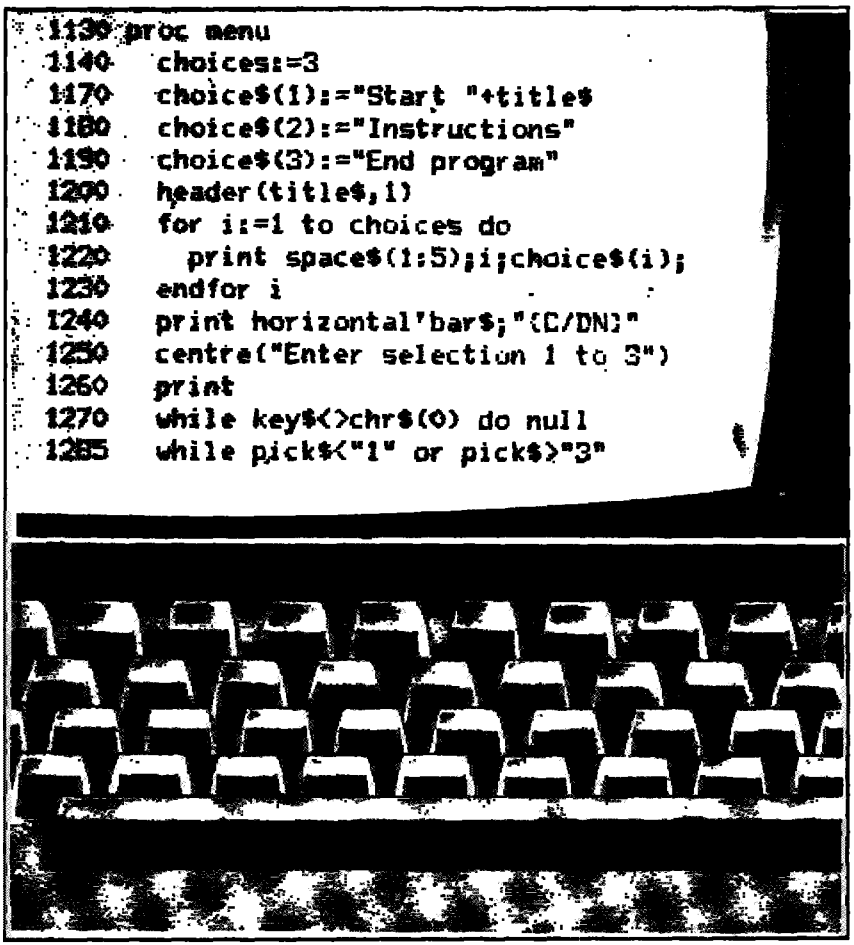
COMAL
Reference Guide



by Borge R. Christensen

With a foreword by Jim Butterfield

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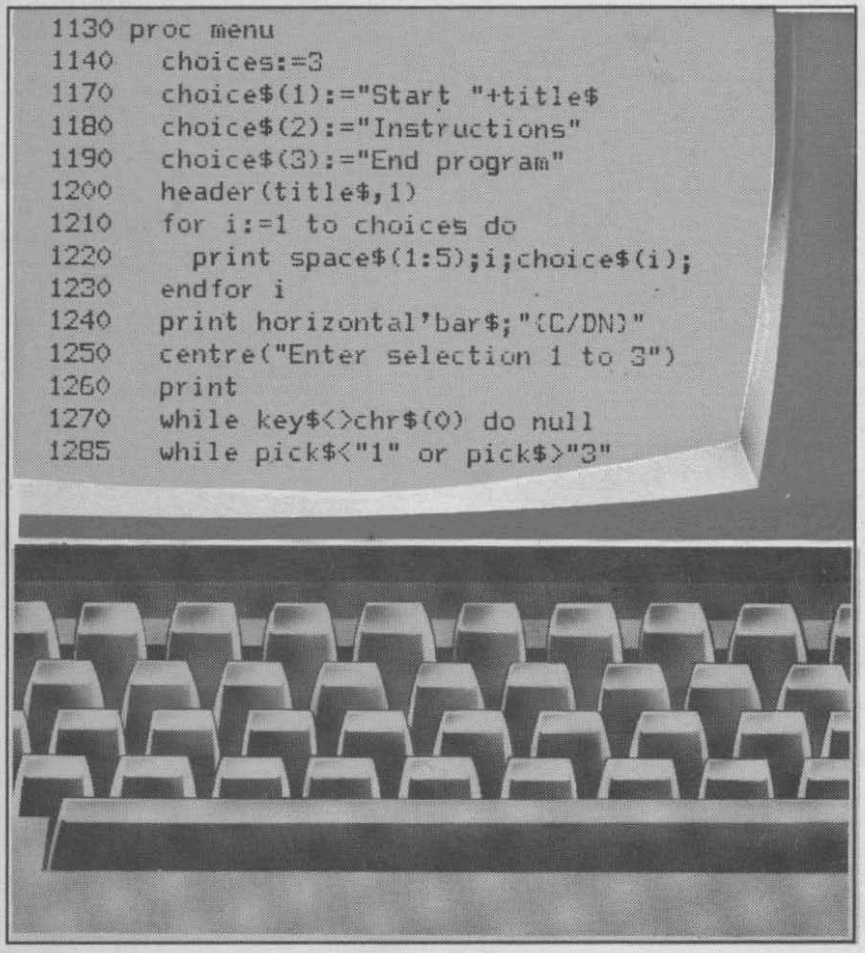

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FOREWORD by Jim Butterfield

COMAL is an attractive language. It's as friendly as BASIC for the beginner, and yet allows the programmer to use advanced program stucture features when needed. In fact, one of COMAL's greatest benefits is in its helpfulness at different skill levels: easy for the beginner, effective for the advanced programmer.

