximum length of the target. Pascal/VS will never truncate implicitly.

```
function GETCHAR(
         const S : STRING;
               IDX : INTEGER) : CHAR;
  begin
   { Subscripted string variable }
    GETCHAR := S[IDX]
  end;
  .
  .
var
  S1: STRING(10);
  S2: STRING(5);
  C:  CHAR;
begin
  S1 := 'MESSAGE:';
  C  := GETCHAR(S1,4);
  { C assigned 'S' }
     .
     .
  S2 := 'FIVE';
  C  := GETCHAR(S2,2);
  { C assigned 'I' }
end;
```

Usage of STRING Variables

The following table describes the operations and predefined functions that apply to the variables of type STRING.

STRING		
operation	form	description
=	binary	compares for equality*
<> or ¬=	binary	compares for inequality*
<	binary	compares for left less than right+*
<=	binary	compares for left less than or equal to right+*
>=	binary	compares for left greater than or equal to right+*
>	binary	compares for left greater than right+*
||	binary	concatenates the operands
LENGTH	function	returns the length of the STRING (see "LENGTH Function" on page 139).
MAXLENGTH	function	returns the declared length of a STRING (see "MAXLENGTH Function" on page 139).
LBOUND	function	returns the value 1, STRINGS always have a lower bound of one (see "LBOUND Function" on page 126).
HBOUND	function	returns the declared maximum number of elements of the string (see "HBOUND Function" on page 126).
SUBSTR	function	returns a specified portion of a STRING (see "SUBSTR Function" on page 140).
DELETE	function	returns a STRING with a portion removed (see "DELETE Function" on page 140).
TRIM	function	returns a STRING with trailing blanks removed (see "TRIM Function" on page 141).
LTRIM	function	returns a STRING with leading blanks removed (see "LTRIM Function" on page 141).
COMPRESS	function	returns a STRING with multiple blanks removed (see "COMPRESS Function" on page 142).
INDEX	function	locates a STRING in another STRING (see "INDEX Function" on page 142).
ADDR(x)	function	returns the location in memory of STRING variable x
SIZEOF(x)	function	returns the number of bytes required for a value of the type of x
READSTR	procedure	converts a STRING to values by assigning variables (see "READSTR" on page 143).
WRITESTR	procedure	produces a STRING by converting the internal values of a list of expressions (see "WRITESTR" on page 144).

* If two STRINGs being compared are of different lengths, the shorter is assumed to be padded with blanks on the right until the lengths match.
+ Relative magnitude of two strings is based upon the collating sequence of EBCDIC.

STRING Conversions with Relational Operators

LEFT OPERAND \ RIGHT OPERAND: relational operations	CHAR	**packed array**[1..n] **of** CHAR	STRING
CHAR	allowed	not permitted	use STR on the CHAR
packed array[1..n] **of** CHAR	not permitted	okay if the types are compatible	use STR on the array
STRING	use STR on the CHAR	use STR on the array	allowed

STRING Conversions on Assignment

TO \ FROM: assignment	CHAR	**packed array**[1..n] **of** CHAR	STRING
CHAR	allowed	not permitted	use string indexing to obtain char
packed array[1..n] **of** CHAR	not permitted	okay if the types are compatible	okay, STRING is converted. If truncation is required, then an error results.
STRING	use STR to convert CHAR to a STRING	use STR to convert array to a STRING	allowed

5.10.2 The Type ALFA

The standard type ALFA is defined as:

```
 const
   ALFALEN = 8;

 type
   ALFA = packed
            array[1..ALFALEN] of
              CHAR;
```

Any **'packed array**[1..n] **of** CHAR', including ALFA, may be converted to type STRING by the predefined function STR. The following table describes the operations and predefined functions that apply to the variables of the predefined type ALFA.

ALFA		
operation	form	description
=	binary	compares for equality
<> or ¬=	binary	compares for inequality
<	binary	compares for left less than right
<=	binary	compares for left less than or equal to right
>=	binary	compares for left greater than or equal to right
>	binary	compares for left greater than right
STR(x)	function	converts the ALFA to a STRING
ADDR(x)	function	returns the location in memory of ALFA variable x
SIZEOF(x)	function	returns the number of bytes required for a value of the type of an ALFA, which is always 8

5.10.3 The Type ALPHA

The standard type ALPHA is defined as:

```
const
  ALPHALEN = 16;

type
  ALPHA = packed
            array[1..ALPHALEN] of
             CHAR;
```

Any **'packed array**[1..n] **of** CHAR', including ALPHA, may be converted to type STRING by the predefined function STR. The following table describes the operations and predefined functions that apply to the variables of the predefined type ALPHA.

ALPHA		
operation	form	description
=	binary	compares for equality
<> or ¬=	binary	compares for inequality
<	binary	compares for left less than right
<=	binary	compares for left less than or equal to right
>=	binary	compares for left greater than or equal to right
>	binary	compares for left greater than right
STR(x)	function	converts the ALPHA to a STRING
ADDR(x)	function	returns the location in memory of ALPHA variable x
SIZEOF(x)	function	returns the number of bytes required for a value of the type of an ALPHA, which is always 16

5.10.4 The Type TEXT

The standard type TEXT is defined as:

```
type
  TEXT     = file of CHAR;
```

In addition to the predefined procedures to do input and output, Pascal/VS defines several procedures which operate only on files of type TEXT. These procedures perform character to internal representation (EBCDIC) conversions and give you some control over output field lengths. The predefined routines that may be used on TEXT files are:

- GET ("GET Procedure" on page 109)
- PUT ("PUT Procedure" on page 110)
- EOF ("EOF Function" on page 111)
- EOLN ("EOLN function" on page 117)
- RESET ("RESET Procedure" on page 105)
- REWRITE ("REWRITE Procedure" on page 106)
- READ ("READ and READLN (TEXT Files)" on page 111)
- READLN ("READ and READLN (TEXT Files)" on page 111)
- WRITE ("WRITE and WRITELN (TEXT Files)" on page 114)
- WRITELN ("WRITE and WRITELN (TEXT Files)" on page 114)
- PAGE ("PAGE Procedure" on page 117)
- CLOSE ("CLOSE Procedure" on page 109)
- COLS ("COLS Function" on page 118)
- PDSIN ("PDSIN Procedure" on page 107)
- PDSOUT ("PDSOUT Procedure" on page 108)
- TERMIN ("TERMIN Procedure" on page 106)
- TERMOUT ("TERMOUT Procedure" on page 107)

Pascal/VS predefines two TEXT variables named OUTPUT and INPUT. You may use these files without declaring them in your program.

5.11 THE POINTER TYPE

```
Syntax:

pointer-type:

  ---> @ --->{id:type}---------------------------------------------->
```

Pascal/VS allows variables to be created during program execution under your explicit control. These variables, which are called dynamic variables, are generated by the predefined procedure NEW. NEW creates a new variable of the appropriate type and assigns its address to the argument of NEW. You must explicitly deallocate a dynamic variable; the predefined procedures DISPOSE and RELEASE are provided for this purpose.

Dynamic variables are created in an area of storage called a heap. A new heap is created with the MARK predefined procedure; a heap is released with the RELEASE predefined procedure. An initial heap is allocated by Pascal/VS. All variables that were allocated in a heap are deallocated when the heap is released. An attempt to use a dynamic variable that has been deallocated (either via DISPOSE or RELEASE) is an error.

Pascal/VS pointers are constrained to point to a particular type. This means that on declaration of a pointer, you must specify the type of the dynamic variable that will be generated by NEW or referenced.

Pascal/VS defines the named constant **nil** as the value of a pointer which does not point to any dynamic variable (empty pointer). Nil is type compatible to every pointer type.

The only operators that can be applied to variables of pointer type are the test for equality and inequality. The predefined function ORD may be applied to a pointer variable; the result of the function is an integer value which is equal to the address of the dynamic variable referenced by the pointer. There is no function in Pascal/VS to convert an integer into a pointer.

```
type
  PTR = @ ELEMENT;
  ELEMENT = record
              PARENT : PTR;
              CHILD  : PTR;
              SIBLING: PTR
            end;
```

A Pointer Declaration

This example illustrates a data types that can be used to build a tree. With this structure the parent node contains a pointer to the eldest child, the eldest points to the next sibling who points to the next, and so forth.

In the above example type ELEMENT was used before it was declared. Referencing an identifier prior to its declaration is generally not permitted in Pascal/VS. However, a type identifier which is used as the base type to a pointer declaration is an exception to this rule.

5.12 THE TYPE STRINGPTR

Variables of type STRING have two lengths associated with them:

- The current length which defines the number of characters in the string at any instant in time.
- The maximum length which defines the storage required for the string.

The predefined type STRINGPTR defines a pointer to a string which has no "maximum length" associated with it until execution time. The procedure NEW is used to allocate storage for this type of pointer; an integer expression is passed to the procedure that specifies the maximum length of the allocated string. See "NEW Procedure" on page 121.

```
var
  P        : STRINGPTR;
  Q        : STRINGPTR;
  I        : 0..32767;
begin
    ...
    NEW(P,(I+1) div 2);
    WRITELN( MAXLENGTH(P@) );
            {writes '30' to output }
    NEW(Q,5);
    Q@ := '1234567890';
            {causes a truncation }
            {error at execution  }
end
```

Using the Predefined type STRINGPTR

5.13 STORAGE, PACKING, AND ALIGNMENT

For each variable declared with a particular type, Pascal/VS allocates a specific amount of storage on a specific alignment boundary. The Programmer's Guide describes implementation requirements and defaults.

Pascal/VS provides the packed record feature in which all boundary alignment is suppressed. Fields of a packed record are allocated on the next byte, ignoring alignment requirements.

Packed data occupies less space and is more compact but may increase the execution time of the program. Moreover, a field of a packed record or an element of a packed array may not be passed by read/write reference (**var**) to a routine.

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Syntax:

routine-dcl:

```
 ──┬──>{procedure-heading}──────────────>┐
   └──>{function-heading}───────────────>┤
                                         │
   ┌<────────────────── ; <──────────────┘
   │
   ├──>{directive}──> ; ───────────────────────>┐
   │                                            │
   ├<──────────────────┐                        │
   ├──>{declaration}──>┘                        │
   │                                            │
   └──>{compound-statement}──> ; ───────────────┴────────────────>
```

procedure-heading:

```
 ──> procedure ──>{id}──>{formal-parameters}─────────────────────>
```

function-heading:

```
 ──> function ──>{id}──>{formal-parameters}──> : ──>{id:type}────>
```

directive:

```
 ──┬──> FORWARD ────────────────────────────>┬───────────────────>
   ├---> EXTERNAL ---------------------------->┤
   ├---> FORTRAN ----------------------------->┤
   ├---> MAIN -------------------------------->┤
   └---> REENTRANT --------------------------->┘
```

formal-parameters:

```
 ──┬──> ( ──┬──>{formal}──┬──> ) ──┬─────────────────────────────>
   │        └<──── ; <────┘        │
   └──────────────────────────────>┘
```

formal:

```
 ──┬──┬────────────┬──┬──{id}──┬──> : ──>{id:type}──┬────────────>
   │  ├──> var ───>┤  └<── , <─┘                    │
   │  └---> const -->┘                              │
   │                                                │
   ├──>{procedure-heading}─────────────────────────>┤
   └──>{function-heading}──────────────────────────>┘
```

There are two categories of routines: procedures and functions. Procedures should be thought of as adding new statements to the language. These new statements effectively increase the language to a superset language containing statements tailored to your specialized needs. Functions should also be thought of as increasing the flexibility of the language: functions add to your ability to express data transformation in expressions.

Routines can return data to the caller by altering the var parameters or by assigning to variables that are common to both the invoker and the invoked routine. In addition, functions also return a value to the invoker upon return from the function.

6.1 ROUTINE DECLARATION

Routines must be declared prior to their use. The routine declaration consists of the routine heading, declarations and one compound statement.

The heading defines the name of the routine and binds the formal parameters to the routine. The heading of a function declaration also binds the function name to the type of value returned by the function. Formal parameters specify data that is to be passed to the routine when it is invoked. The declarations are described in chapter 4. The compound statement will be executed when the routine is invoked.

6.2 ROUTINE PARAMETERS

Formal parameters are bound to the routine when the routine is defined. The formal parameters define what kind of data may be passed to the routine when it is invoked. These parameters also specify how the data will be passed.

When the routine is invoked, a parameter list is built. At the point of invocation the parameters are called the actual parameters.

Pascal/VS permits parameters to be passed in following ways:

- pass by value
- pass by read/write reference (**var**)
- pass by read only reference (**const**)
- pass by conformant string (**var** or **const**)
- formal routine parameter

6.2.1 Pass by Value Parameters

Pass by value parameters can be thought of as local variables that are initialized by the caller. The called routine may change the value of this kind of parameter but the change is never reflected back to the caller. Any expression, variable or constant (except of file type) may be passed with this mechanism.

6.2.2 Pass by Var Parameters

Pass by Var (variable) is also called pass by reference. Parameters that are passed by var reflect modifications to the parameters back to the caller. Therefore you may use this parameter type as both an input and output parameter. The use of the **var** symbol in a parameter indicates that the parameter is to be passed by read/write reference. Only variables may be passed by this mechanism; expressions and constants may not. Also, fields of a packed record or elements of a packed array may not be passed as var parameters in standard Pascal (but may be in Pascal/VS).

6.2.3 Pass by Const Parameters

Parameters passed by const may not be altered by the called routine. Also you should not modify the actual parameter value while the call to the routine has not yet completed. If you attempt to alter the actual parameter while it is being passed by const, the result is not defined. This method could be called pass by read only reference. The parameters appear to be constants from the called routine's point of view. Any expression, variable or constant may be passed by const (fields of a packed record and elements of a packed array may also be passed). The use of the "**const**" reserved word in a parameter indicates that the parameter is to be passed by this mechanism. With parameters which are structures (such as strings), passing by const is usually more efficient than passing by value.

6.2.4 Formal Routine Parameters

A procedure or function may be passed to a routine as a formal parameter. Within the called routine the formal parameter may be used as if it were a procedure or function.

6.2.5 Conformant String Parameters

It is often desirable to call a procedure or function and pass in a string whose declared length does not match that of the formal parameter. The conformant string parameter is used for this purpose.

The conformant string parameter is a pass by **const** or pass by **var** parameter with a type specified as STRING without a length qualifier. Strings of any declared length will conform to such a parameter. You can use the MAXLENGTH function to obtain the declared length. See "MAXLENGTH Function" on page 139.

```
procedure TRANSLATE
   (var   S    : STRING;
    const TABLE: STRING);
   var
     I   : 0..32767;
     J   : 1..ORD(HIGHEST(CHAR))+1;
   begin
     for I := 1 to LENGTH(S) do
       begin
         J := ORD(S[I])+1;
         if J > LENGTH(TABLE) then
           S[I] := ' '
         else
           S[I] := TABLE[J];
       end;
   end;
```

Example of Conformant Strings

6.3 ROUTINE COMPOSITION

There are six kinds of routines:

- internal
- FORWARD
- EXTERNAL
- FORTRAN
- REENTRANT
- MAIN

The directive used to identify each kind of declaration is shown in upper case above.

Note: A routine must be declared before it can be referenced. This allows the compiler to assure the validity of a call by checking parameter compatibility.

6.3.1 Internal Routines

An internal routine may be invoked only from within the lexical scope that contains the routine definition.

6.3.2 FORWARD Routines

A routine declared FORWARD is the means by which you can declare the routine heading before declaring the declarations and compound statement. The routine heading is declared followed by the symbol 'FORWARD'. This allows you to have a call to a routine prior to defining the routine's body. If two routines are to be mutually recursive and are at the same nesting level, one of the routines must be declared FORWARD.

To declare the body of the FORWARD routine, you declare the routine leaving off the formal parameter definition.

6.3.3 EXTERNAL Routines

An EXTERNAL routine is a procedure or function that can be invoked from outside of its lexical scope (such as, another module). The EXTERNAL directive is used to specify the heading of such a routine. While many modules may call an EXTERNAL routine, only one module will actually contain the body of the routine. The formal parameters defined in the EXTERNAL routine declaration must match those in the module where the routine is defined. An EXTERNAL routine declaration may refer to a Pascal/VS routine which is located later in the same module or located in another module or it may refer to code produced by other means (such as assembler code).

The following example illustrates two modules (a program module and a segment module) that share a single EXTERNAL routine. Both modules may invoke the routine but only one contains the definition of the routine.

```
program TEST;
  function SQUARE(X : REAL) : REAL;
    EXTERNAL;
begin
  WRITELN(  SQUARE(44) );
end .

SEGMENT S;
  function SQUARE(X : REAL) : REAL;
    EXTERNAL;
  function SQUARE;
  begin
    SQUARE := X * X
  end; .
```

Example of an EXTERNAL Function

The body of an EXTERNAL routine may only be defined in the outermost nesting level of a module; that is, it must not be nested within another routine.

6.3.4 FORTRAN Routines

A FORTRAN routine is similar to an EXTERNAL routine in that it specifies a routine that is defined outside the module being compiled. In addition, it specifies that the routine is a FORTRAN subprogram and therefore the conventions of FORTRAN are to be used. A FORTRAN routine is never defined within a Pascal/VS module. If you pass a literal constant to a FORTRAN subprogram by CONST, then you must assure that the FORTRAN subprogram does not alter the contents of parameter. In order to meet the requirements of FORTRAN you must obey the following restrictions:

- All parameters may be only var or const parameters.

- If the routine is a function, it may only return a scalar result (this includes REAL and SHORTREAL).

- Routines may not be passed.

- Multi-dimensional arrays are not remapped to conform to FORTRAN indexing, that is, an element of an array A[n,m] in Pascal will be element A(m,n) in FORTRAN.

6.3.5 MAIN Procedures

The MAIN directive is used to identify a Pascal procedure that may be invoked as if it were a main program. It is sometimes desirable to invoke a Pascal/VS procedure from a non-Pascal routine, for example FORTRAN or assembler language. In this case it is necessary for certain initializing operations to be performed prior to actually executing the Pascal procedure. The MAIN directive specifies that these actions are to be performed.

There are several restrictions on the use of the MAIN directive.

- only procedures may have the MAIN directive;

- a procedure that is declared to be MAIN must have its body located in the same module;

- the execution of a MAIN procedure will not be reentrant;

- the MAIN directive may only be applied to procedures in the outermost nesting level.

Consult Pascal/VS Programmer's Guide, order number SH20-6162 for further details on using MAIN.

6.3.6 REENTRANT Procedures

The REENTRANT directive is used to identify a Pascal procedure that may be invoked as if it were a main program like a MAIN procedure. In addition, invocations of these procedures will be reentrant.