COMAL is, in fact, a dialect of BASIC. But it's a BASIC which has been expanded, standardized and rationalized. COMAL does more, as compared to "garden variety" BASIC. The various implementations of COMAL are relatively compatible. COMAL statements fit together to create programs that are efficient and reliable. And COMAL programs use relatively small amounts of memory, yet run quickly.

COMAL is not yet a universal computer language. At the present time, it's available on a limited number of computers. Only a few books and magazine articles dealing with COMAL are to be found.

But COMAL is gaining in popularity. More people than ever before are learning about - and using - COMAL.

This reference guide will help you put COMAL 0.14 to work, quickly and efficiently.

Jim Butterfield
Toronto, Ontario, November 1984

PREFACE

The programming language COMAL (COMmon Algorithmic Language) was designed in 1973 by Benedict Loefstedt and me in order to make life easier and safer for people who wanted to use computers without being computer people. We combined the simplicity of BASIC with the power of Pascal.

If you take a close look at BASIC you will see that its simplicity stems mainly from its operating environment, and not from the language itself. Using BASIC, a beginner can type in one or two statements and have his small program executed immediately by means of one simple command. Line numbers are used to insert, delete and sequence statements. You do not need a sophisticated Text Editor or an ambitious Operating System Command Language. Input and output take place in a straightforward way at the terminal.

On the other hand there is no doubt that as a programming language, BASIC is hopelessly obsolete. It was never a very good language, and seen from a modern point of view it is a disaster. People who start to learn programming using BASIC may easily be led astray and, after some time, may find themselves fighting with problems that could be solved with almost no effort using programming languages more adequate to guide human thinking.

COMAL includes the gentle operating environment of BASIC and its usual simple statements, such as INPUT, PRINT, READ, etc., but it adds to all that a set of statements modelled after Pascal that makes it easy to write well structured programs. Instead of leading people away from the modern effective way of professional programming, COMAL offers a perfect introduction to this new art.

With C64 COMAL 0.14 by UniCOMAL Aps it is now possible for anyone to become familiar with modern principles of programming. It includes simple but effective and versatile instructions to control hi-res graphics and sprites.

Borge R. Christensen
Tonder, Denmark, April 22, 1984

INTRODUCTION

The contents are arranged in paragraphs or articles; one about each COMAL keyword and four additional about assignments, expressions, procedures and parameters, and standard functions. These paragraphs and articles are arranged alphabetically according to the keywords and the four titles just mentioned. Some of the paragraphs are very short and hold only a reference to an article. An article normally consists of definitions, comments, and examples.

Most **<items>** are defined on location but a few fundamental ones are explained below and used without futher notice in the articles. These are:

<identifier> is a string of up to 78 characters. The leading character must be a letter, and the following may be letters, digits, or any one of the characters: apostrophe ('), [,], backslash, or left arrow (displayed as underscore on the printer).

<variable name> can be an <identifier> to name a real (floating) variable, <identifier># to name an integer variable, or <identifier>$ to name a string variable.

<file name> is a <string expression> that returns a valid CBM disk operative system file name.

<expression> can be either a <numeric expression> or a <string expression>. A <numeric expression> returns a numeric value (integer or real), and a <string expression> returns a string. Note that only <numeric expressions> that return values in the range from -32768 to 32767 can be assigned to integer variables. Details about <expressions> may be found in the survey (see EXPRESSIONS).

<numeric constant> is a usual decimal representation of a number, and a <string constant> is a string of characters enclosed in double quotes.

<file no.> is a <numeric expression> that returns a value in the range 1-255. A <unit no.> is a <numeric expression> that returns a value in the range 0-15. The COMAL System uses file #1 and #255 for system use.

<line number> is an integer in the range 1-9999.

In the syntax definitions, items in square brackets [ ] are optional. Items enclosed in braces { } are also optional, but may have several occurences.

It should be stressed that this survey of CBM COMAL is neither a full formal definition nor a textbook. Though it is believed to be complete and correct it presupposes a certain knowledge about programming in general and about CBM computers in particular. A handbook that explains more detailed about CBM COMAL and also contains much useful additional information about CBM computers is

Len Lindsay: **COMAL HANDBOOK**

If you want a textbook about COMAL you could use

Roy Atherton: **Structured Programming With COMAL**

Borge R. Christensen: **Beginning COMAL**

A newsletter about COMAL and structured programming is

COMAL TODAY (Editor: Len Lindsay)

All available from COMAL Users Group, U.S.A., Limited, 5501 Groveland Ter, Madison, WI 53716.

Borge R. Christensen
Tonder, Denmark, April 1984

ABS

is a standard function. ABS(X) returns the absolute value of X.

AND

is a Boolean operator that denotes logical conjugation. **See also EXPRESSIONS.**

APPEND

is a keyword used to specify that a sequential file is opened in append mode. **See also OPEN.**

ASSIGNMENTS

The syntax of an assignment is

```
<variable>:=<expression>
```

If the <variable> is of type string, the <expression> must be of the same type. Type conflicts between numerics and strings are normally found and reported as program lines are entered.

The system is, however, very tolerant when numeric types (reals and integers) are concerned. Thus a variable of type real will accept integer values and you may use variables of type integer in real expressions. An integer variable will accept any number in the range from -32768 to 32767. If a real number in that range is assigned to an integer the number is first rounded.

With numeric types, assignments like the following:

```
<variable>:=<variable>+<expression>  and
<variable>:=<variable>-<expression>
```

may respectively be written in a shorthand form as

```
<variable>:+<expression>  and
<variable>:-<expression>
```

ASSIGNMENTS (continued)

If the keyword LET is typed in before an assignment it is ignored by the system. If the sign of equality is entered instead of the sign of assignment, the system automatically converts "=" into ":=".

```
VOLUME:=LENGTH*WIDTH*HEIGHT/3
COUNTER:+INCREMENT
ADDRESS$:=STR$(NO)+NAME$+"@"+STREET$+"@"+CITY$+"*"
MAX#:=32128
```

ATN

is a standard function. ATN(X) returns the arctangent in radians of X.

AUTO

AUTO is a command that makes the COMAL system generate line numbers automatically as a program is entered. Its syntax is:

```
AUTO [<line number>] [,<increment>]
```

where <increment> is a positive integer.

COMMAND	GENERATES LINE NUMBERS:
AUTO	0010, 0020, 0030, 0040, etc.
AUTO 110	0110, 0120, 0130, 0140, etc.
AUTO ,2	0010, 0012, 0014, 0016, etc.
AUTO 110,2	0110, 0112, 0114, 0116, etc.

If a valid line number is added to the word AUTO, the generated sequence of numbers will start with the number thus indicated.

If a positive integer preceded by a comma is added, the system will use this integer as an increment in line numbers.

AUTO mode is switched off by pressing the RETURN key twice in succession.

BASIC

BASIC is a command that makes the computer switch back to the built-in BASIC interpreter. The syntax of the command is

```
BASIC
```

To return to COMAL the interpreter must be reloaded.

Note: The C64 reset function sometimes fails when the BASIC command is used. To be sure that the system is truly reset to BASIC mode press <STOP>+<RESTORE> once or twice.

CASE, WHEN, OTHERWISE, ENDCASE

The CASE statement is the head of the CASE structure that controls multi-way branching. The syntax of the case structure and its individual statements is given in the following diagram:

```
 CASE <case selector> [OF]
{WHEN <choice list>
   <statement list>}
[OTHERWISE
   <statement list>]
 ENDCASE
```

The <case selector> is an <expression>. The <choice list> is a list of <expressions>. The expressions on the <choice list> following a WHEN statement must be of the same type (real, integer, or string) as the <case selector>.

If the value of the <case selector> is equal to the value of one of the expressions on a <choice list> the corresponding <statement list> is executed.

As soon as a <statement list> has been executed, the COMAL interpreter transfers control to the statement following the ENDCASE statement, or stops if no more statements follow. If the value of the <case selector> does not match any of the expressions on the choice lists the <statement list> following OTHERWISE is executed, but if no OTHERWISE statement is present, an error message is emitted and execution of the program is stopped.

CASE, WHEN, OTHERWISE, ENDCASE (continued)

On the listing of a program statements in a <statement list> are indented automatically relative to the control statements:

```
CASE GUESS OF
WHEN 1,2,3,4,5
  COLOUR$:="RED"
  FACTOR:=1.5
WHEN 6,7,8
  COLOUR$:="YELLOW"
  FACTOR:=3
WHEN 9
  COLOUR$:="BLUE"
  FACTOR:=10
ENDCASE
```

If the <case selector> GUESS is equal to 1, 2, 3, 4, or 5, the first case is executed. If GUESS is equal to 6, 7, or 8, the second case is executed, and if GUESS is equal to 9 the last of the cases is executed.

```
CASE MONTH$ OF
WHEN "JAN","MAR","MAY","JUL","AUG","OCT","DEC"
  PRINT "THE MONTH HAS 31 DAYS."
WHEN "APR","JUN","SEP","NOV"
  PRINT "THE MONTH HAS 30 DAYS."
WHEN "FEB"
  IF YEAR MOD 4=0 THEN
    PRINT "THE MONTH HAS 29 DAYS"
  ELSE
    PRINT "THE MONTH HAS 28 DAYS"
  ENDIF
OTHERWISE
  PRINT "OLD MAN GREGOR TURNS OVER IN HIS GRAVE."
ENDCASE
```

CAT

is a command used to display the contents of a diskette. Its syntax is

```
CAT [<drive no.>]
```

The command

```
CAT
```

CAT (continued)

causes the system to display catalogs of all diskettes mounted in system disk drives. The command

```
CAT 0
```

shows the catalog of the diskette in drive 0, unit 8.