In order to achieve this additional feature, some help is required from you. The first parameter of a procedure defined with the REENTRANT directive must be an INTEGER passed by **var**. Prior to the very first call from a non-Pascal/VS program you must initialize this variable to zero (0). On subsequent calls you must pass the same variable back unaltered (Pascal/VS sets the variable on the first call and needs that value on the subsequent invocations). You need not call the same procedure each time, you may call different procedures - just continue to pass this variable on each call.

Consult Pascal/VS Programmer's Guide, order number SH20-6162 for further details on using REENTRANT.

Note: All Pascal/VS internal procedures and functions are reentrant. The REENTRANT directive is used to specify a procedure that is both reentrant and invokable from outside the Pascal/VS execution environment.

6.3.7 Examples of Routines

```
static
  C: CHAR;

function GETCHAR:CHAR;
  EXTERNAL;

procedure EXPR(var VAL: INTEGER);
  EXTERNAL;

procedure FACTOR(var VAL: INTEGER);
  EXTERNAL;
procedure FACTOR;
  begin
    C := GETCHAR;
    if C = '(' then
      begin
        C := GETCHAR;
        EXPR(VAL)
      end
    else
      ...
  end;

procedure EXPR {var VAL: INTEGER};
  begin
    FACTOR(VAL);
      ...
  end;
```

Examples of Routine Declarations

```
function CHARFOUND
    (const S: STRING;
           C: CHAR): BOOLEAN;
  var I: 1..255;
  begin
    for I := 1 to LENGTH(S) do
      if S[I] = C then
        begin
          CHARFOUND := TRUE;
          return
        end;
    CHARFOUND := FALSE;
  end;
```

Example of Const Parameter

6.4 FUNCTION RESULTS

A value is returned from a function by assigning the value to the name of the function prior to leaving the function. This value is inserted within the expression at the point of the call. The value must be assignment conformable to the type of the function.

If the function name is used on the right side of an assignment, it will be interpreted as a recursive call.

```
function FACTORIAL
           (X: INTEGER): INTEGER;
  begin
    if X <= 1 then
      FACTORIAL := 1
    else
      FACTORIAL := X * FACTORIAL(X-1)
  end;
```

Example of Recursive Function

Standard Pascal permits a function to return only a scalar value. Pascal/VS provides for a function to return any type except a file. This means that you can write a Pascal/VS function that returns a record structure as its result (such as you might wish to do for implementing a complex arithmetic library). A function may also return a string, however you must specify the maximum length of the string to be returned.

```
type
  COMPLEX = record
              R,I : REAL
            end

function CADD
  (const A,B : COMPLEX) : COMPLEX;
  var
    C : COMPLEX;
  begin
    C.R := A.R + B.R;
    C.I := A.I + B.I;
    CADD := C
  end;
```

Example of a Function Returning a Record

6.5 PREDEFINED PROCEDURES AND FUNCTIONS

Pascal/VS predefines a number of procedures and functions that you may find valuable. Details of the predefined procedures and functions are given in section titled "I/O Facilities" on page 105.

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```
Syntax:

variable:
                                                                  notes:
 ——>{id}——>┐
           ├<——————————————————————————————————————————┐
           │                                           │
           ├——> [ ——┬——>{expr}——┬———> ] ————>┤           subscripted variable
           │        └<——— , ————┘             │
           │                                           │
           ├——> . ——>{id:field}————————————————————>┤  field reference
           │                                           │
           ├——> @ ————————————————————————————————————>┘  pointer reference
           │
           └————————————————————————————————————————————————————————————>
```

Pascal/VS divides variables into five classes depending on how they are declared:

- automatic (var variables)
- dynamic (pointer-qualified variables)
- \+ static (static variables)
- \+ external (def/ref variables)
- parameter (declared on a routine declaration)

A variable may be referenced in several ways depending on the variable's type. You may always refer to the entire variable by specifying its name. You may refer to a component of a structured variable by using the syntax shown in the syntax diagram.

If you simply specify the name of the variable, then you are referring to the entire variable. If that variable is declared as an array, then you are referring to the entire array. You may assign an entire array. Similarly, you may also deal with record and set variables as units.

```
var
  LINE1,
  LINE2 : packed
            array[ 1..80 ] of
              CHAR;
       .
       .
 { assign all 80 characters   }
 { of the array               }
 LINE1 := LINE2;
```

Using Variables in their entirety

7.1 SUBSCRIPTED VARIABLE

An element of an array is selected by placing an indexing expression enclosed within square brackets, after the name of the array. The indexing expression must be of the same type as declared on the corresponding array index definition.

A multi-dimensional array may be referenced as an array of arrays. For example, let variable A be declared as follows:

```
A: array [a..b,c..d] of T
```

As explained in "The Array Type" on page 44, this declaration is exactly equivalent to:

```
A: array [a..b] of
     array [c..d] of T
```

A reference of the form A[I] would be a variable of type:

```
array [c..d] of T
```

and would represent a single row in array A. A reference of the form A[I][J] would be a variable of type T and would represent the Jth element of the Ith row of array A. This latter reference would customarily be abbreviated as

```
A[I,J]
```

Any array reference with two or more subscript indices can be abbreviated by writing the subscripts in a comma separated list. That is, A[I][J]... could be written as A[I,J,...].

If the '%CHECK SUBSCRIPT' option is enabled, the index expression will be checked at execution time to make sure its value does not lie outside of the subscript range of the array. An execution time error diagnostic will occur if the value lies outside of the prescribed range. (For a description of the CHECK feature see "The %CHECK Statement" on page 150.)

A variable of type STRING may be subscripted with an integer expression to reference individual characters. The value of the subscript must not be less than 1 or greater than the length of the string. String subscripts are checked at run time if %CHECK SUBSCRIPT is enabled.

```
A[12]
A[I]
A[ I+J ]
DECK[ CARD-FIFTY ]
MATRIX[ ROW[I], COLUMN[J] ]
```

Subscripted Variables

7.2 FIELD REFERENCING

A field of a record is selected by following the record variable by a period and by the name of the field to be referenced.

```
var
  PERSON:
    record
      FIRST_NAME,
      LAST_NAME: STRING(15);
    end;

  DATE:
    record
      DAY: 1..31;
      MONTH: 1..12;
      YEAR: 1900..2000
    end;

  DECK:
    array[1..52] of
      record
        CARD: 1..13;
        SUIT:
          (SPADE, HEART,
           DIAMOND, CLUB)
      end;
      .
      .
PERSON.LAST_NAME := 'SMITH';
DATE.YEAR := 1978;
DECK[ I ].CARD := 2;
DECK[ I ].SUIT := SPADE;
```

Field Referencing Examples

7.3 POINTER REFERENCING

A dynamic variable is created by the predefined procedure NEW or by an implementation provided routine which assigns an address to a pointer variable. You may refer either to the pointer or to the dynamic variable; referencing the dynamic variable requires using the pointer notation.

For example

```
var P : @ R;

 P    refers to the pointer
 P@   refers to the dynamic variable
```

If the '%CHECK POINTER' option is enabled, any attempt to reference a pointer that has not been assigned the address of an allocated variable will result in an execution time error diagnostic. (For a description of the CHECK feature see "The %CHECK Statement" on page 150.)

```
type
  INFO = record
           AGE:  1..99;
           WEIGHT: 1..400;
         end;

   FAMILY =
     record
       FATHER,
       MOTHER,
       SELF: @INFO;
       KIDS: 0..20
     end;

var
  FAMILY_POINTER : @FAMILY
      .
      .
NEW(FAMILY_POINTER);
FAMILY_POINTER@.KIDS := 2;
NEW(FAMILY_POINTER@.FATHER);
FAMILY_POINTER@.FATHER@.AGE := 35;
      .
      .
```

Pointer Referencing Examples

7.4 FILE REFERENCING

A component of a file is selected from the file buffer by a pointer notation. The file variable is assigned by using the predefined procedures GET and PUT. Each use of these procedures moves the current component to the output file (PUT) or assigns a new component from the input file (GET). (For a description of GET and PUT, see "GET Procedure" on page 109 and "PUT Procedure" on page 110.)

If the '%CHECK POINTER' option is enabled, any attempt to reference a file pointer which has no value will result in an execution time error diagnostic. (For a description of the CHECK feature see "The %CHECK Statement" on page 150.)

```
var
  INPUT    : TEXT;
  OUTPUT   : TEXT;
  LINE1    : array [1..80] of CHAR;
  .
  .
{ scan off blanks               }
{ from a file of CHAR           }
GET(INPUT);
while INPUT@ = ' ' do
  GET(INPUT);


{ transfer a line to the        }
{ OUTPUT file                   }
for I := 1 to 80 do
  begin
    OUTPUT@ := LINE1[I];
    PUT(OUTPUT)
  end;
```

File Referencing Examples

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Syntax:

constant-expr:
expr:

```
 --->{simple-expression}--+--------------------------------------------+-->
                          |                                            |
                          +--> =  ------+->{simple-expression}---->----+
                          +--> <> --->--|
                          +--> <  --->--|
                          +--> <= --->--|
                          +--> >= --->--|
                          +--> >  --->--|
                          +--> in --->--+
```

simple-expression:

```
 --------+-------------+------+--->{term}--+-----------------------------------------+-->
         +--> + --->---|      |            +--> + ----->--+
         +--> - --->---+      |            +--> - ----->--|
+                             |            +---> && --->--|
                              |            +--> | ----->--|
                              +-<--------------------------+
```

term:

```
 -------+--->{factor}--+----------------------------------------------------------+-->
        |              +--> *   -------->--+
        |              +--> /   -------->--|
        |              +--> div  ------>---|
        |              +--> mod  ------>---|
+       |              +---> >>  ----->----|
+       |              +---> <<  ----->----|
+       |              +---> ||  ----->----|
        |              +--> &   -------->--|
        +-<-----------------------------------+
```

factor:

```
 -------+--->{function-call}------------------------------------------------+------->
        |                                                                    |
        +--->{variable}---------------------------------------------------->-|
        |                                                                    |
        +--->{set-constructor}--------------------------------------------->-|
        |                                                                    |
        +--> ( ---->{expr}---> ) ------------------------------------------>-|
        |                                                                    |
+       +---->{structured-constant}---------------------------------------->-|
        |                                                                    |
        +--> not --->{factor}---------------------------------------------->-|
        |                                                                    |
        +--->{unsigned-constant}------------------------------------------->-+
```

Pascal/VS expressions are similar in function and form to expressions found in other high level programming languages. Expressions permit you to combine data according to specific computational rules. The type of computation to be performed is directed by operators which are grouped into four classes according to precedence:

- the **not** operator (highest)
- the multiplying operators
- the adding operators
- the relational operators (lowest)

An expression is evaluated by performing the operators of highest precedence first, operators of the next precedence second and so forth. Operators of equal precedence are performed in a left to right order. If an operator has an operand which is a parenthesized sub-expression, the sub-expression is evaluated prior to applying the operator.

The operands of an expression may be evaluated in either order; that is, you should not expect the left operand of dyadic operator to be evaluated before the right operand. If either operand changes a global variable through a function call, and if the other operand uses that value, then the value used is not specified to be the updated value. The only exception is in boolean expressions involving the logical operations of 'and' (&) and 'or' (|); for these operations the right operand will not be evaluated if the result can be determined from the left operand. See "Boolean Expressions" on page 79.

Examples of Expressions

Assume the following declarations:

```
const
  ACME     = 'acme';

type
  COLOR    = (RED, YELLOW, BLUE);
  SHADE    = set of COLOR;
  DAYS     = (SUN, MON, TUES, WED, THUR, FRI, SAT);
  MONTHS   = (JAN, FEB, MAR, APR, MAY, JUN,
              JUL, AUG, SEP, OCT, NOV, DEC);

var
  A_COLOR  : COLOR;
  A_SET    : SHADE;
  BOOL     : BOOLEAN;
  MON      : MONTHS
  I,
  J        : INTEGER;
```

factors:

I	variable
15	unsigned constant
(I*8+J)	parenthetical expression
[RED]	set of one element
[ ]	empty set
ODD(I*J)	function call
not BOOL	complement expression
COLOR(1)	scalar type converter
ACME	constant reference

terms:

I	factor
I * J	multiplication
I **div** J	integer division
ACME || ' TRUCKING'	catenation
A_SET * [RED]	set intersection
I & 'FF00'X	logical **and** on integers
BOOL & ODD(I)	boolean **and**

simple expression:

I * J	term
I + J	addition
I | '80000000'X	logical **or** on integers
A_SET + [BLUE]	set union
- I	unary minus on an integer

expression:

I + J	simple expression
RED = A_COLOR	relational operations
RED **in** A_SET	test for set inclusion

8.1 OPERATORS

Multiplying Operators			
operator	operation	operands	result
*	multiplication	INTEGER REAL REAL, INTEGER SHORTREAL SHORTREAL, INTEGER SHORTREAL, REAL	INTEGER REAL REAL SHORTREAL SHORTREAL REAL
/	real division	INTEGER REAL REAL, INTEGER SHORTREAL SHORTREAL, INTEGER SHORTREAL, REAL	REAL REAL REAL SHORTREAL SHORTREAL REAL
div	integer division	INTEGER	INTEGER
mod	modulo	INTEGER	INTEGER
& (**and**)	boolean and	BOOLEAN	BOOLEAN
& (**and**)	logical and	INTEGER	INTEGER
*	set intersection	**set of** t	**set of** t
||	string catenation	STRING	STRING
<<	logical left shift	INTEGER	INTEGER
>>	logical right shift	INTEGER	INTEGER

Adding Operators			
operator	operation	operands	result
+	addition	INTEGER, INTEGER REAL, REAL REAL, INTEGER SHORTREAL, SHORTREAL SHORTREAL, INTEGER SHORTREAL, REAL	INTEGER REAL REAL SHORTREAL SHORTREAL REAL
-	subtraction	INTEGER, INTEGER REAL, REAL REAL, INTEGER SHORTREAL, SHORTREAL SHORTREAL, INTEGER SHORTREAL, REAL	INTEGER REAL REAL SHORTREAL SHORTREAL REAL
-	set difference	**set of** t	**set of** t
| (**or**)	boolean or	BOOLEAN	BOOLEAN
| (**or**)	logical or	INTEGER	INTEGER
+	set union	**set of** t	**set of** t
&& (**xor**)	exclusive or	INTEGER	INTEGER
&& (**xor**)	'exclusive' union	**set of** t	**set of** t

The Not Operator			
operator	operation	operand	result
¬ (**not**)	boolean not	BOOLEAN	BOOLEAN
¬ (**not**)	logical one's complement	INTEGER	INTEGER
¬ (**not**)	set complement	**set of** t	**set of** t

Relational Operators			
operator	operation	operands	result
=	compare equal	any set, scalar type, pointer or string	BOOLEAN
<> (¬=)	compare not equal	any set, scalar type, pointer or string	BOOLEAN
<	compare less than	scalar type or string	BOOLEAN
<=	compare < or =	scalar type, string	BOOLEAN
<=	subset	**set of** t	BOOLEAN
>	compare greater	scalar type, string	BOOLEAN
>=	compare > or =	scalar type, string	BOOLEAN
>=	superset	**set of** t	BOOLEAN
in	set membership	t and **set of** t	BOOLEAN

8.2 CONSTANT EXPRESSIONS

Constant expressions are expressions which can be evaluated by the compiler and replaced with a result at compile time. By its nature, a constant expression may not contain a reference to a variable or to a user-defined function. Constant expressions may appear in constant declarations.

The following predefined functions are permitted in constant expressions:

Function	Page
ABS	134
CHR	128
HIGHEST	125
LENGTH	139
LOWEST	125
MAX	132
MAXLENGTH	139
MIN	132
ODD	134
ORD	128
PRED	133
scalar conversion functions	129
SIZEOF	127
SUCC	133

constant expression	type
ORD('A')	INTEGER
SUCC(CHR('F0'X))	CHAR
256 **div** 2	INTEGER
'TOKEN'||STR(CHR(0))	STRING
'8000'X | '0001'X	INTEGER
['0'..'9']	**set of** CHAR
32768*2-1	INTEGER

Examples of Constant Expressions

8.3 BOOLEAN EXPRESSIONS

You should recognize that Pascal assigns the operations of "&" (**and**) and "|" a higher precedence than the relational operators. This means that the expression:

```
A<B & C<D
```

will be evaluated as :

```
(A < (B&C)) < D
```

Thus, it is advisable to use parenthesis when writing expressions of this sort.

Pascal/VS will optimize the evaluation of BOOLEAN expressions involving '&' (**and**) and '|' (**or**) such that the right operand of the expression will not be evaluated if the result of the operation can be determined by evaluating the left operand. For example, given that A, B, and C are boolean expressions and X is a boolean variable, the evaluation of

```
X := A or B or C
```

would be performed as

```
if A then
  X := TRUE
else
  if B then
    X := TRUE
  else
    X := C
```

The evaluation of

```
X := A and B and C
```

would be performed as

```
if ¬A then
  X := FALSE
else
  if ¬B then
    X := FALSE
  else
    X := C
```

The evaluation of the expression will always be left to right.

The following example demonstrates logic which depends on the conditional evaluation of the right operand of the "**and**" operator.

```
type
  RECPTR = @REC;
  REC = record
          NAME: ALPHA;
          NEXT: RECPTR;
        end;

var
  P : RECPTR;
  LNAME : ALPHA;

begin
  ...
  while (P<>nil) and
        (P@.NAME <> LNAME)
  do
    P := P@.NEXT;
  ...
end;
```

Example of a BOOLEAN Expression that Depends on Order of Evaluation

Notes:

- If you use a function in the right operand of a boolean expression, then you must be aware that the function may not be evaluated. Further, you should note that relying on side-effects from functions is considered a bad programming practice.
- Not all Pascal compilers support this interpretation of BOOLEAN expressions. If you wish to assure portability between Pascal/VS and other Pascal implementations you should write the compound tests in a form that uses nested if-statements.

8.4 LOGICAL EXPRESSIONS

Many of the integer operators provided in Pascal/VS perform logical operations on their operands; that is, the operands are treated as unsigned strings of binary digits instead of signed arithmetic quantities. For example, if the integer value of -1 was used as an operand of a logical operation, it would be viewed as a string of binary digits with a hexadecimal value of 'FFFFFFFF'X.

The logical operations are defined to apply to 32 bit values. Such an operation on a subrange of an INTEGER could yield a result outside the subrange.

The following operators perform logical operations on integer operands:

- '&' (**and**) performs a bit-wise **and** of two integers.
- '|' (**or**) performs a bit-wise inclusive **or**.
- '&&' (**xor**) performs a bit-wise exclusive **or**.
- '¬' (**not**) performs a one's complement of an integer.
- '<<' shifts the left operand value left by the amount indicated in the right operand. Zeroes are shifted in from the right.
- '>>' shifts the left operand value right by the amount indicated in the right operand. Zeroes are shifted in from the left.