CHAIN

The CHAIN statement or command is used to load a program stored on disk and run it. Its syntax is

```
CHAIN <file name> [,<unit no.>]
```

If no <unit no.> is specified, disk unit number 8 is used. Programs already in main storage will be deleted when the CHAIN statement is invoked. Only programs stored by means of the SAVE command can be retrieved via CHAIN.

```
CHAIN "UPDATE"
```

loads the program named "UPDATE" from drive 0, unit 8, and runs it. **See also SAVE and LOAD.**

CHR$

is a standard function. CHR$(X) returns the character whose ASCII value is X.

CLOSE

CLOSE is a statement or command used to sign-off data files. Its syntax is

```
CLOSE [FILE] [<file number>]
```

CLOSE (continued)

The statement (or command)

```
CLOSE
```

closes all files that have been opened. The statement (or command)

```
CLOSE 3
```

closes file number 3 only.

The keyword FILE is added automatically by the interpreter if not entered by the user. **See also OPEN, READ, PRINT, INPUT.**

CLOSED

If the keyword CLOSED terminates the procedure heading, all variables in the procedure will be local. Normally this is only the case with the parameters.

```
PROC WINDOW(X,Y) CLOSED
  SCREEN(X,1)
  FOR I:=1 TO Y-X+1 DO ERASE'LINE(I)
  SCREEN(X,1)
ENDPROC WINDOW
//
PROC SCREEN(L,C) CLOSED
  X:=984+L*40
  POKE 209,X MOD 256 //LINE LOW BYTE
  POKE 210,X DIV 256 //LINE HIGH BYTE
  POKE 211,C-1 //COLUMN
ENDPROC SCREEN
//
PROC ERASE'LINE(L) CLOSED
  SCREEN(L,1)
  FOR I:=1 TO 40 DO PRINT " ",
ENDPROC ERASE'LINE
```

The variables X, Y, L, C, and I are all local, X, Y, L, AND C because they are parameters and I because the procedures are closed. Thus the X used in SCREEN and the X used in WINDOW are different objects. The same goes for I in WINDOW and ERASE'LINE. **See also PROCEDURES AND PARAMETERS and FUNC.**

CON

CON is a command that restarts a program which has been stopped.

```
CON
```

Due to the internal linking of structures in a COMAL program, the CON command cannot be used after deletion or insertion of statements or introduction of new variables. **See also STOP.**

COS

is a standard function. COS(X) returns the cosine of X (X in radians).

DATA

A DATA statement is used to hold numeric or string constants that may be retrieved in a READ statement. Its syntax is:

```
DATA <value> {,<value>}
```

where <value> is a <numeric constant> or a <string constant>.

```
REPEAT
  READ NAME$,TEL
  FOUND:=(THISNAME$=NAME$)
UNTIL FOUND OR EOD
DATA "COLLINS",23,"JACOBS",34,"HUDSON",45
DATA "KILROY",14,"ATHERTON",10,"BRAMER",15
```

See also EOD, READ, and RESTORE.

DEL

The DEL command is used to remove one or more lines from a program in main storage:

```
DEL [<line number> [-[<line number>]]]  or
DEL -<line number>
```

DEL (continued)

COMMAND	RESULTS
DEL 100	Removes line 100 from program
DEL 100-200	Removes lines between 100 and 200 inclusive
DEL -300	Removes all lines up to and including 300
DEL 300-	Removes all lines numbered 300 or greater

Important note. A line cannot be removed by just giving its line number. This is because empty statements are allowed in versions 2.00 and later, so entering a line number and nothing else would simply introduce an empty statement with that line number. The DEL command should not be confused with the DELETE command which is used to remove files from a disk.

DELETE

The DELETE statement or command is used to remove files from a disk. Its syntax is

```
DELETE <file name> [,<unit no.>]
```

The <file name> must include the drive number. Thus the command

```
DELETE "0:MYPROG"
```

deletes the file "MYPROG" stored on the diskette in drive number 0, unit no. 8, whereas

```
DELETE "0:YOURPROG",9
```

erases the file "YOURPROG" stored on the diskette in drive number 0, unit number 9.

DIM

The DIM statement is used to declare strings and arrays of numerics and strings. Its syntax is

```
DIM <declaration> {,<declaration>}
```

A <declaration> could be a <numeric declaration> as in

```
DIM TABLE(-1:100)
```

or a <string declaration> as in

```
DIM NAME$(0:20) OF 30
```

Since the DIM statement is very versatile and powerful, it is not all that simple to give a detailed description of its syntax. Instead we shall look at some examples. The statement

```
DIM TABLE(-1:100),MARKS(1000:1500,8:10)
```

declares an array of real numbers, named TABLE, with indices ranging from -1 to 100, and a two dimensional numeric array, named MARKS, with indices ranging from 1000 to 1500 and 8 to 10. You may use any <numeric expression> for lower bound and upper bound, as long as the value returned for the lower one is smaller than or equal to the value returned for the upper one. Non-integer values are truncated. If no lower bound is given the interpreter uses 1 in its place. Thus the statement

```
DIM JOBCODE(100)
```

declares an array of numerics with indices ranging from 1 to 100 and is totally equivalent to

```
DIM JOBCODE(1:100)
```

The statement

```
DIM NAME$ OF 30, ANSW$ OF 3
```

DIM (continued)

declares two single string variables such that the first one may hold up to 30 characters and the second one up to 3 characters. Single string variables must be declared. The following statement

```
DIM PUPIL$(30:100,8:10) OF 30
```

declares an array of strings with indices ranging from 30 to 100 and 8 to 10 where each component may hold up to 30 characters.