```
257 & 'FF'X     yields   1
2 | 4 | 8       yields   14
4 << 2          yields   16
-4 << 1         yields   -8
8 >> 1          yields   4
-8 >> 1         yields   '7FFFFFFC'X
'FFFF'X >> 3    yields   '1FFF'X
¬1 & 'FF'X      yields   'FE'X
¬0              yields   -1
'FF'X && 8      yields   'F7'X
```

Examples of Logical Operations

8.5 FUNCTION CALL

Syntax:

function-call:

```
──>{id:function}──>{actual-parameters}──────────────────────────────────>
```

actual-parameters:

```
──┬────> ( ──┬──────>{expr}──┬────┬──> ) ──┬──────────────────────────>
  │          │    └<──── , <──┘    │        │
  │          └─────────────────────>┘        │
  └────────────────────────────────────────>┘
```

A function returns a value to the invoker. A call to a function passes the actual parameters to the corresponding formal parameters. Each actual parameter must be of a type that is conformable to the corresponding formal parameter. You may not pass a field of a packed record as a var parameter. You also may not pass an element of a packed array as a var parameter.

The parenthesis list may be dropped if the function requires no parameters. However, if you wish to draw attention to a function call that has no parameters and make it appear different from a variable reference, you can follow the function name with an empty set of parenthesis.

```
var A,B,C: INTEGER;

function SUM
  (A,B: INTEGER): INTEGER;
  begin
    SUM := A+B
  end;
  ...
begin
  ...
  C := SUM(A,B) * 2
  ...
end;
```

Function Example

8.6 SCALAR CONVERSIONS

Pascal/VS predefines the function ORD that converts any scalar value into an integer. The scalar conversion functions convert an integer into a specified scalar type. An integer expression is converted to another scalar type by enclosing the expression within parentheses and prefixing it with the type identifier of the scalar type. If the operand is not in the range 0 .. ORD(HIGHEST(scalar type)), then a subrange error will result. The conversion is performed in such a way as to be the inverse of the ORD function. See "Scalar Conversion" on page 129.

The definition of any type identifier that specifies a scalar type (enumerated scalars or subranges) forms a scalar conversion function. By definition, the expression CHAR(x) is equivalent to CHR(x); INTEGER(x) is equivalent to x; and ORD(type(x)) is equivalent to x.

```
  type
    WEEK =
       (SUN,MON,TUE,WED,THU,FRI,SAT);
  var
    DAY: WEEK;
     .
     .
{The following assigns SAT to DAY}
  DAY := WEEK(6);
```

Scalar Conversion Functions

8.7 SET CONSTRUCTOR

Syntax:

<u>set-contructor:</u>

```
──> [ ──┬──┬──>{expr}──┬───────────────────────┬──┬──> ] ──────>
        │  │           └──> ..  ──>{expr}──>┘  │  │
        │  └<──────────────── , <──────────────┘  │
        └─────────────────────────────────────────>┘
```

A set constructor is used to compute a value of a set type within an expression.

The set constructor is list of comma separated expressions or expression pairs within square brackets. An expression pair designates that all values from the first expression through the last expression are to be included in the resulting set; the evaluation of the first expression must produce a value less than or equal to the value computed by the second expression. Each expression must be of the same type; this type becomes the base scalar type of the set. If the set specifies INTEGER valued expressions, then there is an implementation restriction of 256 elements permitted in the set.

```
type
  DAYS    = set of
    (SUN,MON,TUES,WED,THU,FRI,SAT);
  CHARSET= set of CHAR;

var
  WORKDAYS,
  WEEKEND:     DAYS
  NONLETTERS: CHARSET;
  .
  .
  WORKDAYS := [MON..FRI];
  WEEKEND  := ¬ WORKDAYS;
  .
  .
  NONLETTERS :=
            ¬ ['a'..'z','A'..'Z'];
```

Set Constructor

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Syntax:

statement:

```
  ──┬──>{label}──> : ──>┐
    ├<──────────────────┘
+   ├--->{assert-statement}------------------------------------->┐
    ├───>{assignment-statement}──────────────────────────────────>┤
    ├───>{case-statement}────────────────────────────────────────>┤
    ├───>{compound-statement}────────────────────────────────────>┤
+   ├--->{continue-statement}----------------------------------->┤
    ├───>{empty-statement}───────────────────────────────────────>┤
    ├───>{for-statement}─────────────────────────────────────────>┤
    ├───>{goto-statement}────────────────────────────────────────>┤
    ├───>{if-statement}──────────────────────────────────────────>┤
+   ├--->{leave-statement}-------------------------------------->┤
    ├───>{procedure-call}────────────────────────────────────────>┤
    ├───>{repeat-statement}──────────────────────────────────────>┤
+   ├--->{return-statement}------------------------------------->┤
    ├───>{while-statement}───────────────────────────────────────>┤
    └───>{with-statement}────────────────────────────────────────>┴──────────>
```

Statements are your directions to perform specific operations based on the data. The statements are similar to those found in most high level programming languages.

9.1 THE ASSERT STATEMENT

Syntax:

assert-statement:

```
---> assert --->{expr}----------------------------------------------------->
```

The assert-statement is used to check for a specific condition and signal a runtime error if the condition is not met. The condition is specified by the expression which must evaluate to a BOOLEAN value. If the condition is not TRUE then the error is raised. The compiler may remove the statement from the program if it can be determined that the assertion is always true.

Example:

```
assert A >= B
```

The Assert Statement

9.2 THE ASSIGNMENT STATEMENT

Syntax:

assignment-statement:

```
———┬———>{variable}——————————┬———> := ———>{expr}————————————————————————————>
   └———>{id:function}———>———┘
```

The assignment-statement is used to assign a value to a variable. This statement is composed of a reference to a variable followed by the assignment symbol (':='), followed by an expression which when evaluated is the new value. The variable must be conformable to the expression. The rules for expression conformability are given in "Type Compatibility" on page 33.

You may make array assignments (assign one array to another array) or record assignments (assign one record to another). When doing this, the entire array or record is assigned.

A result is returned from a function by assigning the result to the function name prior to leaving the function. See "Function Results" on page 67

Pascal/VS will not permit the assignment of a value to a pass by const parameter.

Example:

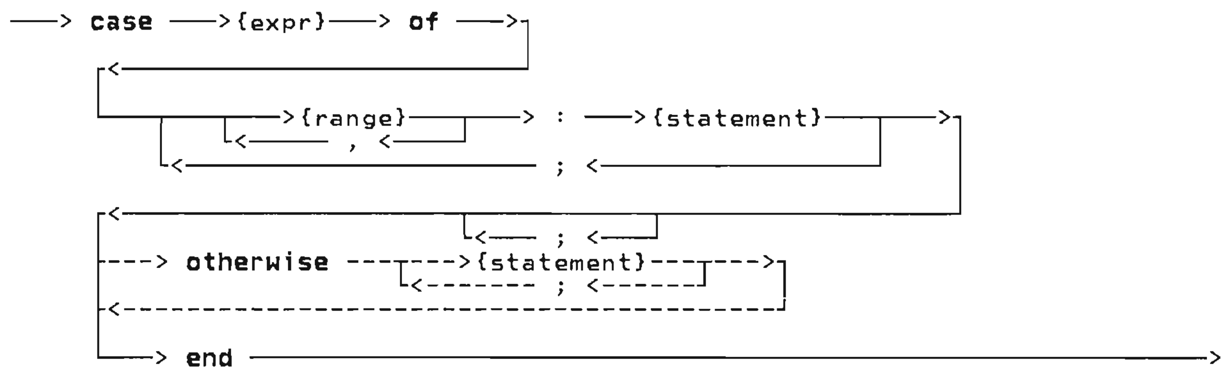
```
type
  CARD = record
         SUIT : (SPADE,
                 HEART,
                 DIAMOND,
                 CLUB);
         RANK : 1..13
         end;

var
  X, Y, Z : REAL;

  LETTERS,
  DIGITS,
  LETTER_OR_DIGIT
     : set of CHAR;

  I, J, K : INTEGER;

  DECK : array[ 1..52 ] of
         CARD;
  ...
  X := Y*Z;
  LETTERS           := [ 'A' .. 'Z' ];
  DIGITS            := [ '0' .. '9' ];
  LETTER_OR_DIGIT   := LETTERS + DIGITS;
  DECK[ I ].SUIT    := HEART;
  DECK[ J ]         := DECK[ K ];
```

Assignment Statements

9.3 THE CASE STATEMENT

Syntax:

case-statement:



The case-statement provides you with a multiple branch based upon the evaluation of an expression. This statement consists of an expression called the selector and a list of statements. The selector must be of scalar type (except type REAL). Each statement is prefixed with one or more ranges of the same type as the selector; each range is separated by a comma. Each range designates one or more values called case labels.

Pascal/VS evaluates the expression and executes the statement whose case label equals the value of the expression. If no case label equals the value of the expression, then the otherwise statement is executed if it is present; if there is no otherwise statement and the %CHECK CASE option is on, then a runtime error will result. If the checking is not enabled the results will not be predictable.

The range values of a case-statement may be written in any order. However, you may not designate the same case label on more than one statement.

Example:

```
type
  SHAPE = (TRIANGLE, RECTANGLE,
           SQUARE,   CIRCLE);
  COORDINATES =
    record
      X,Y    : REAL;
      AREA   : REAL;
      case S : SHAPE of
        TRIANGLE:
           (SIDE : REAL;
            BASE : REAL);
        RECTANGLE:
           (SIDEA,SIDEB : REAL);
        SQUARE:
           (EDGE : REAL);
        CIRCLE:
           (RADIUS : REAL)
    end;
var
  COORD  : COORDINATES;
   ...
with COORD do
  case S of
  TRIANGLE:
    AREA := 0.5 * SIDE * BASE;
  RECTANGLE:
    AREA := SIDEA * SIDEB;
  SQUARE:
    AREA := SQR(EDGE);
  CIRCLE:
    AREA := 3.14159 * SQR(RADIUS)
  end;
```

The Case Statement

Example:

```
 type
   RANK = (ACE,  TWO,   THREE,FOUR,
           FIVE, SIX,   SEVEN,EIGHT,
           NINE, TEN,   JACK, QUEEN,
           KING);
   SUIT = (SPADE,HEART,DIAMOND,CLUB);
   CARD = record
          R   : RANK;
          S   : SUIT
          end;
 var
   POINTS : INTEGER;
   A_CARD : CARD;
      ...
 case A_CARD.R of
   ACE:
     POINTS := 11;
   TWO..TEN:
     POINTS := ORD(A_CARD.R)+1
+  otherwise
+    POINTS := 10
 end;
```

The Case Statement with otherwise

9.4 THE COMPOUND STATEMENT

Syntax:

compound-statement:

```
——> begin ——┬——>{statement}——┬——> end ——————————————————————>
            └<——————— ; <—————┘
```

The compound-statement serves to bracket a series of statements that are to be executed sequentially. The reserved words **"begin"** and **"end"** delimit the statement. Semicolons are used to separate each statement in the list of statements.

Example:

```
if A > B then
  begin { swap A and B }
    TEMP := A;
    A    := B;
    B    := TEMP
  end
```

Compound Statement

9.5 THE CONTINUE STATEMENT

```
Syntax:

continue-statement:

  ---> continue ------------------------------------------------------------>
```

The **continue** statement causes a jump to the loop-continuation portion of the inner-most enclosing **for**, **while**, or **repeat** statement. In other words, it is a **goto** to the end of the loop.

The following examples illustrate how the **continue** statement functions in each of the loop constructs.

```
while expr do begin
   ...
   continue
   ...
  (*continue jumps to here*)
end
```

```
for i := expr1 to expr2 do
  begin
   ...
     continue
   ...
  (*continue jumps to here*)
  end
```

```
repeat
   ...
  continue
   ...
  (*continue jumps to here*)
until expr;
```

9.6 THE EMPTY STATEMENT

Syntax:

empty-statement:

```
──────────────────────────────────────────────────────────>
```

The empty-statement is used as a place holder and has no effect on the execution of the program. This statement is often useful when you wish to place a label in the program but do not want it attached to another statement (such as, at the end of a compound-statement). The empty-statement is also useful to avoid the ambiguity that arises in nested if-statements. You may force an else-clause to be paired with an outer nested if-statement (see page 96) by using an empty-statement after an **else** in the inner nested if-statement (see below).

```
if b1 then
  if b2 then
    s1
  else
                { empty-statement }
else
  s2
```

9.7 THE FOR STATEMENT

Syntax:

for-statement:

```
──> for ──>{id}──> := ──>{expr}──┬──> to ──────┬──>{expr}──>┐
                                 └──> downto ──>┘            │
                   ┌<────────────────────────────────────────┘
                   └──────────> do ──>{statement}──────────────>
```

The for-statement repeatedly executes a statement while a control variable is assigned a series of values. The value of the control variable is incremented (**to**) or decremented (**downto**) for each iteration of the loop. The increment (decrement) is computed by the SUCC (PRED) function. That is, the control variable is changed to the succeeding (preceding) value of the type of the control variable.

The for-statement initializes the control variable to the first expression. Prior to each execution of the component statement, the control variable is compared less than or equal to (**to**), or greater than or equal to (**downto**) the second expression. Pascal/VS computes the value of the second expression at the beginning of the for-statement and uses the result for the duration of the statement. Thus the ending value expression is computed once and can not be changed during the for-statement.

The control variable must be an automatic variable which is declared in the immediately enclosing routine. Also, it may not be subscripted, field qualified or referenced through a pointer. The type of the control variable must be a scalar type.

The executed statement must not alter the control variable. If the control variable is altered within the loop, the resultant loop execution is not predictable. The value of the control variable after the for-statement is executed is undefined (you should not expect the control variable to contain any particular value).

Given the following statement

```
for I := expr1 to expr2 do stmt
```

where I is an automatic scalar variable; expr1 and expr2 are scalar expressions which are type-compatible with I; and 'stmt' is any arbitrary statement. The following compound statement is functionally equivalent:

```
begin
  TEMP1 := expr1;
  TEMP2 := expr2;
  if TEMP1 <= TEMP2 then
    begin
    I := TEMP1;
    repeat
      stmt;
      if I = TEMP2 then
        leave;
      I := SUCC(I)
    until FALSE; {forever}
    end
end
```

where 'TEMP1' and 'TEMP2' are compiler generated temporary variables.

And given the following statement

```
for I := expr1 downto expr2 do stmt
```

where I is an automatic scalar variable; expr1 and expr2 are scalar expressions which are type-compatible with I; and 'stmt' is any arbitrary statement. The following compound statement is functionally equivalent:

```
begin
  TEMP1 := expr1;
  TEMP2 := expr2;
  if TEMP1 >= TEMP2 then
    begin
    I := TEMP1;
    repeat
      stmt;
      if I = TEMP2 then
        leave;
      I := PRED(I)
    until FALSE; {forever}
    end
end
```

where 'TEMP1' and 'TEMP2' are compiler generated temporary variables.

Examples:

```
{ find the maximum INTEGER in    }
{ an array of INTEGERs           }
MAX := A[1];
LARGEST := 1;
for I := 2 to SIZE_OF_A do
 if A[I] < MAX then
   begin
     LARGEST := I;
     MAX := A[I]
   end


{ matrix multiplication: C<-A*B  }

for I := 1 to N do
  for J:= 1 to N do
    begin
      X := 0.0;
      for K := 1 to N do
        X := A[I,K] * B[K,J] + X;
      C[I,J] := X
    end


{ sum the hours worked this week }

SUM := 0;
for DAY := MON to FRI do
  SUM := SUM + TIMECARD[ DAY ]
```

The For Statement

9.8 THE GOTO STATEMENT

Syntax:

goto-statement:

```
————> goto ——>{label}——————————————————————————>
```

The goto-statement changes the flow of control within the program.

Examples:

```
goto 10
goto ERROR_EXIT
```

The Goto Statement

The label must be declared within the routine that contains the goto-statement.

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

- You may not branch into a compound statement from a goto-statement which is not contained within the statement.
- You may not branch into the then-clause or the else-clause from a goto-statement that is outside the if-statement. Further, you may not branch between the then-clause and the else-clause.
- You may not branch into a case-alternative from outside the case-statement or between case-alternative statements in the same case-statement.
- You may not branch into a for, repeat, or while loop from a goto statement that is not contained within the loop.
- You may not branch into a with-statement from a goto-statement outside of the with-statement.
- For a goto-statement that specifies a label that is defined in an outer routine, the target label may not be defined within a compound statement or loop.

The following example illustrates legal and illegal goto-statements.

```
procedure GOTO_EXAMPLE;
label
  L1, L2, L3, L4

  procedure INNER;
    begin
       goto L4;    { permitted      }
       goto L3;    { not permitted  }
    end;
begin
  goto L3;         { not permitted  }
  begin
    L3:
      goto L4;     { permitted      }
      goto L3;     { permitted      }
  end;
L4:if expr then
    L1: goto L2    { not permitted  }
  else
    L2: goto L1    { not permitted  }
end;
```

Goto Target Restrictions

9.9 THE IF STATEMENT

Syntax:

if-statement:

```
—> if —>{expr}—> then —>{statement}—┬———————————————————————┬——>
                                    └—> else —>{statement}—>┘
```

The if-statement allows you to specify that one of two statements is to be executed depending on the evaluation of a boolean expression. The if-statement is composed of an expression and a then-clause and an optional else-clause. Each clause contains one statement.

The expression must evaluate to a BOOLEAN value. If the result of the expression is TRUE, then the statement in the then-clause is executed. If the expression evaluates to FALSE and there is an else-clause, then the statement in the else-clause is executed; if there is no else-clause, control passes to the next statement.

Example:

```
if A <= B then
   A := (A+1.0)/2.0

if ODD(I) then
   J:=J+1
else
   J:=J div 2 + 1
```

The If Statement

Nesting of an if-statement within an if-statement could be interpreted with two different meanings if only one statement had an else-clause. The following example illustrates the condition that produces the ambiguity. Pascal/VS always assumes the first interpretation. That is, the else-clauses are paired with the innermost if-statement.

The following line could be interpreted two ways.

```
if b1 then if b2 then stmt1 else stmt2
```

Interpretation 1
(assumed by Pascal/VS)

```
if b1 then
  begin
    if b2 then
       stmt1
    else
       stmt2
  end
```

Interpretation 2
(incorrect interpretation)

```
if b1 then
  begin
    if b2 then
       stmt1
  end
else
   stmt2
```

If the second interpretation is desired you could code it as shown or you could take advantage of the empty-statement.

```
if b1 then
  if b2 then
    stmt1
  else
                              { empty statement }
else
  stmt2
```

9.10 THE LEAVE STATEMENT

Syntax:

leave-statement:

```
---> leave ------------------------------------------------------------------->
```

The **leave** statement causes an immediate, unconditional exit from the inner-most enclosing **for**, **while** or **repeat** loop. For example, the following two code segments are functionally equivalent:

```
while expr do
  begin
    ...
    leave
  end;

while expr do
  begin
    ...
    goto lab;
  end;
lab: ;
```

Example:

```
P:=FIRST;
while P<>nil do
  if P@.NAME = 'JOE SMITH' then
    leave
  else
    P:=P@.NEXT;
{ P either points to the desired }
{ data or is nil                 }
```

The Leave Statement

9.11 THE PROCEDURE CALL

Syntax:

procedure-call:

```
──>{id:procedure}──┬──────────────────────────────────────────┬──────────>
                   └──> ( ───┬──>{expr}───┬────> ) ──>────────┘
                             └<──── , <───┘
```

The procedure-statement causes the invocation of a procedure. When a procedure is invoked, the actual parameters are substituted for the corresponding formal parameters. The actual parameters must be conformable to the formal parameters. The rules for expression conformability are given in "Type Compatibility" on page 33.

Parameters which are passed by read/write reference (var) may only be variables, never expressions or constants. Also, fields of a packed record may not be passed by var. Parameters passed by value or read-only reference (const) may be any expression.

A procedure invocation that requires no parameters does not use the list of operands.

Example:

```
TRANSPOSE(AN_ARRAY,
          NUM-OF_ROWS,
          NUM-OF_COLUMNS);

MATRIX_ADD(A_ARRAY,
           B_ARRAY,
           C_ARRAY,
           N,M);

XYZ(I+J, K*L)
```

Procedure Invocations

9.12 THE REPEAT STATEMENT

Syntax:

repeat-statement:

```
---> repeat ---------+--->{statement}---+---> until --->{expr}----------------->
                     └<-------- ; <-----┘
```

The statements contained between the statement delimiters **repeat** and **until** are executed until the control expression evaluates to TRUE. The control expression must evaluate to type BOOLEAN. Because the termination test is at the end of the loop, the body of the loop is always executed at least once. The structure of the repeat-statement allows it to act like a compound statement in that it encloses a list of statements.

Example:

```
repeat
  K := I mod J;
  I := J;
  J := K
until J = 0
```

The Repeat Statement

9.13 THE RETURN STATEMENT

```
Syntax:

return-statement:

 ---> return ------------------------------------------------------------>
```

The return-statement permits an exit from a procedure or function. This statement is effectively a goto to an imaginary label after the last statement within the routine being executed. If the %CHECK FUNCTION option is enabled, Pascal/VS will insure that a function has been assigned a value prior to the return from the function. If a value has not been assigned, a runtime error will occur.

9.14 THE WHILE STATEMENT

Syntax:

while-statement:

```
———> while ———>{expr}———> do ———>{statement}————————————————————————————>
```

The while-statement allows you to specify a statement that is to be executed while a control expression evaluates to TRUE. The control expression must evaluate to type BOOLEAN. The expression is evaluated prior to each execution of the statement.

Example:

```
 { Compute the decimal size of N }
 { assume N >= 1                 }
 I := 0;
 J := 1;
 while N > 10 do
   begin
     I := I + 1;
     J := J * 10;
     N := N div 10
   end
 { I is the power of ten of the  }
 {    original N                 }
 { J is ten to the I power       }
 { 1 <= N <= 9                   }
```

The While Statement

9.15 THE WITH STATEMENT

Syntax:

with-statement:

```
---> with ---+--->{variable}---+---> do --->{statement}----------------->
             |<------- , <-----|
```

The with-statement is used to simplify references to a record variable by eliminating an addressing description on every reference to a field. The with-statement makes the fields of a record available as if the fields were variables within the nested statement.

The with-statement effectively computes the address of a record variable upon executing the statement. Any modification to a variable which changes the address computation will not be reflected in the pre-computed address during the execution of the with statement. The following example illustrates this point.

```
var A : array[ 1..10 ] of
          record
            FIELD : INTEGER
          end;
     ...
I:=1;
with A[ I ] do
  begin
  K := FIELD;     {K:=A[1].FIELD}
  I := 2;
  K := FIELD;     {K:=A[1].FIELD}
  end;
```

The Address of A is Computed on Entry to the Statement

The comma notation of a with-statement is an abbreviation of nested with-statements. The names within a with-statement are scoped such that the last with statement will take precedence. A local variable with the same name as a field of a record becomes unavailable in a with statement that specifies the record.

Example:

```
type
  EMPLOYEE =
      record
        NAME    : STRING(20);
        MAN_NO  : 0..999999;
        SALARY  : INTEGER;
        ID_NO   : 0..999999
      end;

var
  FATHER : @ EMPLOYEE;
     ...
with FATHER@ do
  begin
    NAME   := 'SMITH';
    MAN_NO := 666666;
    SALARY := WEEKLY_SALARY;
    ID_NO  := MAN_NO
  end
```

is equivalent to:

```
begin
  FATHER@.NAME    := 'SMITH';
  FATHER@.MAN_NO := 666666;
  FATHER@.SALARY := WEEKLY_SALARY;
  FATHER@.ID_NO   := FATHER@.MAN_NO
end
```

Note: The variable FATHER is of type pointer to EMPLOYEE, thus the pointer notation must be used to specify the record pointed to by the pointer.

The With Statement

Example:

```
V : record
      V2 : INTEGER;
      V1 : record A : REAL end;
      A : INTEGER
    end;
A : CHAR;
...
with V,V1 do
  begin
    V2  := 1;    { V.V2 := 1      }
    A   := 1.0;  { V.V1.A := 1.0  }
    V.A := 1     { V.A  := 1      }
                 { CHAR A is not  }
                 { available here}
  end;
A := 'A';        { CHAR A is now  }
                 { available      }
```

With Statements Can Hide a Variable

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Input and output are done using the file data structure. The Pascal/VS Programmer's Guide provides more detail on how to use the I/O facilities in a specific operating system. Pascal/VS provides predefined routines which operate on variables of a file type. The routines are:

- RESET
- REWRITE
- READ
- WRITE
- GET
- PUT
- EOF
- CLOSE
- UPDATE
- TERMIN
- TERMOUT
- PDSIN
- PDSOUT
- SEEK

To facilitate input and output operations that require conversion to and from a character representation, the predefined file type TEXT is provided. The type TEXT is predefined as a file of CHAR. Each GET and PUT transfers one CHAR of information. There are additional predefined routines that may be executed on variables of type TEXT that perform the required conversions.

- READLN
- WRITELN
- EOLN
- PAGE
- COLS

10.1 RESET PROCEDURE

Open a File for Input

<u>Definition:</u>

```
procedure RESET(
          F : filetype;
    const S : STRING);
```

<u>Where:</u>

F is a variable of a file type
S is an optional string value that specifies options

RESET positions the file pointer to the beginning of the file and prepares the file to be used for input. After you invoke RESET the file pointer is pointing to the first data element of the file. If the file is associated with a terminal, the terminal user would be prompted for data when the RESET is executed. This procedure can be thought of as:

1. Closing the file (if open).
2. Rewinding the file.
3. Opening the file for input.
4. Getting the first component of the file.

The string parameter is used to specify any special file dependent options to be used in opening the file. Consult the <u>Pascal/VS Programmer's Guide</u>, order number SH20-6162 which describes the options that are available.

10.2 REWRITE PROCEDURE

Open a File for Output

Definition:

```
procedure REWRITE(
            F : filetype;
    const S : STRING);
```

Where:

F is a variable of a file type
S is an optional string value that
  specifies options

REWRITE positions the file pointer to the beginning of the file and prepares the file to be used for output. This procedure can be thought of as:

1. Closing the file (if open).

2. Rewinding the file.

3. Opening the file for output.

The string parameter is used to specify any special file dependent options to be used in opening the file. Consult the Pascal/VS Programmer's Guide, order number SH20-6162 which describes the options that are available.

10.3 TERMIN PROCEDURE

Open a File for Input from the Terminal

Definition:

```
procedure TERMIN(
            F : TEXT;
    const S : STRING);
```

Where:

F is a variable of type TEXT
S is an optional string value that
  specifies options

TERMIN opens the designated file for input from the users terminal. The string parameter is used to specify any special file dependent options to be used in opening the file. Consult the Pascal/VS Programmer's Guide, order number SH20-6162, which describes the options that are available and operating system dependencies on this procedure.

10.4 TERMOUT PROCEDURE

Open a File for Output from the Terminal

Definition:

```
procedure TERMOUT(
              F : TEXT;
     const S : STRING);
```

Where:

F is a variable of type TEXT
S is an optional string value that specifies options

TERMOUT opens the designated file for output to the users terminal. The string parameter is used to specify any special file dependent options to be used in opening the file. Consult the Pascal/VS Programmer's Guide, order number SH20-6162, which describes the options that are available and operating system dependencies on this procedure.

10.5 PDSIN PROCEDURE

Open a File for Input from a PDS

Definition:

```
procedure PDSIN(
            F : filetype;
    const S : STRING);
```

Where:

F is a variable of a file type
S is a string value that specifies options

PDSIN opens a member in a library (partitioned) file for input.

The string parameter is used to specify any special file dependent options to be used in opening the file. Consult the Pascal/VS Programmer's Guide, order number SH20-6162 which describes the options that are available.

10.6 PDSOUT PROCEDURE

Open a File for Output to a PDS

Definition:

```
procedure PDSOUT(
              F : filetype;
    const S : STRING);
```

Where:

F is a variable of a file type,
S is a string value that specifies options.

PDSOUT opens a member in a library (partitioned) file for output.

The string parameter is used to specify any special file dependent options to be used in opening the file. Consult the Pascal/VS Programmer's Guide, order number SH20-6162 which describes the options that are available.

10.7 UPDATE PROCEDURE

Open a File for Input and Output

Definition:

```
procedure UPDATE(
              F : filetype;
    const S : STRING);
```

Where:

F is a variable of a file type,
S is a string value that specifies options.

UPDATE opens a file for both input and output (updating). A PUT operation replaces a file component obtained from a preceding GET operation. The execution of UPDATE causes an implicit GET of the first file component (as in RESET). The following program fragment illustrates the use of UPDATE.

```
var
 FILEVAR : file of record
             CNT : INTEGER;
             ...
           end;
...
UPDATE(FILEVAR);  {open and get    }
while not EOF(FILEVAR) do
  begin
    FILEVAR@.CNT := FILEVAR@.CNT+1;
    PUT(FILEVAR); {update last elem}
    GET(FILEVAR); {get next elem   }
  end;
```

The string parameter is used to specify any special file dependent options to be used in opening the file. Consult the Pascal/VS Programmer's Guide, order number SH20-6162 which describes the options that are available.

10.8 CLOSE PROCEDURE

Close a File

Definition:

```
procedure CLOSE(
            F : filetype);
```

Where:

F is a variable of a file type

CLOSE closes a file; all processing to the file is completed. You must open the file prior to using it again.

10.9 GET PROCEDURE

Position a File to Next Element

Definition:

```
procedure GET( F : filetype );
```

Where:

F is a variable of a file type.

GET positions the file pointer of a file (previously opened for input) to the next component in the file. For example, if the file is defined as an array of 80 characters, then each GET returns the next 80 character record. A GET invocation on a file of type TEXT returns a single character.

10.10 PUT PROCEDURE

Position a File to Next Element

Definition:

```
procedure PUT( F : filetype );
```

Where:

F is a variable of a file type.

PUT releases the current component of the file variable by effectively writing the component to the associated physical file. A call to PUT with a file of type TEXT transfers a single character. The file must have been previously opened for output.

10.11 SEEK PROCEDURE

Position a File to a Specified Element

Definition:

```
procedure SEEK(
          F : filetype;
          N : INTEGER);
```

Where:

F is a variable of a file type,
N is a component number of the file.

SEEK specifies the number of the next file component to be operated on by a GET or PUT operation. File components have an origin of 1. The SEEK procedure is not supported for TEXT files. The file specified in the SEEK procedure must have been opened by RESET, REWRITE or UPDATE. For more infomation, consult the Pascal/VS Programmer's Guide, order number SH20-6162.

10.12 EOF FUNCTION

Test File for End Of File

Definition:

function EOF(F:filetype):BOOLEAN;

function EOF:BOOLEAN;

Where:

F is a variable of a file type.

EOF is a BOOLEAN valued function which returns TRUE if the end-of-file condition is true for the file. This condition occurs in an input file when an attempt is made to read past the last record element of the file. If the file is open for output, this function always returns TRUE.

If the file variable F is omitted, then the function assumes the predefined file INPUT.

Example:

```
{ The following will read all of }
{ the records from File SYSIN    }
{ and write then out to SYSOUT   }

type FREC =
       record
         A,B : INTEGER
       end;

var
  SYSIN,
  SYSOUT: file of FREC;

begin
  RESET(SYSIN);
  REWRITE(SYSOUT);
  while not EOF(SYSIN) do
    begin
      SYSOUT@ := SYSIN@;
      PUT(SYSOUT);
      GET(SYSIN)
    end;
end;
```

10.13 READ AND READLN (TEXT FILES)

Read Data from TEXT File

Definition:

```
procedure READ(
            f : TEXT;
            v : see below);

procedure READLN(
            f : TEXT;
            v : see below);

procedure READLN(
            f : TEXT);
```

Where:

f is an optional text file that is to be used for input.
v is one or more variables, each must be one of the following types:
- INTEGER (or subrange)
- CHAR (or subrange)
- REAL
- SHORTREAL
- STRING
- **packed array of** CHAR

The READ procedure reads character data from the TEXT file f. READ converts character data to conform to the type of the operand(s). The file parameter is optional; the default file is INPUT.

READLN reads in data (if any variables are specified) the same way READ does and then positions the file at the beginning of the next line. You may use more than one variable on each call by separating each with a comma. The effect is the same as multiple calls to READ.

```
        READ(f,v1,v2)

is equivalent to:

        begin
          READ(f,v1);
          READ(f,v2)
        end

    and

        READLN(f,v1,v2,v3)

is equivalent to:

        begin
          READ(f,v1);
          READ(f,v2);
          READ(f,v3);
          READLN(f);
        end
```

Multiple Variables on READ or READLN

Reading INTEGER Data

INTEGER data from a TEXT file is read by scanning off leading blanks, accepting an optional sign and converting all characters up to the first non-numeric character or end-of-line.

Reading CHAR Data

A variable of type CHAR is assigned the next character in the file.

Reading STRING Data

Characters are read into a STRING variable until the variable has reached its maximum length or until the end of the line is reached.

Reading REAL (SHORTREAL) Data

REAL (SHORTREAL) data is read by scanning off leading blanks, accepting an optional sign and converting all characters up to the first non-numeric character not conforming to the syntax of a REAL number.

+ Reading packed array of CHAR Data

+ If the variable is declared as a '**packed array**[1..n] **of** CHAR', characters are stored into each element of the array. This is equivalent to a loop ranging from the lower bound of the array to the upper bound, performing a read operation for each element. If the end-of-line condition should become true before the variable is filled, the rest of the variable is filled with blanks.

+ Consult the Programmer's Guide for more details on the use of READ and READLN.

```
var
  I,J: INTEGER;
  S: STRING(100);
  CH: CHAR;
  CC: packed array[1..10] of CHAR;
  F: TEXT;
    .
    .
  READLN(F,I,J,CH,CC,S);

assume the data is:

| 36 24 ABCDEFGHIJKLMNOPQRSTUVWXYZ

the variables would be assigned:

    I             36
    J             24
    CH            ' '
    CC            'ABCDEFGHIJ'
    S             'KLMNOPQRSTUVWXYZ'
    LENGTH(S)     16
```

The READ Procedure

+ Reading Variables with a Length

+ You may optionally qualify a variable of READ with a field length expression:

+ READ(f,v:n)

+ where "v" is the variable being read and "n" is the field length expression.

+ This expression denotes the number of characters in the input line to be processed for that variable. If the number of characters indicated by the field length is exhausted during a read operation, then the reading operation will stop so that a subsequent read will begin at the first character following the field. If the reading completes prior to processing all characters of the field then the rest of the field is skipped.

```
var
  I,J: INTEGER;
  S: STRING(100);
  CH: CHAR;
  CC: packed array[1..10] of CHAR;
  F: TEXT;
   .
   .
  READLN(F,I:4,J:10,CH:J,CC,S);


assume the data is:

36 24 ABCDEFGHIKLMNOPQRSTUVWXYZ


the variables would be assigned:

    I             36
    J             4
    CH            'I'
    CC            'NOPQRSTUVW'
    S             'XYZ'
    LENGTH(S)     3

    The READ Procedure with Lengths
```

10.14 READ (NON-TEXT FILES)

Read Data from Non-TEXT Files

Definition:

```
procedure READ(
          f : file of t;
          v : t);
```

Where:
- f is an arbitrary file variable.
- v is a variable whose type matches the file component type of f

Each call to READ will read one file element from file 'f' and assign it to variable 'v'. If the file is not open, the READ procedure will open it prior to assigning to the argument.

READ(f,v) is functionally equivalent to the following compound statement:

```
begin   v := f@;   GET(f) end
```

For more details consult the Programmer's Guide.

Write Data to FIle

Definition:

```
procedure WRITE(
          f : TEXT;
          e : see below);

procedure WRITELN(
          f : TEXT;
          e : see below);

procedure WRITELN(
          f : TEXT);
```

Where:
- f is an optional TEXT file variable.
- e is an expression of one of the following types:
  - INTEGER (or subrange)
  - CHAR (or subrange)
  - REAL
  - SHORTREAL
  - BOOLEAN
  - STRING
  - **packed array**[1..n] **of** CHAR

Pascal/VS accepts a special parameter format which is only allowed in the WRITE routine for TEXT files. See the following description.

The WRITE procedure writes character data to the TEXT file specified by f. The data is obtained by converting the expression e into an external form. The file parameter is optional; if not specified, the default file OUTPUT is used.

WRITELN writes out data (if any expressions are specified) the same way WRITE does and then positions the file to the beginning of the next line. WRITELN is only applicable to TEXT files. You may use more than one expression on each call by separating each with a comma. The effect is the same as multiple calls to WRITE.