An array may have any number of dimensions.

DIV

is an operator that denotes integer division. **See also EXPRESSIONS.**

DO

DO is used with FOR and WHILE statements. **See FOR and WHILE.**

EDIT

The EDIT command is used to display a list of the program presently in workspace, but without the structured indentation invoked by the LIST command. The syntax of the EDIT command is

```
EDIT [<line number> [-[<line number>]]]  or
EDIT -<line number>
```

The EDIT command is used when editing to avoid including "false spaces" caused be the automatic indentation of lines that are wrapped around. **See also LIST.**

ELIF

The ELIF ("ELSEIF") statement can only be used with the IF statement. **See IF.**

ELSE

The ELSE statement can only be used with the IF statement. **See IF.**

END

The END statement makes the system terminate execution of a program. **See also STOP.**

ENDCASE

The ENDCASE statement is used to terminate the last block in a CASE multi-way branching structure. **See CASE.**

ENDFOR

The ENDFOR statement is used to terminate the block controlled by a FOR statement. **See FOR.**

ENDFUNC

The ENDFUNC statement is used to terminate the definition of a user defined function. **See FUNC.**

ENDIF

The ENDIF statement is used to terminate the last block of statements in an IF branching. **See IF.**

ENDPROC

The ENDPROC statement is used to terminate the definition of a procedure. **See PROCEDURES AND PARAMETERS.**

ENDWHILE

The ENDWHILE statement is used to terminate the block of statements controlled by a WHILE statement. **See WHILE.**

ENTER

The ENTER command is used to enter a program stored on disk or tape into workspace:

```
ENTER <file name> [,<unit no.>]
```

Default value of <unit no.> is 8. The command

```
ENTER "0:MYPROG",9
```

ENTER (continued)

is used to enter the program "MYPROG" found on drive number 0, unit number 9, whereas the command

```
ENTER "YOURPROG",1
```

retrieves the program "YOURPROG" found on the cassette in unit number 1 (datasette).

Only programs stored by means of the LIST command may be retrieved with the ENTER command.

Important note: Program lines that are taken in by the ENTER command are merged into an existing program in the same way as lines typed from the keyboard. **See also LOAD, LIST and SAVE.**

EOD

is a standard Boolean function. EOD returns a value of TRUE (numeric 1) if the last element in a data queue has been read, otherwise a value of FALSE (numeric 0) is returned. **See also READ.**

EOF

is a standard Boolean function. EOF(X) returns a value of TRUE (numeric 1) if the end-of-file in a sequential file has been reached, otherwise a value of FALSE (numeric 0) is returned. **See also READ and INPUT.**

```
OPEN 2,"PERSONS",READ
WHILE NOT EOF(2) DO
  READ FILE 2: NAME$,ADR$,CITY$
  PRINT NAME$
  PRINT ADR$
  PRINT CITY$
ENDWHILE
CLOSE
```

ESC

The function ESC returns a value of TRUE (numeric 1) if the STOP key is depressed, otherwise it returns a value of FALSE (numeric 0). The ESC function is not active unless a TRAP ESC- statement has been encountered. **See also TRAP.**

EXEC

The keyword EXEC, short for EXECute, may be used to indicate a procedure call. The syntax of a procedure call is

```
[EXEC] <identifier>(<list of actual parameters>)
```

The normal way of calling a procedure is by simply stating the name of the procedure followed by the parameter list, if any. But for sake of compatibility with earlier versions of COMAL the dummy keyword EXEC may still be used. Normally the EXEC is suppressed on the listing of the program, but by using the SETEXEC command (see SETEXEC) you can force the interpreter to display it.

The following statements

```
PRINTOUT(NAME$,ADDRESS$)
EXEC PRINTOUT(NAME$,ADDRESS$)
```

are equivalent. They are both calling the procedure PRINTOUT passing the parameters NAME$ and ADDRESS$. **See PROCEDURES AND PARAMETERS.**

EXP

is a standard function. EXP(X) returns the value of e (nat. log. base) to the power of X (thus being the inverse of nat. log.)

EXPRESSIONS

A <numeric expression> can contain constants, variables, and numeric functions, used with parentheses and the following operators according to the usual rules of mathematics:

+	monadic +	+A
-	monadic -	-A
↑	power	A↑B
*	multiplication	A*B
/	division	A/B
DIV	integer division (see below)	A DIV B
MOD	remainder from division (see below)	A MOD B
+	addition	A+B
-	subtraction	A-B

If A and B are integers then A MOD B is the so-called principal remainder from division of A by B, i.e. the smallest non-negative integer R such that

```
A = B*Q + R
```

and A DIV B is the quotient Q.

Numeric values may be compared by means of the following relational operators:

```
<   <=   =   >=   >   <>
```

i.e. "less than", "less than or equal to", "equal to", "greater than or equal to", "greater than", and "is not equal to".

Numeric expressions may be used as Boolean expressions. A numeric value equal to zero is interpreted as FALSE, whereas any value other than zero is interpreted as TRUE. A logical operation returns a numeric 1 for TRUE and 0 for FALSE.