```
WRITE(f,e1,e2)
```

is equivalent to:

```
begin
  WRITE(f,e1);
  WRITE(f,e2)
end
```

and

```
WRITELN(f,e1,e2,e3)
```

is equivalent to:

```
begin
  WRITE(f,e1);
  WRITE(f,e2);
  WRITE(f,e3);
  WRITELN(f);
end
```

Multiple Expressions on WRITE

Pascal/VS supports a specialized form for specifying actual parameters on WRITE and WRITELN to TEXT files. This provides a means by which you can specify the length of the resulting output. Each expression in the WRITE procedure call may be represented in one of three forms:

1. e
2. e : len1
3. e : len1 : len2

The expression e may be of any of the types outlined above and represents the data to be placed on the file. The data is converted to a character representation from the internal form. The expressions len1 and len2 must evaluate to an INTEGER value.

The expression len1 supplies the length of the field into which the data is written. The data is placed in the field justified to the right edge of the field. + If len1 specifies a negative + value, the data is justified to the left + within a field whose length is + ABS(len1).

The len2 expression (form 3) may be specified only if e is an expression of type REAL.

If len1 is unspecified (form 1) then a default value is used according to the table below.

type of expression e	default value of len1
INTEGER	12
REAL	20 (E notation)
SHORTREAL	20
CHAR	1
BOOLEAN	10
STRING	LENGTH(expression)
array of CHAR	length of array

Default Field Width on WRITE

Writing INTEGER Data

The expression len1 represents the minimum width of the field in which the integer is to be placed. The value is converted to character format and placed in a field of the specified length. If the field is shorter than the size required to represent the value, the length of the field will be extended.

Examples:

```
   Call:                     Result:

 WRITE(1234:6)               '  1234'

 WRITE(1234:-6)              '1234  '

 WRITE(1234:1)               '1234'

 WRITE(1234)                 '        1234'

 WRITE(1234:-3)              '1234'
```

Writing CHAR Data

The value of len1 is used to indicate the width of the field in which the character is to be placed. If len1 is not specified, a field width of 1 is assumed. If len1 is greater than 1 then the character will be padded on the left with blanks; if len1 is negative, then the character will be padded on the right.

Example:

```
   call:           Result:

 WRITE('a':6)               '     a'
 WRITE('a':-6)              'a     '
```

Writing REAL (SHORTREAL) Data

REAL expressions may be printed with any one of the three operand formats. If len1 is not specified (form 1), the result will be in scientific notation in a 20 character field.

If len1 is specified and len2 is not (form 2), the result will be in scientific notation but the number of characters in the field will be the value of len1.

If both len1 and len2 are specified (form 3), the data will be written in fixed point notation in a field with length len1; len2 specifies the number of digits that will appear to the right of the decimal point. The REAL expression is always rounded to the last digit to be printed.

If len1 is not large enough to fully represent the number, it will be extended appropriately.

Examples:

```
   Call:                 Result:

 WRITE(3.14159:10)
                          ' 3.142E+00'

 WRITE(3.14159)
                    ' 3.1415900000000E+00'

 WRITE(3.14159:10:4)
                          '    3.1416'
```

Writing BOOLEAN Data

The expression len1 is used to indicate the width of the field in which the boolean is to be placed. If the width is less than 6, then either a 'T' or 'F' will be printed. Otherwise, 'TRUE' or 'FALSE' will be sent to the file. The data is placed in the field and justified according to the previously stated rules.

Examples:

```
   Call:                 Result:

 WRITE(TRUE:10)           '      TRUE'

 WRITE(TRUE:-10)          'TRUE      '

 WRITE(FALSE:2)           ' F'
```

Writing STRING Data

The expression len1 is used to indicate the width of the field in which the string is to be placed. The data is placed in the field and justified according to the previously stated rules. If ABS(len1) is too small to hold the data, the string is truncated on the right.

Examples:

```
   Call:              Result:

WRITE('abcd':6)    '  abcd'

WRITE('abcd':-6)   'abcd  '

WRITE('abcd':2)    'ab'

WRITE('abcd')      'abcd'
```

Writing Packed Array of CHAR Data

The expression len1 is used to indicate the width of the field in which the array is to be placed. The data is placed in the field and justified according to the previously stated rules. If ABS(len1) is too small to hold the data, the string is truncated on the right.

Examples:

```
var
  A : packed
        array[ 1..4] of CHAR;
  .
  .
  A := 'abcd';
  .
  .
     Call:                Result:

   WRITE(A:6)             '  abcd'

+  WRITE(A:-6)            'abcd  '

   WRITE(A:2)             'ab'

   WRITE(A)               'abcd'
```

10.16 WRITE (NON-TEXT FILES)

Write Data to Non-TEXT Files

Definition:

```
procedure WRITE(
            f : file of t;
            e : t);
```

Where:
f is an arbitrary file variable.
e is an expression whose type matches the file component type of f

Each call to WRITE will write the value of expression e to file 'f'.

WRITE(f,e) is functionally equivalent to the following compound statement:

```
begin   f@ := e;   PUT(f) end
```

For more details consult the Programmer's Guide.

10.17 EOLN FUNCTION

Test a File for End of Line

Definition:

```
function EOLN( f: TEXT ):BOOLEAN;

function EOLN:BOOLEAN;
```

Where:

f is a TEXT file set to input.

The EOLN function returns a BOOLEAN result of TRUE if TEXT file f is positioned to an end-of-line character; otherwise, it returns FALSE.

If EOLN(f) is true, then f@ has the value of a blank. That is, when EOLN is TRUE the file is positioned to a blank. This character is not in the file but will appear as if it were. In many applications the extra blank will not affect the result; in those instances where the physical layout of the data is significant you must be sensitive to the EOLN condition.

If the file variable F is omitted, then the function assumes the predefined file INPUT.

10.18 PAGE PROCEDURE

Force Skip to Next Page

Definition:

```
procedure PAGE( var f: TEXT );
```

Where:

f is a TEXT file set to output.

This procedure causes a skip to the top of the next page when the text-file is printed. The file parameter is optional and defaults to the standard file variable OUTPUT.

10.19 COLS FUNCTION

Determine Current Column

Definition:

```
function COLS(
    var f: TEXT ) : INTEGER;
```

Where:

f is a TEXT file set to output.

This function returns the current column number (position of the next character to be written) on the output file designated by the file variable. You may force the output to a specific column with the following code:

```
if TAB > COLS(F) then
  WRITE(F,' ':TAB-COLS(F));
```

The file name is never defaulted on the COLS procedure.

11.0 EXECUTION LIBRARY FACILITIES

The runtime library consists of those routines that are predefined in Pascal/VS. In addition to the routines described in this chapter, Pascal/VS provides routines with which to do input and output. Consult the I/O chapter for a description of those routines. The predefined procedures and functions are:

- ABS Function
- ADDR Function
- ARCTAN Function
- CHR Function
- CLOCK Function
- COMPRESS Function
- COS Function
- DATETIME Procedure
- DELETE Function
- DISPOSE Procedure
- EXP Function
- FLOAT Function
- INDEX Function
- HALT Procedure
- HBOUND Function
- HIGHEST Function
- LBOUND Function
- LENGTH Function
- LN Function
- LOWEST Function
- LTRIM Function
- MARK Procedure
- MAX Function
- MAXLENGTH Function
- MIN Function
- NEW Procedure
- ODD Function
- ORD Function
- PACK Procedure
- PARMS Function
- PRED Function
- RANDOM Function
- READSTR Procedure
- RELEASE Procedure
- RETCODE Procedure
- ROUND Function
- Scalar Conversion
- SIN Function
- SIZEOF Function
- SQR Function
- SQRT Function
- STR Function
- SUBSTR Function
- SUCC Function
- TRUNC Function
- TRIM Function
- TOKEN Function
- TRACE Procedure
- UNPACK Procedure
- WRITESTR Procedure

11.1 MEMORY MANAGEMENT ROUTINES

These routines provide means by which you can control the allocation of dynamic variables.

11.1.1 MARK Procedure

Mark Heap

```
Definition:

procedure MARK(
  var P      : pointer );

Where:

P is a pointer to any type
```

The MARK procedure allocates a new area of memory from where dynamic variables are to be allocated. Such an area is called a heap.. The predefined procedure NEW allocates a dynamic variable from the most recently created heap. The predefined procedure DISPOSE de-allocates a dynamic variable from the heap.

RELEASE is the complementary procedure which destroys a heap. Heaps are created and destroyed in a stack-like fashion.

MARK does not allocate dynamic variables. The pointer variable passed as parameter P is set to the address of the associated heap control block; thus, the returned pointer must not be used as the base of a dynamic variable.

11.1.2 RELEASE Procedure

Release Heap

```
Definition:

procedure RELEASE(
  var P      : pointer );

Where:

P is a pointer to any type.
```

RELEASE frees one or more heaps that were previously allocated by calls to MARK. (See the description of MARK for a definition of "heap.") The parameter of RELEASE must contain the address returned by a previous call to MARK; it is through this parameter that the heap is identified.

RELEASE frees all heaps that were allocated since the corresponding MARK was executed. Thus, heaps are created and destroyed in a stack-like manner.

When a heap is freed, all of the dynamic variables which were allocated from the heap are also freed. As a result, RELEASE is a means for disposing of many dynamic variables at one time.[4]

RELEASE sets its parameter variable (P) to **nil**.

[4] Pointers which reference dynamic variables of a heap are no longer defined when the heap is freed. Subsequent uses of such pointer values may cause unpredictable results.

```
type
  MARKP = @INTEGER;
  LINKP = @LINK;
  LINK = record
           NAME: STRING(30);
           NEXT: LINKP
         end;
var
  P     : MARKP;
  Q1,
  Q2,
  Q3    : LINKP;
begin
  ...
  MARK(P);
  ...
  NEW(Q1);
  NEW(Q2);
  NEW(Q3);
  ...
  { Frees Q1, Q2 and Q3      }
  RELEASE(P);
  ...
end;
```

Example of MARK and RELEASE

11.1.3 NEW Procedure

Allocate Dynamic Variable

Definition:

```
form 1:
procedure NEW(
  var P        : pointer );

form 2:
procedure NEW(
  var P1       : pointer;
          t1,t2... : scalar);

form 3:
procedure NEW(
  var SP       : STRINGPTR;
    LEN        : INTEGER;
```

Where:

P is a pointer to any type except a dynamic array.
P1 is a pointer to a record type with variants
SP is a STRINGPTR
t1,t2... are scalar constants representing tag fields
LEN is an integer valued expression

The NEW procedure allocates a dynamic variable from the most recent heap and sets the pointer to point to the variable.

form 1

The first form of procedure NEW allocates the amount of storage that is necessary to represent a value of the type to which the pointer refers. If the type of the dynamic variable is a record with a variant part, the space allocated is the amount required for the record when the largest variant is active.

```
type
  LINKP = @LINK;
  LINK = record
           NAME: STRING(30);
           NEXT: LINKP
         end;
var
  P,
  HEAD : LINKP;
  ...
begin
  ...
  NEW(P);
  with P@ do
    begin
      NAME := '';
      NEXT := HEAD;
    end;
  HEAD := P;
  ...
end;
```

Example of using Simple Form of Procedure NEW

form 2

The second form is used to allocate a variant record when it is known which variant (and sub-variants) will be active, in which case the amount of storage allocated will be no larger than necessary to contain the variant specified. The scalar constants are tag field values. The first one indicates a particular variant in the record which will be active; subsequent tags indicate active sub-variants, sub-sub-variants, and so on.

Note: This procedure does not set tag fields. The tag list only serves to indicate the amount of storage required; it is the programmer's responsibility to set the tag fields after the record is allocated.

```
type
  AGE = 0..100;
  RECP = @REC;
  REC  =
     record
       NAME: STRING(30);
       case HOW_OLD: AGE of
        0..18:
          (FATHER: RECP);
        19..100:
          (case MARRIED: BOOLEAN of
            TRUE: (SPOUSE: RECP);
            FALSE: ()
          )
     end;
var
  P    : RECP;
  ...
begin
  ...
  NEW(P,18);
  with P@ do begin
    NAME := 'J. B. SMITH, JR'
    HOW_OLD := 18;
    NEW(FATHER,54,TRUE);
    with FATHER@ do begin
      NAME := 'J. B. SMITH';
      HOW_OLD := 54;
      MARRIED := TRUE;
      NEW(SPOUSE,50,TRUE);
        ...
    end {with father@};
  end {with p@};
  ...
end;
```

Using NEW for Allocating Records with Variants

+ form 3
+
+ The third form is used to allocate a string whose maximum length is known only during program execution. The amount of storage to be available for the string is defined by the required second parameter. See "The Type STRINGPTR" on page 60.

11.1.4 DISPOSE Procedure

De-allocate Dynamic Variable

Definition:

```
procedure DISPOSE(
  var P      : pointer);
```

Where:

P is any pointer type.

DISPOSE returns storage for a dynamic variable and sets the pointer to **nil**. You may de-allocate a dynamic variable from any heap. This procedure only returns the storage referred to by the pointer and does not return any storage which the dynamic variable references. That is, if the dynamic variable is part of a linked list, and your intent is to DISPOSE of the whole list, you must explicitly DISPOSE of every element of the list. If you have other pointers which reference the same DISPOSEd dynamic variable, then it is your responsibility not to use these pointers because the dynamic variable which they represented is no longer allocated.

11.2 DATA MOVEMENT ROUTINES

These routines provide you with convenient ways to handle large amounts of data movement efficiently.

11.2.1 PACK Procedure

Copy Unpacked Array to Packed Array

```
Definition:

procedure PACK(
  const SOURCE : array-type;
        INDEX  : index_of_source;
    var TARGET : pack_array_type)

Where:

SOURCE is an array.
INDEX  is an expression which is
       compatible with the index
       of SOURCE.
TARGET is a packed array variable.
```

This procedure copies elements from the unpacked source array, starting with the Ith element, to the packed target array. The types of the elements of the two arrays must be identical. This procedure operates as:

```
Given:
  A : array[m..n] of T;
  Z : packed array[u..v] of T;

Call:
  PACK(A, I, Z);

Operation:
  k := I;
  for j := LBOUND(Z) to HBOUND(Z) do
    begin
    Z[j] := A[k];
    k := SUCC(k)
    end;

Where:
  j and k are temporary variables.
```

It is an error if the number of elements in Z is greater than the number of elements in A starting with the Ith element to the end of the array.

11.2.2 UNPACK Procedure

Copy Packed Array to Unpacked Array

```
Definition:

procedure UNPACK(
  const SOURCE : pack_array_type;
    var TARGET : array-type;
        INDEX  : index_of_target);

Where:

SOURCE is a packed array.
TARGET is an array variable.
INDEX  is an expression which is
       compatible with the index
       of TARGET.
```

This procedure copies elements from the packed source array to the unpacked target array, starting with the Ith element of the target array. The type of the elements of the two arrays must be identical. This procedure operates as:

```
Given:
  A : array[m..n] of T;
  Z : packed array[u..v] of T;

Call:
  UNPACK(Z, A, I);

Operation:
  k := I;
  for j := LBOUND(Z) to HBOUND(Z) do
    begin
    A[k] := Z[j];
    k := SUCC(k)
    end;

Where:
  j and k are temporary variables.
```

It is an error if the number of elements in Z is greater than the number of elements in A starting with the Ith element to the end of the array.

11.3 DATA ACCESS ROUTINES

These routines provide you a means to inquire about compile and run time bounds and values.

11.3.1 LOWEST Function

Lowest Value of a Scalar

```
Definition:

function LOWEST(
         S        : scalar-type)
                  : scalar;

Where:

S is an identifier that has been
  declared as a scalar type, or
  a variable which is of a scalar
  type.
```

This function returns the lowest value that is in the scalar type. The operand may be either a type identifier or a variable. If the operand is a type identifier, the value of the function is the lowest value that a variable of that type may be assigned. If the operand is a variable, the value of the function is the lowest value that the variable may be assigned.

Example:

```
type
  DAYS   = (SUN,  MON,  TUES,  WED,
            THU,  FRI,  SAT);
  SMALL  = 0 .. 31;
var
  I      : INTEGER;
  J      : 0 .. 255;
  .
  .
  LOWEST(DAYS)    is SUN
  LOWEST(BOOLEAN) is FALSE
  LOWEST(SMALL)   is 0
  LOWEST(I)       is MININT
  LOWEST(J)       is 0
```

The LOWEST Function

11.3.2 HIGHEST Function

Highest Value of a Scalar

```
Definition:

function HIGHEST(
         S        : scalar-type)
                  : scalar;

Where:

S is an identifier that has been
  declared as a scalar type, or
  a variable which is of a scalar
  type.
```

This function returns the highest value that is in the scalar type. The operand may be either a type identifier or a variable. If the operand is a type identifier, the value of the function is the highest value that a variable of that type may be assigned. If the operand is a variable, the value of the function is the highest value that the variable may be assigned.

Example:

```
type
  DAYS   = (SUN,  MON,  TUES,  WED,
            THU,  FRI,  SAT);
  SMALL  = 0 .. 31;
var
  I      : INTEGER;
  J      : 0 .. 255;
  .
  .
  HIGHEST(DAYS)    is SAT
  HIGHEST(BOOLEAN) is TRUE
  HIGHEST(SMALL)   is 31
  HIGHEST(I)       is MAXINT
  HIGHEST(J)       is 255
```

The HIGHEST Function

11.3.3 LBOUND Function

Lower Bound of Array

```
Definition:

function LBOUND(
            V       : arraytype;
            I       : integer-const)
                    : scalar;

function LBOUND(
            T       : type-identifier;
            I       : integer-const)
                    : scalar;

Where:

V is a variable which is declared
  as an array type.
T is an type identifier declared
  as an array.
I is an positive integer valued
  constant expression and is
  optional.
```

The LBOUND function returns the lower bound of an index to an array. The array may be specified in two ways:

- an identifier which was declared as an array type via the type construct;
- a variable which is of an array type.

The value returned is of the same type as the type of the index. The second parameter defines the dimension of the array for which the lower bound is returned. It is assumed to be "1" if it is not specified.

The LBOUND function also works on space types.

Example:

```
type
  GRID = array[-10..10,-10..10] of
             REAL;
var
  A       : array[ 1..100 ] of ALFA;
  B       : array[ 1..100 ] of
             of array[ 0..9 ] of CHAR;
  .
  .
  LBOUND( A )          is 1
  LBOUND( GRID, 1)     is -10
  LBOUND( B, 2 )       is 0
  LBOUND( B[1] )       is 0
```

The LBOUND Function

11.3.4 HBOUND Function

Upper Bound of Array

```
Definition:

function HBOUND(
            V       : arraytype;
            I       : integer-const)
                    : scalar;

function HBOUND(
            T       : type-identifier;
            I       : integer-const)
                    : scalar;

Where:

V is a variable which is declared
  as an array type.
T is an type identifier declared
  as an array.
I is an positive integer-valued
  constant expression and is
  optional.
```

The HBOUND function returns the upper bound of an index to an array. The array may be specified in two ways:

- an identifier which was declared as an array type via the type construct;
- a variable which is of an array type.

The value returned is of the same type as the type of the index. The second parameter defines the dimension of the array for which the upper bound is returned. It is assumed to be "1" if it is not specified.

The HBOUND function also works on space types.

Example:

```
type
  GRID = array[-10..10,-10..10] of
             REAL;

var
  A       : GRID;
  B       : array[ 1..100 ] of
               of array[ 0..9 ] of CHAR;
  .
  .
  HBOUND( A )          is 10
  HBOUND( GRID )       is 10
  HBOUND( B, 2 )       is 9
  HBOUND( B[1] )       is 9
```

The HBOUND Function

11.3.5 SIZEOF Function

Allocation Size of Data

Definition:

```
function SIZEOF(
           S     : anytype)
                 : INTEGER;

function SIZEOF(
           S     : recordtype;
      t1,t2,...  : tags);
                 : INTEGER;
```

Where:

S is an identifier that has been declared as a type, or any variable.

The SIZEOF function returns the amount of storage in bytes required to contain the variable or a variable of the type specified.

If the argument S refers to a record-type which has a variant part, and if no tag values are specified, then the storage required for the record with the largest variant will be returned.

If S is a record variable or a type identifier of a record, it may be followed by tag list which defines a particular variant configuration of the record. In this case the function will return the amount of storage required within the record to contain that variant configuration.

11.3.6 ADDR Function

Storage Location of Data

Definition:

```
function ADDR(
           V     : anyvariable)
                 : INTEGER;
```

Where:

V is an identifier that has been declared as a variable

The ADDR function returns the location in memory of the given variable. A variable includes qualified variables such as dereferenced pointers, subscripted variables and fields of records.

11.4 CONVERSION ROUTINES

This section documents predefined routines which preform conversions from one data type to another. Refer to "READSTR" on page 143 and "WRITESTR" on page 144 for character string conversions.

11.4.1 ORD Function

Ordinal Value of Scalar

```
Definition:

function ORD(
         S        : scalar )
                  : INTEGER;

Where:

S may be any scalar type or
  a pointer.
```

This function returns an integer that corresponds to the ordinal value of the scalar. If the operand is of type CHAR then the value returned is the position in the EBCDIC character set for the character operand. If the operand is an enumerated scalar, then it returns the position in the enumeration (beginning at zero); for example, if COLOR = (RED, YELLOW, BLUE), then ORD(RED) is 0 and ORD(BLUE) is 2.

If the operand is a pointer, then the function returns the machine address of the dynamic variable referenced by the pointer. Although pointers can be converted to INTEGERs, there is no function provided to convert an INTEGER to a pointer.

11.4.2 CHR Function

Integer to Character Conversion

```
Definition:

function CHR(
         I        : INTEGER )
                  : CHAR;

Where:

I is an INTEGER expression that is
  to be interpreted as a character.
```

This function is the inverse function to ORD for characters. That is, 'ORD(CHR(I))=I' if I is in the subrange:

ORD(LOWEST(CHAR))..ORD(HIGHEST(CHAR))

If the operand is not within this range and checking is enabled then a runtime error will result, otherwise the result is unpredictable.

11.4.3 Scalar Conversion

Integer to Scalar Conversion

```
Definition:

function type-id(
          I        : INTEGER)
                   : scalar-type;

Where:

I  is an integer valued expression
   that is to be converted to an
   enumerated scalar.
```

Every type identifier for an enumerated scalar or subrange scalar can be used as a function that converts an integer into a value of the enumerated scalar. These functions are the inverse of ORD.

Example:

```
type
  DAYS    = (SUN,  MON,  TUES,  WED,
             THU,  FRI,  SAT);
  .
  .
  DAYS(0)          is SUN
  DAYS(3)          is WED
  DAYS(6)          is SAT
  DAYS(7)          is an error
  BOOLEAN(0)       is FALSE
  BOOLEAN(1)       is TRUE
```

The Enumerated Scalar Function

11.4.4 FLOAT Function

Integer to Real Conversion

```
Definition:

function FLOAT(
          I        : INTEGER )
                   : REAL;

Where:

I is an INTEGER valued expression.
```

This function converts an INTEGER to a REAL. Pascal/VS will convert an INTEGER to a REAL implicitly if one operand of an arithmetic or relation operator is REAL and the other is INTEGER. This function is useful in making the conversion explicit in the program.

11.4.5 TRUNC Function

Real to Integer Conversion

```
Definition:

function TRUNC(
         R          : REAL )
                    : INTEGER;

function TRUNC(
         S          : SHORTREAL )
                    : INTEGER;

Where:

R is a REAL valued expression.
S is a SHORTREAL valued expression.
```

This function converts a REAL expression to an INTEGER by truncating the operand toward zero.

Examples:

```
TRUNC( 1.0) is  1
TRUNC( 1.1) is  1
TRUNC( 1.9) is  1
TRUNC( 0.0) is  0
TRUNC(-1.0) is -1
TRUNC(-1.1) is -1
TRUNC(-1.9) is -1
```

11.4.6 ROUND Function

Real to Integer Conversion

```
Definition:

function ROUND(
         R          : REAL )
                    : INTEGER;

function ROUND(
         S          : SHORTREAL )
                    : INTEGER;

Where:

R is a REAL valued expression.
S is a SHORTREAL valued expression.
```

This function converts a REAL expression to an INTEGER by rounding the operand. This function equivalent to

```
if R > 0.0 then
  ROUND := TRUNC(R + 0.5)
else
  ROUND := TRUNC(R - 0.5)
```

Examples:

```
ROUND( 1.0) is  1
ROUND( 1.1) is  1
ROUND( 1.9) is  2
ROUND( 0.0) is  0
ROUND(-1.0) is -1
ROUND(-1.1) is -1
ROUND(-1.9) is -2
```

11.4.7 STR Function

Convert to String

<u>Definition:</u>

```
function STR(
      X         : CHAR or packed
                    array[1..n] of
                        CHAR )
                : STRING;
```

<u>Where:</u>

X is CHAR or **packed array**[1..n] **of** CHAR expression.

This function converts either a CHAR or **packed array**[1..n] **of** CHAR to a STRING. Pascal/VS will implicitly convert a STRING to a CHAR or **packed array**[1..n] **of** CHAR on assignment, but all other conversions require you to explicitly state the conversion. You may assign a CHAR to an **packed array**[1..n] **of** CHAR by either:

```
var
   AOC : ALPHA;
   CH  : CHAR;
   ...
   AOC := STR(CH);
        or
   AOC := ' '; AOC[1] := CH;
```

11.5 MATHEMATICAL ROUTINES

These routines define various mathematical transformations.

+ 11.5.1 MIN Function

Minimum Value of Scalars

Definition:

```
function MIN(
          E0,
          .
          .
          En        : scalar-type)
                    : scalar-type;
```

Where:

Ei is an expression of a scalar type. All parameters must be of the same type except where noted below.

+ The MIN function returns the minimum value of two or more expressions. The parameters may be of any scalar type, including REAL. The parameters may be a mixture of INTEGER and REAL expressions, in which case, the result will be of type REAL. In all other cases, the parameters must be conformable to each other.

+ 11.5.2 MAX Function

Maximum Value of Scalars

Definition:

```
function MAX(
          E0,
          .
          .
          En        : scalar-type)
                    : scalar-type;
```

Where:

Ei is an expression of a scalar type. All parameters must be of the same type except where noted below.

+ The MAX function returns the maximum value of two or more parameters. The parameters may be of any scalar type, including REAL. They may be a mixture of INTEGER and REAL expressions, in which case, the result will be of type REAL. In all other cases, the parameters must be conformable to each other.

11.5.3 PRED Function

Predecessor Value of a Scalar

Definition:

```
function PRED(
         S        : scalar)
                  : scalar;
```

Where:

S is any scalar expression.

This function returns the predecessor value of the parameter expression. The PRED of the first element of an enumerated scalar is an error. If the option %CHECK is ON, a runtime error will be raised if the PRED of the first element is attempted. If the checking is not performed, the results of the PRED of the first value is not defined. PRED(TRUE) is FALSE and PRED('B') is 'A'. The PRED of an INTEGER is equivalent to subtracting one. PRED of a REAL argument is an error.

11.5.4 SUCC Function

Successor Value of a Scalar

Definition:

```
function SUCC(
         S        : scalar)
                  : scalar;
```

Where:

S is any scalar expression.

This function returns the successor value of the parameter expression. The SUCC of the last element of an enumerated scalar is an error. If the option %CHECK is ON, a runtime error will be raised if the SUCC of the last element is attempted. If the checking is not performed, the results of the SUCC of the last value is not defined. SUCC(FALSE) is TRUE and SUCC('B') is 'C'. The SUCC of an INTEGER is equivalent to adding one. SUCC of a REAL argument is an error.

11.5.5 ODD Function

Test for Integer is Odd

```
Definition:

function ODD(
         I        : INTEGER)
                  : BOOLEAN;

Where:

I is an INTEGER to be tested
  for being odd.
```

This function returns TRUE if the parameter I is odd, or FALSE if it is even.

11.5.6 ABS Function

Absolute Value

```
Definition:

function ABS(
         I        : INTEGER )
                  : INTEGER;

function ABS(
         R        : REAL)
                  : REAL;

Where:

I is an INTEGER expression.
R is a REAL expression.
```

The ABS function returns either a REAL value or an INTEGER value depending the type of its parameter. The result is the absolute value of the parameter.

11.5.7 SIN Function

Compute Sine

Definition:

```
function SIN(
        X          : REAL)
                   : REAL;
```

Where:

X is an expression that evaluates to a REAL value.

The SIN function computes the sine of parameter X, where X is expressed in radians.

11.5.8 COS Function

Compute Cosine

Definition:

```
function COS(
        X          : REAL)
                   : REAL;
```

Where:

X is an expression that evaluates to a REAL value.

The COS function computes the cosine of the parameter X, where X is expressed in radians.

11.5.9 ARCTAN Function

Compute Arctangent

```
Definition:

function ARCTAN(
           X          : REAL)
                      : REAL;

Where:

X is an expression that evaluates
  to a REAL value.
```

The ARCTAN function computes the arctangent of parameter X. The result is expressed in radians.

11.5.10 EXP Function

Compute Exponential

```
Definition:

function EXP(
           X          : REAL)
                      : REAL;

Where:

X is an expression that evaluates
  to a REAL value.
```

The EXP function computes the value of the base of the natural logarithms, e, raised to the power expressed by parameter X.

11.5.11 LN Function

Compute Natural Log

```
Definition:

function LN(
           X          : REAL)
                      : REAL;

Where:

X is an expression that evaluates
  to a REAL value.
```

The LN function computes the natural logarithm of the parameter X.

11.5.12 SQRT Function

Compute Square Root

```
Definition:

function SQRT(
           X          : REAL)
                      : REAL;

Where:

X is an expression that evaluates
  to a REAL value.
```

The SQRT function computes the square root of the parameter X. If the argument is less than zero, a run time error is produced.

11.5.13 SQR Function

Compute Square

```
Definition:

function SQR(
        X  : REAL): REAL;

function SQR(
        X  : INTEGER): INTEGER;

Where:

X is an expression that evaluates
  to a REAL or INTEGER value.
```

The SQR function computes the square of the argument. If the argument is of type REAL, then a REAL result is returned, otherwise the function returns an INTEGER.

11.5.14 RANDOM Function

Compute a Random Number

```
Definition:

function RANDOM(
          S : INTEGER) : REAL;

Where:

S is an expression that evaluates
  to an INTEGER value.
```

The RANDOM function returns a pseudo random number in the range >0.0 and <1.0. The parameter S is called the seed of the random number and is used to specify the beginning of the sequence. RANDOM always returns the same value when called with the same non-zero seed. If you pass a seed value of 0, RANDOM will return the next number as generated from the previous seed. Thus, the general way to use this function is to pass it a non-zero seed on the first invocation and a zero value thereafter.

11.6 STRING ROUTINES

These routines provide convenient means of operating on string data.

11.6.1 LENGTH Function

Length of String

```
Definition:

function LENGTH(
           S         : STRING)
                     : 0..32767;

Where:

S is a STRING valued expression.
```

This function returns the current length of the parameter. The value will be in the range 0..32767.

11.6.2 MAXLENGTH Function

Maximum Length of a String

```
Definition:

function MAXLENGTH(
           S         : STRING)
                     : 0..32767;

Where:

S is a STRING valued expression.
```

This function returns the maximum length of the parameter string. The value will be in the range 0..32767.

11.6.3 SUBSTR Function

Obtain Substring

Definition:

```
function SUBSTR(
 const SOURCE : STRING;
        START : INTEGER;
         LEN  : INTEGER): STRING;


function SUBSTR(
 const SOURCE : STRING;
        START : INTEGER): STRING;
```

Where:

SOURCE is a STRING expression from which a substring will be returned.
START is an INTEGER expression that designates the first position in the SOURCE to be returned.
LEN is an INTEGER expression that defines the number of characters to be returned.

The SUBSTR function returns a substring from the specified source string (SOURCE). The second parameter (START) specifies the starting position within the source from where the substring is to be extracted. (The first character of the source string is at position 1). The third parameter (LEN) determines the length of the substring. If the length is omitted, the substring returned will be the remaining portion of the source string from position START.

The value of START+LEN-1 must be less than or equal to the current LENGTH of the string, otherwise, an error diagnostic will be produced at run time.

Examples:

```
SUBSTR('ABCDE',2,3) yields 'BCD'
SUBSTR('ABCDE',1,3) yields 'ABC'
SUBSTR('ABCDE',4) yields 'DE'
SUBSTR('ABCDE',1) yields 'ABCDE'
SUBSTR('ABCDE',2,5) is an error
```

11.6.4 DELETE Function

Delete Substring

Definition:

```
function DELETE(
 const SOURCE : STRING;
        START : INTEGER;
         LEN  : INTEGER): STRING;


function DELETE(
 const SOURCE : STRING;
        START : INTEGER): STRING;
```

Where:

SOURCE is a STRING expression from which a portion will be deleted.
START is an INTEGER expression that designates the first position in the SOURCE to be deleted.
LEN is an INTEGER expression that defines the number of characters to be deleted.

The DELETE function returns the source string (SOURCE) with a portion of the string removed. The second parameter (START) specifies the starting position within the source where characters are to be deleted. (The first character of the source string is at position 1). The third parameter (LEN) specifies the number of characters to be deleted. If the length parameter is omitted, all remaining characters are deleted; more precisely, the string is truncated beginning at position START.

An attempt to delete a portion of the source beyond its length is an execution time error.

Examples:

```
DELETE('ABCDE',2,3) yields 'AE'
DELETE('ABCDE',3) yields 'AB'
DELETE('ABCDE',3,1) yields 'ABDE'
DELETE('ABCDE',1) yields ''
```

11.6.5 TRIM Function

Remove Trailing Blanks

```
Definition:

function TRIM(
  const SOURCE : STRING)
                 : STRING;

Where:

SOURCE is the STRING to be trimmed.
```

The TRIM function returns the parameter value with all trailing blanks removed.

Example:

```
 TRIM(' A B  ') yields ' A B'
 TRIM('      ') yields ''
```

11.6.6 LTRIM Function

Remove Leading Blanks

```
Definition:

function LTRIM(
  const SOURCE : STRING)
                 : STRING;

Where:

SOURCE is the STRING to be trimmed.
```

The LTRIM function returns the parameter value with all leading blanks removed.

Example:

```
 LTRIM(' A B  ') yields 'A B  '
 LTRIM('      ') yields ''
```

11.6.7 COMPRESS Function

Remove Multiple Blanks

```
Definition:

function COMPRESS(
  const SOURCE : STRING)
               : STRING;

Where:

SOURCE is a the STRING expression
   to be compressed.
```

The COMPRESS function replaces multiple blanks with a single blank.

Example:

```
 COMPRESS('A B   CD  ') yields 'A B CD '
```

11.6.8 INDEX Function

Lookup String

```
Definition:

function INDEX(
  const SOURCE : STRING;
  const LOOKUP : STRING)
               : 0..32767;

Where:

SOURCE is a STRING that contains
  the data to be compared against.
LOOKUP is the data to be looked
  up in the SOURCE.
```

The INDEX function compares the second parameter against the first and returns the starting index of the first instance where LOOKUP begins in SOURCE. If there are no occurrences, then a zero is returned.

Examples:

```
 var
   S  : STRING;
   ...
   S := 'ABCABC';
   ...
   INDEX(S,'BC') yields 2
   INDEX(S,'X') yields 0
```

11.6.9 TOKEN Procedure

Find Token

Definition:

```
procedure TOKEN(
  var POS    : INTEGER;
  const SOURCE : STRING;
  var RESULT : ALPHA);
```

Where:

POS is the starting index in SOURCE of where to look for a token, it is set to the index of where to resume the search on the next use of TOKEN.
SOURCE is a STRING that contains the data from which a token is to be extracted.
RESULT is the variable which will be returned with token found.

The TOKEN procedure scans the SOURCE string looking for a token and returns it as an ALPHA. The starting position of the scan is passed as the first parameter. This parameter is changed to reflect the position which the scan is to be resumed on subsequent calls. Leading blanks, multiple blanks and trailing blanks are ignored. If there is no token in the string, POS is set to LENGTH(SOURCE)+1 and RESULT is set to all blanks.

A token is defined to be any of:

- Pascal/VS identifier - 1 to 16 alphanumeric characters, '$' or an underscore. The first letter must be alphabetic or a '$'.
- Pascal/VS unsigned integer - see page 18.
- The following special symbols:

```
+    -    *    /    ->   @    ¢
=    <>   <    <=   >=   >    !
(    )    [    ]    '    "    %
|    &    &&   ||   ¬    ¬=   #
:    ;    :=   .    ,    ..
{    }    (*   *)   /*   */
```

Example:

```
I := 2;
TOKEN(I,', Token+', RESULT)

  I is set to 8
  RESULT is set to 'Token          '

  TOKEN would return the same if
  I were set to 3, that is,
  leading blanks are ignored.
```

11.6.10 READSTR

Read Data from a STRING

Definition:

```
procedure READSTR(
    const s : STRING;
          v : see below);
```

Where:

s is a STRING expression that is to be used for input.
v is a list of one or more variables, each must be one of the following types:
- INTEGER (or subrange)
- CHAR   (or subrange)
- REAL
- SHORTREAL
- STRING
- **packed array of** CHAR

The READSTR procedure reads character data from a source string into one or more variables. The actions of READSTR are identical to that of READ except that the source data is extracted from a string expression instead of a text file. See "READ and READLN (TEXT Files)" on page 111. READSTR is especially useful for converting a STRING to a different type.

As in the READ procedure, variables may be qualified with a field length expression. See the example below.

```
var
  I,J: INTEGER;
  S  : STRING(100);
  S1 : STRING(100);
  CH : CHAR;
  CC : packed array[1..10] of CHAR;
   .
   .
  S := '36 245ABCDEFGHIJK';
  READSTR(S,I,J:3,CH,CC:5,S1);
```

the variables would be assigned:

```
    I             36
    J             24
    CH            '5'
    CC            'ABCDE     '
    S1            'FGHIJK';
    LENGTH(S1)    6
```

The READSTR Procedure

11.6.11 WRITESTR

Write Data to a STRING

```
Definition:

 procedure WRITESTR(
       var s : STRING;
           e : see below);

Where:

 s is a STRING variable
 e is an expression of one of the
   following types:
     - INTEGER (or subrange)
     - CHAR    (or subrange)
     - REAL
     - SHORTREAL
     - BOOLEAN
     - STRING
     - packed array[1..n] of CHAR

 Pascal/VS accepts a special para-
 meter format which allows you.
 to specify a length of the result.
```

The WRITESTR procedure converts expressions into character data and stores the data into a string variable. The semantics of WRITESTR are identical to WRITE, except that the target of the data is to a STRING rather than to a text file. See "WRITE and WRITELN (TEXT Files)" on page 114. WRITESTR is especially useful for converting data into string format.

As in the case of WRITE, the expressions being converted may be qualified with a field length expression.