The following Boolean operators are available:

NOT logical negation. NOT A returns a value of FALSE, i.e.numeric 0, if A has a value of TRUE, i.e. a numeric value different from zero, but a value of TRUE (numeric 1) if A has a value of FALSE (is equal to zero).

EXPRESSIONS (continued)

AND logical conjunction. A AND B returns a value of TRUE if A and B are both TRUE, otherwise a value of FALSE is returned.

OR logical disjunction. A OR B returns a value of FALSE if A and B are both FALSE, otherwise a value of TRUE is returned.

A <string expression> may consist of string constants, string variables, string array elements, or string functions concatenated by means of the + sign. String expressions may be compared by means of the operators:

< <= = >= > <>

meaning this time "comes before", "comes before or is equal to", "is equal to", "comes after or is equal to", "comes after", "is not equal to", using lexicographical ordering. Note that strings with relational operators make up expressions that return numerical values; 1 for TRUE and 0 for FALSE.

IN is used for string pattern matching. The expression A$ IN B$ returns a value of zero (i.e. FALSE) if A$ is not found as a substring of B$, but if A$ is found as a substring of B$ the expression returns the position of the first matching character.

If NAME$ has a value of "LOTTIE CHRISTENSEN" then the expression

```
SURNAME$ IN NAME$
```

returns a value of 8 (TRUE) if SURNAME$ is equal to "CHRISTENSEN", but the value 0 (FALSE) if SURNAME$ is equal to "CRISTENSEN".

EXPRESSIONS (continued)

The priority of the above mentioned operators is:

```
↑ (power)
*  /  DIV  MOD
+  -
<  <=  =  >=  >  <>  IN
NOT
AND
OR
```

FALSE

To improve the readability of programs, two constants TRUE or FALSE are predefined. TRUE is equal to 1, and FALSE is equal to 0.

FILE

See OPEN, CLOSE, READ, and WRITE.

FOR

A FOR statement is used to control the execution of a FOR loop. The syntax of the FOR statement and FOR loop is

```
FOR <for range> [<step>] DO
  <statement list>
ENDFOR [<control variable>]
```

where <for range> is

```
<control variable>:=<initial value>
   TO <final value>
```

and <step> is

```
STEP <step value>
```

The <control variable> is a <numeric variable>, and <initial value>, <final value>, and <step value> are <numeric expressions>.

The <control variable> following the keyword ENDFOR has been bracketed to indicate that it is supplied automatically by the interpreter if not entered by the programmer. To ensure compatibility with earlier versions of COMAL the keyword NEXT is accepted on entry instead of ENDFOR. In a listing the keyword ENDFOR is displayed.

```
FOR X:=1 TO 5 DO
  SUM:=SUM+X
  PRINT SUM;
ENDFOR X
```

First the control variable X is set to 1 and the two statements in the range of the loop are executed. Then X is set to 2, and the statements are executed again. This goes on as long as X is not greater than the final value 5. When X assumes a value of 6 execution of the loop is stopped and the interpreter starts on the statement following the ENDFOR statement. Note that X has a value of 6, i.e. <final value>+1, when the loop terminates. Also note that this value is not actually used in the loop.

FOR (continued)

```
FOR N:=1 TO 10 STEP 2 DO
  SUM:=SUM+N
  PRINT SUM
ENDFOR N
```

In this example N assumes the values 1, 3, 5, 7, 9, and 11, since a step value of 2 is prescribed. Note that the control variable N has an unused value of 11 when execution of the loop terminates.

```
FOR P:=10 TO 1 STEP -1 DO
  PRINT TEXT$(1:P)
ENDFOR P
```

The statement in the loop is executed for P equal to 10, 9, 8, ..., 1. The termination value of P is 0 and not used in the loop.

A short FOR loop is available. Its syntax is

```
FOR <for range> [<step>] DO <statement>
```

No ENDFOR statement is allowed in this case. The one-line FOR statement may also be used as a command.

```
FOR P:=10 TO 1 STEP -1 DO PRINT TEXT$(1:P)
```

This loop is functionally equivalent to the previous one only this time the short form is used.

```
FOR T:=1 TO 750 DO NULL
```

This loop waits till COMAL has counted from 1 to 750.

FUNC, ENDFUNC, RETURN

The FUNC statement is used as the first statement - or head - of any user-defined function. The syntax of a user defined function is

```
FUNC <function identifier> <head appendix>
  <function body>
ENDFUNC [<function identifier>]
```

The <function identifier> is a <variable identifier> and the <head appendix> is specified as

```
[(<formal parameter list>)] [CLOSED]
```

The <function body> is made up of COMAL statements.

A function value must be returned in a RETURN statement (see RETURN), and at least one such statement must be present in the <function body>.

The <function identifier> following ENDFUNC is supplied automatically by the system during the prepass if not entered by the programmer.

Note. If you are not very familiar with multi-line functions and parameters, it might be advisable that you read the section about PROCEDURES AND PARAMETERS before continuing the present one.

```
FUNC DISTANCE(X,Y)
  IF X<=Y THEN
    RETURN Y-X
  ELSE
    RETURN X-Y
  ENDIF
ENDFUNC DISTANCE
```

This function is called in a statement like

```
PRINT DISTANCE(10,-4)
```

The values of the actual parameters 10 and -4 are assigned ("passed") to the formal parameters X and Y, respectively, and the value 14 is returned. The PRINT statement displays 14.