```
var
  I,J: INTEGER;
  S  : STRING(100);
  R  : REAL;
  CH : CHAR;
   .
   .
  I := 10; J := -123;
  R := 3.14159;
  CH := '*';
  WRITESTR(S,I:3,J:5,'ABC',CH,
         R:5:2);
```

the variable S would be assigned:

```
  ' 10 -123ABC* 3.14'
```

The WRITESTR Procedure

11.7 GENERAL ROUTINES

These routines provide several useful features of the Pascal/VS runtime environment.

+ ### 11.7.1 TRACE Procedure

Routine Trace

Definition:

```
procedure TRACE(
    var F       : TEXT);
```

Where:

F is the file that will receive the trace listing

+ This procedure displays the current list of procedures and functions that are pending execution (i.e. save chain). Each line of the listing contains the name of the routine, the statement number where the call took place, the return address in hexadecimal and the name of the module that contained the calling procedure.

+ The file F is the TEXT file to which the information is to be written.

+ ### 11.7.2 HALT Procedure

Halt Program Execution

Definition:

```
procedure HALT;
```

+ This routine halts execution of an Pascal/VS program. That is, this can be considered to be a return from the main program.

11.8 SYSTEM INTERFACE ROUTINES

These routines provide interfaces to system facilities: in general they are dependent on the implementation of Pascal/VS.

11.8.1 DATETIME Procedure

Get Date and Time

Definition:

```
procedure DATETIME(
     var DATE,
         TIME : ALFA);
```

where:

DATE is the returned date.
TIME is the returned time.

This procedure returns the current date and time of day as two ALFA arrays. The format of the result is placed in the first and second parameters respectively:

```
mm/dd/yy
HH:MM:SS
```

where:

- mm is the month expressed as a two digit value.
- dd is the day of the month.
- yy is the last two digits of the year.
- HH is the hour of the day expressed in a 24 hour clock.
- MM is the minute of the hour.
- SS is the second of the minute.

11.8.2 CLOCK Function

Get Execution Time

Definition:

```
function CLOCK : INTEGER;
```

The value returned is the number of microseconds the program has been running.

Note: In an MVS system, the time is "TASK" time, while in a CMS system, the time is "CPU virtual" time.

11.8.3 PARMS Function

Get Execution Parameters

```
Definition:

function PARMS : STRING;
```

The PARMS function returns a string that was associated with initial invocation of the Pascal/VS main program.

11.8.4 RETCODE Procedure

Set Program Return Code

```
Definition:

procedure RETCODE(
        RETVALUE : INTEGER);

where:

RETVALUE is the return code to be
  passed to the caller of the
  Pascal/VS program. The value
  is system dependent.
```

The value of the operand will be returned to system when an exit is made from the main program. If this routine is called several times, only the last value specified will be passed back to the system.

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12.0 THE % FEATURE

```
Syntax:

include-statement:

 ---> % ---> INCLUDE ---┬---> id ( id ) ------------------┬---------->
                        └--------> id ------------------->┘

check-statement:

 ---> % ---> CHECK ──┬-------------------┬----┬---> ON ----┬---------->
                     ├---> POINTER ----->┤    └---> OFF --->┘
                     ├---> SUBSCRIPT --->┤
                     ├---> SUBRANGE ---->┤
                     ├---> FUNCTION ---->┤
                     ├---> CASE -------->┤
                     └---> TRUNCATE ---->┘

print-statement:

 ---> % ---> PRINT ---┬---> ON ----┬-------------------------------------->
                      └---> OFF --->┘

list-statement:

 ---> % ---> LIST ---┬---> ON ----┬--------------------------------------->
                     └---> OFF --->┘

page-statement:

 ---> % ---> PAGE --------------------------------------------------------->

cpage-statement:

 ---> % ---> CPAGE ---> unsigned-integer ---------------------------------->

title-statement:

 ---> % ---> TITLE ---> any-character-string ----------------------------->

skip-statement:

 ---> % ---> SKIP ---> unsigned-integer ---------------------------------->

margins-statement:

 ---> % ---> MARGINS ---> unsigned-integer  unsigned-integer -------->
```

The % feature of Pascal/VS is used to enable or disable a number of compiler options and features. The compiler treats a % command as a trigger symbol which causes the compiler to ignore all text between the statement and the end-of-line.

12.1 THE %INCLUDE STATEMENT

The INCLUDE statement causes source from a library file to be inserted into the input stream immediately after the current line. More precisely, the compiler is directed to begin reading its input from a library file; when the end of the file is reached, the compiler will resume reading from the previous source.

There are two forms of the INCLUDE statement:

- %INCLUDE library-name(member-name)
- %INCLUDE member-name

The first form references a library file and a specific member in the file.[5]

The second form references a specific member from a default library.

```
program ABC;
const
  %include CONSTS
type
  %include TYPES
var
  %include VARS
%include LIB1(PROCS)
begin
  ...
end.
```

Example of %INCLUDE statement

12.2 THE %CHECK STATEMENT

The CHECK statement gives you the ability to enable or disable the runtime checking features of Pascal/VS. The checking may be enabled for part or all of the program. The compiler will check the following:

- use of a pointer whose value is NIL (POINTER).
- use of a subscript which is out of range for the array index (SUBSCRIPT).
- lack of an assignment of a value to a function before exiting from the function (FUNCTION).
- assignment of a value which is not in the proper range for the target variable (SUBRANGE).
- use of the predefined functions PRED or SUCC where the result of the function is not a value in the type, i.e. underflow or overflow of the value range (SUBRANGE).
- the value of a CASE statement selector which is not equal to any of the CASE labels (CASE).
- the value of a string will be checked to be sure it will fit into the target string on an assignment (TRUNCATE).

If the check option is missing, then all of the above checks will be assumed applicable. For example, '%CHECK ON' activates all of the checks. '%CHECK POINTER OFF' will disable the check on pointer references. The default is:

    %CHECK ON

The %CHECK statement, like the other statements in this section, is a direction to the compiler. Its effect is based on where it appears in the text and is not subject to any structuring established by the program.

12.3 THE %PRINT STATEMENT

The PRINT statement is used to turn on and off the printing of source in the listing. The default is:

    %PRINT ON

12.4 THE %LIST STATEMENT

The LIST statement is used to enable or disable the pseudo-assembler listing of the Pascal/VS compiler. This option only has affect if the LIST compiler options is enabled.

It is often required to view the pseudo-assembler listing for only a small section of a module, and to have it suppressed elsewhere. This can be done as follows:

1. Insert a line at the beginning of the module that consists of

       %LIST OFF

---

[5] Under VM/CMS, OS, and MVS/TSO operating environments, the specified library name is actually the "DD name" of a partitioned data set (which may be concatenated). If the library name is omitted, the default is SYSLIB.

2. At the beginning of each section of code for which an assembler listing is required, insert

```
%LIST ON
```

3. At the end of each code section insert

```
%LIST OFF
```

4. Compile the module with the LIST option.

12.5 THE %PAGE STATEMENT

The PAGE statement is used to force a skip to the next page on the output listing of the source program.

12.6 THE %CPAGE STATEMENT

The CPAGE statement is used to force a page eject if there are less than a specified number of lines left on the current page of the output listing. This is useful to make sure there is sufficient room for a unit of code, thereby not having it split across two pages. Example:

```
%CPAGE 30
```

12.7 THE %TITLE STATEMENT

The TITLE statement is used to set the title in the listing. It also causes a page skip. The title is printed as specified on the statement, there is no change from lower case to upper case. The default is no title.

12.8 THE %SKIP STATEMENT

The SKIP statement is used to force one or more blank lines to be inserted into the source listing.

12.9 THE %MARGINS STATEMENT

The MARGINS statement redefines the left and right margins of the compiler input. The compiler skips all characters that lie outside the margins. The statement has the form

```
%MARGINS m n
```

where "m" is the new left margin and "n" is the new right margin.

If the MARGINS statement appears in a library member which is being "included" by the %INCLUDE statement, the new margins will have effect for the duration of the member only. When the end of the member is reached and the previous source is resumed, the margin settings will revert back to their previous condition.

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A.1 THE SPACE DECLARATION

Syntax:

space-type:

```
---> space ---> [ --->{constant-expr}---> ] ---> of --->{type}------------->
```

The need arises to represent data within storage areas which do not have the same fixed offset within each instance of the area. Examples of this include entries within a directory, where each entry may be of variable length, and processing variable length records from a buffer. To solve this problem, Pascal/VS provides the space structure.

A variable declared with the space type has a component which is able to "float" over a storage area in a byte oriented manner. Space variables are accessed by following the variable's name with an integer index expression enclosed in square brackets. The index represents the offset (in bytes) within the space storage where the data to be accessed resides. The offset is specified with an origin of zero.

The constant expression which follows the space qualifier in the type definition represents the size of the storage area (in bytes) associated with the type.

The component type of the space may be of any type except a file type.

An element of a space may not be passed as a var parameter to a routine. However, an element may be passed as a const or value parameter.

A.2 SPACE REFERENCING

A component of a space is selected by placing an index expression, enclosed within square brackets, after the space variable (just as in array references).

The indexing expression must be of type INTEGER (or a subrange thereof). The value of the index is the offset within the space at which the component is to be accessed. The unit of the index is the byte. The index is always based upon a zero origin, i.e. the index range of the space is from zero to one less than the value of the constant expression. The component will be of the space base type.

If the "%CHECK SUBSCRIPT" option is enabled, the index expression will be checked at execution time to make sure that the computed address does not lie outside the storage occupied by the space. An execution time error diagnostic will occur if the value is invalid. (For a description of the CHECK feature see "The %CHECK Statement" on page 150).

```
var
  {declare a space variable
   with index range 0..99 }
  S: space[100] of
record
        A,B: INTEGER
end;

begin
  {base record begins
    at offset 10 within
    space }
  S[10].A := 26;
  S[10].B := 0;
end;
```

Space Referencing Examples

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A standard identifier is the name of a constant, type, variable or routine that is predefined in Pascal/VS. The name is declared in every module prior to the start of your program. You may redefine the name if you wish; however, it is better to use the name according to its predefined meaning.

The identifiers that are predefined are:

Standard Identifiers

identifier	form	description
ABS	function	compute the absolute value of an INTEGER or REAL
ADDR	function	returns the address of a variable
ALFA	type	array of 8 characters, indexed 1..ALFALEN
ALFALEN	constant	HBOUND of type ALFA, value is 8
ALPHA	type	array of 16 characters, indexed 1..ALPHALEN
ALPHALEN	constant	HBOUND of type ALPHA, value is 16
ARCTAN	function	returns the arctangent of the argument
BOOLEAN	type	data type composed of the values FALSE and TRUE
CHAR	type	character data type
CHR	function	convert an integer to a character value
CLOCK	function	returns the number of micro seconds of execution
CLOSE	procedure	close a file
COLS	function	returns current column on output line
COMPRESS	function	replaces multiple blanks in a string with one blank
COS	function	returns the cosine of the argument
DATETIME	procedure	returns the current date and time of day
DELETE	function	returns a string with a portion removed
DISPOSE	procedure	deallocate a dynamic variable
EOF	function	test file for end of file condition
EOLN	function	test file for end of line condition
EXP	function	returns the base of the natural log (e) raised to the power of the argument
FALSE	constant	constant of type BOOLEAN, FALSE < TRUE
FLOAT	function	convert an integer to a floating point value
GET	procedure	advance file pointer to next element of input file
HALT	procedure	halts the programs execution
HBOUND	function	determine the upper bound of an array
HIGHEST	function	determine the maximum value of a scalar
INDEX	function	looks up one string in another
INPUT	variable	default input file
INTEGER	type	integer data type
LBOUND	function	determine the lower bound of an array
LENGTH	function	determine the current length of a string
LN	function	returns the natural logarithm of the argument
LOWEST	function	determine the minimum value of a scalar
LTRIM	function	returns a string with leading blanks removed
MARK	procedure	routine to create a new heap
MAX	function	determine the maximum value of a list of scalars
MAXINT	constant	maximum value of type INTEGER
MAXLENGTH	function	determines the maximum length of a string
MAXREAL	constant	maximum value of type REAL
MIN	function	determine the minimum value of a list of scalars
MININT	constant	minimum value of type INTEGER
MINREAL	constant	minimum value of type REAL (smallest non-zero floating point number)
NEW	procedure	allocate a dynamic variable from most recent heap

	Standard Identifiers Continued		
	identifier	form	description
	ODD	function	returns TRUE if integer argument is odd
	ORD	function	convert a scalar value to an integer
	OUTPUT	variable	default output file
	PACK	procedure	copies an array to a packed array
	PAGE	procedure	skips to the top of the next page
+	PARMS	function	returns the system dependent invocation parameters
+	PDSIN	procedure	open a file for input from a partitioned data set
+	PDSOUT	procedure	open a file for output from a partitioned data set
	PRED	function	obtain the predecessor of a scalar
	PUT	procedure	advance file pointer to next element of output file
+	RANDOM	function	returns a pseudo-random number
	READ	procedure	routine to read data from a file
	READLN	procedure	routine to read the end of line character of TEXT file
+	READSTR	procedure	converts a string to values assigned to variables
	REAL	type	floating point represented in 370 long floating point
+	RELEASE	procedure	routine to destroy one or more heaps
	RESET	procedure	open a file for input
+	RETCODE	procedure	sets the system dependent return code
	REWRITE	procedure	open a file for output
	ROUND	function	convert a floating point to an integer by rounding
	SEEK	procedure	positions an opened file at a specific record
	SHORTREAL	type	floating point represented in 370 short floating point
	SIN	function	returns the sine of the argument
+	SIZEOF	function	determine the memory size of a variable or type
	SQRT	function	returns the square root of the argument
	SQR	function	returns the square of the argument
+	STR	function	convert an array of characters to a string
+ +	STRING	type	a type for an array of char whose length varies during execution up to a maximum length
+ +	STRINGPTR	type	a type for dynamically allocated strings of an execution determined length
+	SUBSTR	function	returns a portion of a string
	SUCC	function	obtain the successor of a scalar
	TERMIN	procedure	open a file for input from the terminal
	TERMOUT	procedure	open a file for output from the terminal
	TEXT	type	**file of** CHAR
+	TOKEN	procedure	extracts tokens from a string
+	TRACE	procedure	writes the routine return stack
+	TRIM	function	returns a string with trailing blanks removed
	TRUE	constant	constant of type BOOLEAN, TRUE > FALSE
	TRUNC	function	convert a floating point to an integer by truncating
	UNPACK	procedure	copies a packed array to an array
+	UPDATE	procedure	opens a file for both input and output
	WRITE	procedure	routine to write data to a file
	WRITELN	procedure	routine to write end of line to a TEXT file
+	WRITESTR	procedure	converts a series of expressions into a string

actual-parameters:

```
───┬────> ( ───┬──┬──>{expr}──┬───┬───> ) ──┬────────────────────────>
   │           │  └<──── , <──┘   │          │
   │           └─────────────────>┘          │
   └────────────────────────────────────────>┘
```

array-structure:

```
---->{id:type}---> ( --->┐
   ┌<--------------------┘
   └---┬--┬-->{constant-expr}--┬--> : {repetition}--┬--┬--┬---> ) ---------->
       │  │                    └------------------->┘  │  │
       │  └------------------------------------------->┘  │
       └<------------------ , <---------------------------┘
```

array-type:

```
───┬─────> packed ──┐
   ├<───────────────┘
   └─────────> array [ ──┬──>{index-type}────┬──> ] of ──>{type} ───────>
                         └<────── , <────────┘
```

assert-statement:

```
---> assert --->{expr}----------------------------------------------------->
```

assignment-statement:

```
──────┬──>{variable}──────────┬──> := ───>{expr}─────────────────────────>
      └──>{id:function}────>──┘
```

base-scalar-type:

```
    ┌──>{enumerated-scalar-type}──>┐
────┼──>{id:scalar-type}──────────>┼──────────────────────────────────────>
    └──>{subrange-scalar-type}────>┘
```

case-statement:

```
───> case ───>{expr}───> of ───>┐
   ┌<───────────────────────────┘
   │
   └───┬───┬──>{range}──────┬──> : ───>{statement}──────┬──>┐
       │   └<──── , <───────┘                            │   │
       └<─────────────────────────── ; <────────────────┘   │
   ┌<────────────────────────────────────────────────────────┘
   │                      └<─── ; <───┘
   ├---> otherwise ---┬--->{statement}---┬--->┐
   │                  └<------- ; <------┘    │
   ├<-----------------------------------------┘
   │
   └───> end ──────────────────────────────────────────────────────────>
```

check-statement:

```
---> % ---> CHECK --+----------------------+---+---> ON ----+------------------->
                    +---> POINTER ------>+    +---> OFF --->+
                    +---> SUBSCRIPT ---->+
                    +---> SUBRANGE ----->+
                    +---> FUNCTION ----->+
                    +---> CASE --------->+
                    +---> TRUNCATE------>+
```

cpage-statement:

```
---> % ---> CPAGE ---> unsigned-integer ------------------------------------>
```

compound-statement:

```
---> begin ---+--->{statement}---+---> end ----------------------------------->
              +<------- ; <------+
```

constant:

```
-----+---->{unsigned-constant}--------------------------------------------->
     +-----+--> + -----+--->{unsigned-number}---->+
           +--> - ---->+
```

constant-dcl:

```
---> const -----+--->{id}---> = --->{constant-expr}---> ; --+---------------->
                +<------------------------------------------+
```

continue-statement:

```
+    ---> continue -------------------------------------------------------->
```

declaration:

```
     -----+--->{label-dcl}--------->+
          +--->{constant-dcl}------>+
          +--->{type-dcl}---------->+
          +--->{var-dcl}----------->+
+         +--->{def-dcl}----------->+
+         |                         |
+         +--->{static-dcl}-------->+
+         |                         |
+         +--->{value-dcl}--------->+
          +--->{routine-dcl}------->+-------------------------------------->
```

def-dcl:

```
+    ---+---> def ---+---+---+--->{id}---+---> : --->{type}---> ; ---+---------->
+       +---> ref --->+  |   +<--- , ----+                          |
+                        |                                          |
+                        +<-----------------------------------------+
```

directive:

```
  ───┬───> FORWARD ──────────────────────────────────────>┬────────────────>
+    ├---> EXTERNAL -------------------------------------->┤
+    │
+    ├---> FORTRAN --------------------------------------->┤
+    │
+    ├---> MAIN ------------------------------------------>┤
+    │
+    └---> REENTRANT ------------------------------------->┘
```

empty-statement:

```
  ─────────────────────────────────────────────────────────────────────>
```

enumerated-scalar-type:

```
  ──> ( ──┬──>{id}──┬──> ) ──────────────────────────────────────────────>
          └<── , <──┘
```

expr:
constant-expr:

```
  ──>{simple-expression}──┬───────────────────────────────────────────┬──>
                          ├──> =  ──┬──>{simple-expression}──>────────┘
                          ├──> <> ──>┤
                          ├──> <  ──>┤
                          ├──> <= ──>┤
                          ├──> >= ──>┤
                          ├──> >  ──>┤
                          └──> in ──>┘
```

factor:

```
  ───┬───>{function-call}─────────────────────────────┬───────────>
     ├───>{variable}─────────────────────────────────>┤
     ├───>{set-constructor}──────────────────────────>┤
     ├───> ( ──>{expr}──> ) ─────────────────────────>┤
+    ├--->{structured-constant}---------------------->┤
     ├───> not ──>{factor}───────────────────────────>┤
     └───>{unsigned-constant}────────────────────────>┘
```

field:

```
  ──>{id}──┬───────────────────────────────────────────────┬──────────>
+          └---> ( --->{constant-expr}---> ) ---> ─────────┘
```

field-list:

```
  ───┬───>{fixed-part}──┬──────────────────────>┐
     │                  └──> ; ──┬──>{variant-part}──┴──┬──> ; ──┬──>
     └───────────────────────────>┘                      └───────>┘
```

file-type:

```
──┬──────────────────┬──> file of ──>{type}──────────────────>
  └──> packed ──>────┘
```

fixed-part:

```
──┬───┬──┬──>{field}──┬──┬──> : ──>{type}──┬─────────────────>
  │   │  └<── , <─────┘  │                 │
  │   └----------------->┘                 │
  └<──────────────── ; <───────────────────┘
```

for-statement:

```
──> for ──>{id}──> := ──>{expr}──┬──> to ──────┬──>{expr}──>┐
                                 └──> downto ──>┘            │
                  ┌<─────────────────────────────────────────┘
                  └──────────> do ──>{statement}─────────────>
```

formal:

```
──┬───┬────────────────┬──┬──{id}──┬──> : ──>{id:type}──┬──>
  │   ├──> var ──────>─┤  └<── , <─┘                     │
  │   └---> const -->──┘                                 │
  ├──>{procedure-heading}───────────────────────────────>┤
  └──>function-heading}─────────────────────────────────>┘
```

formal-parameters:

```
──┬──> ( ──┬──>{formal}──┬──> ) ──┬──────────────────────>
  │        └<── ; <──────┘        │
  └──────────────────────────────>┘
```

function-call:

```
──>{id:function}──>{actual-parameters}─────────────────────>
```

function-heading:

```
──> function ──>{id}──>{formal-parameters}──> : ──>{id:type}──>
```

goto-statement:

```
──────> goto ──>{label}────────────────────────────────────>
```

id:

```
                      ┌────────────────────────────────────>
──>{letter}──┬────────┼──>{digit}──────>┐
             │        ├──>{letter}─────>┼──>┐
             │        └--->{underscore}-->┘   │
             └<──────────────────────────────┘
```

if-statement:

```
—> if —>{expr}—> then —>{statement}──┬──────────────────────────────┬──>
                                     └─> else —>{statement}—>────────┘
```

include-statement:

```
---> % ---> INCLUDE ---> id ---┬-----------------------------┬-----------------> 
                               └---> ( ---> id ---> ) --->───┘
```

index-type:

```
──────┬───>{enumerated-scalar-type}───>┐
      ├───>{id:scalar-type}───────────>┼──────────────────────────────────────>
      └───>{subrange-scalar-type}─────>┘
```

label:

```
────────┬──>{unsigned-integer}──┬──────────────────────────────────────────────>
+       └--->{id}--------------->┘
```

label-dcl:

```
───> label ───┬───>{label}───┬───> ; ─────────────────────────────────────────>
              └<─────── , <──┘
```

leave-statement:

```
+ ---> leave ---------------------------------------------------------------------->
```

list-statement:

```
---> % ---> LIST ---┬---> ON ----┬----------------------------------------------->
                    └---> OFF --->┘
```

margins-statement:

```
---> % ---> MARGINS ---> unsigned-integer  unsigned-integer --------------->
```

module:

```
────────┬──>{program-module}───┬───────────────────────────────────────────────>
+       └--->{segment-module}--->┘
```

page-statement:

```
---> % ---> PAGE --------------------------------------------------------------->
```

pointer-type:

```
───> @ ───>{id:type}───────────────────────────────────────────────────────────>
```

print-statement:

```
---> % ---> PRINT ---+---> ON -----+------------------------------------->
                     +---> OFF --->+
```

procedure-call:

```
--->{id:procedure}---+---------------------------------------------+------->
                     +---> ( ---+--->{expr}---+---> ) --->---------+
                                +<--- , <-----+
```

procedure-heading:

```
---> procedure --->{id}--->{formal-parameters}----------------------------->
```

program-module:

```
---> program --->{id}----+---> ( ---+--->{id}---+---> ) ---+--->+
                         |          +<--- , <---+          |    |
                         +-------------------------------->+    |
      +<------------------------------- ; <---------------------+
      |
      +<-----------------------+
      +--->{declaration}------>+
      +--->{compound-statement}---+---> . ---+------------------------------->
                                  +--------->+
```

range:

```
+   --->{constant-expr}---+----------------------------------+------------>
+                         +---> .. --->{constant-expr}--->---+
```

real-number:

```
+   ---+---> ' ---+--->{hex-digit}---+---> 'XR --------------------->+
+      |          +<-----------------+                               |
|      +---+--->{digit}---+------+---> . ---+---+--->{digit}---+---+--+------>
|          +<-------------+      |          |   +<-------------+   |  |
|          +<--------------------+          |                      |  |
|          +<-------------------------------+                      |  |
|          +<------------------------------------------------------+  |
|          |                                                          |
|          +---> E ------+-------->+---+--->{digit}---+-------------->+
                         +---> + ->+   +<-------------+
                         +---> - ->+
```

record-structure:

```
+   --->{id:type}---> ( ---+---+--->{constant-expr}---+---+---> ) ------------>
+                          |   +--------------------->+   |
+                          +<----------- , <--------------+
```

record-type:

```
-------+-------------------+---> record --->{field-list}---> end --------->
       +---> packed ------>+
```

repeat-statement:

```
---> repeat ----------->{statement}---------> until --->{expr}---------------->
                 |<-------- ; <--------|
```

repetition:

```
+     --->{constant-expr}--------------------------------------------------->
```

return-statement:

```
+     ---> return ------------------------------------------------------------>
```

routine-dcl:

```
--------->{procedure-heading}------------------>┐
    └---->{function-heading}------------------->┤
                                                |
   ┌<------------------ ; <---------------------┘
   |
   ├--->{directive}---> ; --------------------------->┐
   |                                                  |
   ├<----------------------┐                          |
   ├--->{declaration}---->-┘                          |
   |                                                  |
   └--->{compound-statement}---> ; ------------------┴--------------->
```

segment-module:

```
+     ---> SEGMENT --->{id}---> ; --->┐
+                                     |
+        ┌<---------------------------┤
+        |                        |
+        ├--->{constant-dcl}---->-┤
+        |                        |
+        ├--->{type-dcl}-------->-┤
+        |                        |
+        ├--->{var-dcl}--------->-┤
+        |                        |
+        ├--->{def-dcl}--------->-┤
+        |                        |
+        ├--->{static-dcl}------>-┤
+        |                        |
+        ├--->{value-dcl}------->-┤
+        |                        |
+        ├--->{routine-dcl}----->-┘
+        |
|        └----┬---> . --┬------------------------------------------------->
|             └-------->┘
```

set-constructor:

```
---> [ ----┬----┬---->{expr}----┬--------------------------┬----┬---> ] ------->
           |    |               └---> .. --->{expr}---->---┘    |
           |    └<---------------- , <--------------------┘     |
           └---------------------------------------------->-----┘
```

set-type:

```
---+--------------------+---> set of --->{base-scalar-type}------------------------->
   |                    |
   +---> packed ------->+
```

simple-expression:

```
---+--------------+---+--->{term}---+------------------------------------------------>
   +---> + ------>+   |             +---> + ---->+
   +---> - ------>+   |             +---> - ---->+
                      |             +---> && --->+
                      |             +---> | ---->+
                      |                          |
                      +<-------------------------+
```

skip-statement:

```
---> % ---> SKIP ---> unsigned-integer ----------------------------------->
```

space-type:

```
---> space ---> [ --->{constant-expr}---> ] ---> of --->{type}------------>
```

statement:

```
---+--->{label}---> : --->+
   +<---------------------+
   |
   +--->{assert-statement}-------------------------------------->+
   +--->{assignment-statement}---------------------------------->+
   +--->{case-statement}---------------------------------------->+
   +--->{compound-statement}------------------------------------>+
   +--->{continue-statement}------------------------------------>+
   +--->{empty-statement}--------------------------------------->+
   +--->{for-statement}----------------------------------------->+
   +--->{goto-statement}---------------------------------------->+
   +--->{if-statement}------------------------------------------>+
   +--->{leave-statement}--------------------------------------->+
   +--->{procedure-call}---------------------------------------->+
   +--->{repeat-statement}-------------------------------------->+
   +--->{return-statement}-------------------------------------->+
   +--->{while-statement}--------------------------------------->+
   +--->{with-statement}---------------------------------------->+------------>
```

static-dcl:

```
---> static ---+---+--->{id}---+---> : --->{type}---> ; ---+----------------->
               |   +<--- , ----+                           |
               |                                           |
               +<------------------------------------------+
```

string:

```
         ───┬────> ' ──┬───────────────────────┬──> ' ────┬──────────────────────────>
            │          └<───{character}<───────┘          │
+           └───> ' ───┬───>{hex-digit}───┬───> 'XC ─────>┘
+                      └<─────────────────┘
```

string-type:

```
+        ---> STRING ---┬---> ( --->{constant-expr}---> ) ---┬----------------------->
+                       └----------------------------------->┘
```

structured-constant:

```
+        ---┬--->{record-structure}---┬------------------------------------------------>
+           └--->{array-structure}--->┘
```

subrange-scalar-type:

```
+        ───┬---> packed --->┐
            ├<---------------┘
            │
+           └─────┬───>{constant}───> .. ───>{constant-expr}────────────────────┬───────>
                  │                                                             │
+                 └---> range --->{constant-expr}---> .. --->{constant-expr}--->┘
```

term:

```
         ───┬─────>{factor}─────┬──────────────────────────────────────────────────────>
            │                   ├───> *  ──────>┐
            │                   ├───> /  ──────>┤
            │                   ├───> div ────>┤
            │                   ├───> mod ────>┤
+           │                   ├---> >> ---->┤
+           │                   ├---> << ---->┤
+           │                   ├---> || ---->┤
            │                   └───> &  ──────>┤
            └<──────────────────────────────────┘
```

title-statement:

```
         ---> % ---> TITLE ---> any-character-string -------------------------------->
```

type:

```
  ------+---->{id:type}-------------------------------------------------------->+
        |                                                                      |
        +---->{enumerated-scalar-type}---------------------------------------->+
        |                                                                      |
        +---->{subrange-scalar-type}------------------------------------------>+
        |                                                                      |
        +---->{array-type}---------------------------------------------------->+
        |                                                                      |
        +---->{record-type}--------------------------------------------------->+
        |                                                                      |
        +---->{set-type}------------------------------------------------------>+
        |                                                                      |
        +---->{file-type}----------------------------------------------------->+
|       |                                                                      |
+       +---->{pointer-type}-------------------------------------------------->+
+       L---->{string-type}-------------------------------------------------->+------>
```

type-dcl:

```
  ---> type -----+---->{id}---> = --->{type}---> ; ---+-------------------------->
                 L<-----------------------------------+
```

unsigned-constant:

```
  ------+---->{unsigned-number}------+------------------------------------------>
        |                            |
        +---->{string}-------------->+
        |                            |
        +---->{id:constant}--------->+
        |                            |
        L----> nil ----------------->+
```

unsigned-integer:

```
  ------+-------->{digit}-----+--------------------------------------------------->
        |     L<--------------+                                    |
+       +---> ' ---+--->{binary digit}---+---> 'B --->+
+       |          L<---------------------+                        |
+       L---> ' ---+--->{hex-digit}---+---> 'X ------>+
+                  L<------------------+
```

unsigned-number:

```
  ------+---->{unsigned-integer}--->+-------------------------------------------->
        L---->{real-number}-------->+
```

value-assignment:

```
+ --->{variable}---> := ---+--->{constant-expression}----+-------------------->
+                          L--->{structured-constant}--->+
```

value-dcl:

```
+ ---> value ---+---{value-assignment}---> ; ---+------------------------------>
+               L<------------------------------+
```

var-dcl:

```
──> var ───┬───────┬──>{id}──────┬────> : ───>{type}───> ; ───┬──────────────────────>
           │       └<─── , ──────┘                             │
           └<──────────────────────────────────────────────────┘
```

variable:

```
──>{id}───>┐
           ├<──────────────────────────────────────────┐
           ├───> [ ───┬───>{expr}───┬────> ] ─────>────┤
           │          └<──── , ─────┘                  │
           ├───> . ───>{id:field}──────────────────>───┤
           ├───> @ ────────────────────────────────>───┘
           └──────────────────────────────────────────────────────────────>
```

variant-part:

```
                               ┌------------------->┐
──> case ───┬────>{id}───> : ──┴──┬──>{id:type}─────┴──> of ───>┐
            └─────────────────────┘>                             │
   ┌<────────────────────────────────────────────────────────────┘
   └───┬───┬────>{range}───┬────> : ( ───┬───>{field-list}───┬──> ) ───┬─────────>
       │   └<──── , <──────┘              └───────────────────┘>        │
       └<────────────────────────── ; <─────────────────────────────────┘
```

while-statement:

```
────> while ───>{expr}───> do ───>{statement}──────────────────────────────>
```

with-statement:

```
──> with ───┬───>{variable}───┬────> do ───>{statement}────────────────────>
            └<───────── , <───┘
```

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Actual parameter specifies what is to be passed to a routine.

Array type is the structured type that consists of a fixed number of elements, each element of the same type.

Assignment compatible is the term used to indicate whether a value may be assigned to a variable.

Automatic variable is a variable which is allocated on entry to a routine and is deallocated on the subsequent return. An automatic variable is declared with the var declaration.

Base scalar type is the name of the type on which another type is based.

Bit is one binary digit.

Byte is the unit of addresability on the System/370, its length is eight bits.

Compatible types is the term which is used to indicate that operations between values of those types are permited.

Component is the name of a value in a structured type.

Constant is a value which is either a literal or an identifier which has been associated with a value in a const declaration.

Constant expression is an expression which can be completely evaluated by the compiler at compile time.

Dynamic variable is a variable which is allocated under programmer control. Explicit allocates and deallocates are required; the predefined procedures NEW and DISPOSE are provided for this purpose.

Element is the component of an array.

Entry routine is a procedure or function which may be invoked from outside the module in which it is defined. The routine is called entry in the module in which is defined. An entry routine may not be imbedded in another routine; it must be defined on the outermost level of a module.

Enumerated scalar type is a scalar that is defined by enumerating the elements of the type. Each element is represented by an identifier.

External routine is a procedure or function which may be invoked from outside the module in which the routine is defined.

Field is the component of a record.

File type is a data type which is the mechanism to do input and output in Pascal/VS.

Fixed part is that part of a record which exists in all instances of a particular record type.

Formal parameter is a parameter as declared on the routine heading. A formal parameter is used to specify what is permitted to be passed to a routine.

Function is a routine, invoked by coding its name in an expression, which passes a result back to the invoker through the routine name.

Identifier is the name of a declared item.

Index is the selection mechanism applied to an array to identify an element of the array.

Internal routine is a routine which can be used only from within the lexical scope in which it was declared.

Lexical scope identifies the portion of a module in which a name is known. An identifier declared in a routine is known within that routine and within all nested routines. If a nested routine declares an item with the same name, the outer item is not available in the nested routine.

Module is the compilable unit in Pascal/VS.

Offset is the selection mechanism of a space. An element is selected by placing an integer value in parenthesis. The origin of a space is based on zero.

Packed record type is a record structure in which fields are allocated in the minimum number of bytes. Implementation defined alignment of data types will not be preserved in order to pack the record. Packed records may not be passed by read/write reference.

Pass by read only reference is the parameter passing mechanism by which the address of a variable or temporary is passed to the called routine. The called routine is not permitted to modify the formal parameter. If the actual parameter is an expression, a temporary will be created and its address will be passed to the called routine. A temporary is also created for fields of packed records.

Pass by read/write reference is the parameter passing mechanism by which the address of a variable is passed to the called routine. If the called routine modifies the formal parameter, the corresponding actual parameter is changed. Only variables may be passed via this means. Fields of packed records will not be permitted to be passed in this way.

Pass by value is the parameter passing mechanism by which a copy of the value of the actual parameter is passed to the called routine. If the called routine modifies the formal parameter, the corresponding actual parameter is not affected.

Pointer type is used to define variables that contain the address of dynamic variables.

Procedure is a routine, invoked by coding its name as a statement, which does not pass a result back to the invoker.

Program module is the name of the compilable unit which represents the first unit executed.

Record type is the structured type that contains a series of fields. Each field may be of a type different from the other fields of the record. A field is selected by the name of the field.

Reserved word is an identifier whose use is restricted by the Pascal/VS compiler.

Routine is a unit of a Pascal/VS program that may be called. The two type of routines are: procedures and functions.

Scalar type defines a variable that may contain a single value at execution.

Segment module is a compilable unit in Pascal/VS that is used to contain entry routines.

Set type is used to define a variable that represents all combinations of elements of some scalar type.

Space type is used to define a variable whose components may be positioned at any byte in the total space of the variable.

Statement is the executable unit in a Pascal/VS program.

String represents an ordered list of characters whose size may vary at execution time. There is a maximum size for every string.

String constant is a string whose value is fixed by the compiler.

Structured type is any one of several data type mechanisms that defines variables that have multiple values. Each value is referred to generally as a component.

Subrange scalar type is used to define a variable whose value is restricted to some subset of values of a base scalar type.

Tag field is the field of a record which defines the structure of the variant part.

Type defines the permissible values a variable may assume.

Type definition is a specification of a data type. The specification may appear in a type declaration or in the declaration of a variable.

Type identifier is the name given to a declared type.

Variant part is that portion of a record which may vary from one instance of the record to another. The variant portion consists of a series of variants that may share the same physical storage.

Special Characters

A

B

C

D

E

F

G

H

I

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