FUNC, ENDFUNC, RETURN (continued)

```
FUNC POS(A$,B$)
  RETURN A$ IN B$
ENDFUNC POS
```

This function represents nothing but a renaming of the IN operator. In some cases such a renaming could contribute to better documentation.

```
FUNC GCD#(X#,Y#)
  IF (X# MOD Y#)=0 THEN
    RETURN Y#
  ELSE
    RETURN GCD#(Y#,X# MOD Y#)
  ENDIF
ENDFUNC GCD#
```

This function returns the GCD (Greatest Common Divisor) of two integers. Note that the function itself is of type integer, and that it calls itself recursively.

```
FUNC VALUE(A$) CLOSED
  LN:=LEN(A$)
  ONES:=ORD(A$(LN))-ORD("0")
  IF LN=1 THEN
    RETURN ONES
  ELSE
    RETURN ONES+VALUE(A$(1:LN-1))*10
  ENDIF
ENDFUNC VALUE
```

This function also calls itself recursively from the expression in the last RETURN statement.

```
FUNC HASH(A$,HASHER) CLOSED
  LN:=LEN(A$); T:=0
  FOR I:=1 TO LN DO T:+ORD(A$(I))
  RETURN T MOD HASHER
ENDFUNC HASH

FUNC MEAN(N,REF A()) CLOSED
  SUM:=0
  FOR I:=1 TO N DO SUM:+A(I)
  RETURN SUM/N
ENDFUNC
```

FUNC, ENDFUNC, RETURN (continued)

This function uses an array A passed as a parameter by reference. **See also PROCEDURES AND PARAMETERS and CLOSED.**

GOTO

The syntax of a GOTO is:

```
GOTO <label>
```

where <label> is an <identifier>. The GOTO statement transfers control to a <label statement> thus defined:

```
<label>:

IF FATALERROR THEN
  PRINT "FATAL ERROR. CANNOT CONTINUE."
  GOTO HALT
ENDIF
...
HALT:
STOP
```

Using a GOTO statement you can jump out of any structure, but not out of a procedure. If you try to jump into a structure the result is unpredictable. Jumping into a procedure may cause a system breakdown.

IDENTIFIERS

Identifiers are used to name variables, labels, functions, and procedures. An identifier may contain as many as 78 characters, all significant. The first character must be a letter, the rest may be letters, digits, or any one of the following characters: apostrophe ('), [,], backslash, or left arrow (<-).

Here are some legal identifiers:

```
MAXNUMBER, HOUSENO, NUMBER'OF'VOWELS, NAME$,
  NAME'OF'MY'UNCLE$
N1, N2, N3, CREATE'RECORD,  GET'DIGIT,
  GET'CHARACTER$
```

IF, ELSE, ELIF, ENDIF

The IF statement is the head of the IF structure that controls conditional branching. The syntax of the IF structure and the statements that go with it is shown in the following diagram:

```
  IF <logical expression> [THEN]
    <statement list>
 {ELIF <logical expression> [THEN]
    <statement list>}
 [ELSE
    <statement list>]
  ENDIF
```

where <logical expression> is the same as <numerical expression>. The keyword THEN is supplied automatically by the system if not entered by the user. The lines in a <statement list> are automatically indented by the interpreter on the program listing.

In COMAL you also have a short form of the IF statement. Its syntax is:

```
  IF <logical expression> THEN <statement>
```

Note that no ENDIF is allowed in this case. On the other hand the keyword THEN must be entered.

```
  IF I<=J THEN
    W:=A(I); A(I):=A(J); A(J):=W
    I:=I+1; J:=J-1
  ENDIF
```

If the expression I<=J evaluates to TRUE (numeric 1) the statement list between IF and ENDIF is executed. If, however, it returns FALSE (numeric 0) the statement list is skipped and control is transferred to the statement following ENDIF.

```
  IF TRY<3 THEN
    PRINT "NO, TRY AGAIN"
  ELSE
    PRINT "NO, THE ANSWER IS ",RESULT
    PRINT "TYPE THAT!"
  ENDIF
```

IF, ELSE, ELIF, ENDIF (continued)

If the expression TRY<3 evaluates to TRUE, the statement between IF and ELSE is executed, but if it returns the value FALSE, the statements between ELSE and ENDIF are executed. In both cases control is then transferred to the statement following ENDIF.

```
D:=B*B-4*A*C
IF D>0 THEN
  PRINT "TWO REAL ROOTS:"
  PRINT "X1 = ",(-B+SQR(D))/2/A
  PRINT "X2 = ",(-B-SQR(D))/2/A
ELIF D=0 THEN
  PRINT "ONE REAL ROOT:"
  PRINT "X = ",-B/2/A
ELSE
  PRINT "DISCRIMINANT NEGATIVE"
  PRINT "NO REAL ROOTS."
ENDIF
```

If the expression D>0 returns the value TRUE the first three-statement list is executed, and the rest is skipped. If, however, it is evaluated to FALSE, the interpreter evaluates the expression D=0 following ELIF. If that appears to be TRUE, the second statement list is executed. If the second expression also has a value of FALSE, execution finally falls through to the last statement list, i.e. the one following the ELSE statement. Note that never more than one statement list is executed. This means that if two expressions may become TRUE, only the statement list following the first of them is executed.

```
IF OBS<10 THEN
  FREQUENCY(1):+1
ELIF OBS<20 THEN
  FREQUENCY(2):+1
ELIF OBS<30 THEN
  FREQUENCY(3):+1
ELIF OBS<40 THEN
  FREQUENCY(4):+1
ELSE
  FREQUENCY(5):+1
ENDIF
```

IF, ELSE, ELIF, ENDIF (continued)

In this example it is utilized that one <statement list> at most is executed. If it is TRUE that OBS<10 all the rest of the Boolean expressions are also TRUE, but only FREQUENCY(1) is increased by 1. If on the other hand it is TRUE that 10<=OBS and OBS<20 only the second assignment is executed. It is easy to see how this could be used in statistics.

```
IF CHAR$ IN SET'OF'LETTERS$ THEN
  IF CHAR$ IN SET'OF'VOWELS$ THEN
    VOWELS:+1 //ANOTHER VOWEL
  ELSE
    CONSONANTS:+1 //ANOTHER CONSONANT
  ENDIF
ELIF CHAR$=" " THEN
  WORDS:+1 //ANOTHER WORD
ELIF CHAR$ IN SET'OF'DIGITS$ THEN
  DIGITS:+1 //ANOTHER DIGIT
ELSE
  SPECIALS:+1 //ANOTHER SPECIAL
ENDIF

IF JOB=3 THEN PRINTOUT
```

is functionally equivalent to

```
IF JOB=3 THEN
  PRINTOUT
ENDIF
```

In both cases the procedure PRINTOUT is called if JOB has a value of 3.

IN

is a Boolean operator used for string matching. For further explanation **see EXPRESSIONS.**

INPUT

The INPUT statement is used to fetch data from keyboard. Its syntax is

```
INPUT [<prompt>:] <input list> [<print end>]
```

INPUT (continued)

where <prompt> is a <string expression>, <input list> is a list of variable identifiers, and <print end> is a semicolon (;).

```
INPUT MAXNUMBER
```

When this statement is executed, the system displays the sign "?" and waits for the user to enter a number and press the RETURN key. The number typed in is assigned as a value to MAXNUMBER.

```
INPUT "ENTER NAME: ": NAME$
```

When this statement is executed the system displays the user defined prompt

```
ENTER NAME:
```

and pauses to let the user type in a string to be assigned as a value to the variable NAME$.

```
INPUT NAME$,AGE
```

When this statement is executed the system displays its standard prompt "?" and pauses. The user is expected to type in a string and press the RETURN key. The string is then assigned to NAME$ and the system submits another "?" on the same line and pauses to let the user type in a number.

```
INPUT A,B,C
```

This statement will ask the user to enter three numbers. The following options may be chosen: You can enter three numbers like

```
5 80 34
```

and then press RETURN. The variable A is then set to 5, B to 80, and C to 34. You can also enter the three numbers in the following manner:

```
5,80,34
```

INPUT (continued)

and then press RETURN. Finally you may obtain the same result by entering 5 and press RETURN, then 80 and press RETURN, and finally 34 and press RETURN. In the first two cases only one "?" is displayed, in the last case three "?" are submitted.

```
INPUT "FROM: ":FIRST$;
INPUT "  TO: ":LAST$
```

The semicolon terminating the first statement prevents the line from being shifted after the first string has been typed in. The result of a program-user dialog might look like this:

```
FROM: 12.DEC.80  TO: 23.DEC.80
```

The RETURN key was pressed after each entry.

Note that a string variable in an <input list> will pick up all characters entered from the keyboard. Therefore you can not have more than one string variable in the list, and it must always be the last one.

INPUT FILE

is used to retrieve data from a file that was created using PRINT FILE. It will also allow characters to be read directly off the screen. The syntax of an INPUT FILE statement is:

```
INPUT FILE <file no.>[,<rec. no.>]: <input list>
[<print end>]
```

where <input list> is a list of variable identifiers, <rec. no.> is a <numeric expression> and <print end> is comma (,) or semicolon (;).

```
OPEN FILE 3,"MYDATA",READ
REPEAT
  INPUT FILE 3: LINE$
  PRINT LINE$
UNTIL EOF(3)
CLOSE
```

This program reads and displays the contents of the sequential file "MYDATA".

INPUT FILE (continued)

```
VIDEO:=3
OPEN FILE VIDEO,"",UNIT 3,READ
SELECT "LP:"
FOR ROW:=1 TO 25 DO
  INPUT FILE VIDEO: TEXT$
  PRINT TEXT$
ENDFOR ROW
CLOSE VIDEO
SELECT "DS:"
```

This program reads the screen line by line and prints a hard copy of its contents.

INT

is a standard function. INT(X) returns the integer part of X, i.e. the greatest integer less than or equal to X.

KEY$

is a standard function. It returns the first ASCII character in the input buffer. If no key has been depressed, an ASCII null is returned.

```
PROC GET'CHAR(REF T$)
  T$:=CHR$(0)
  WHILE T$=CHR$(0) DO T$:=KEY$
ENDPROC GET'CHAR
```

LABELS

A label is used as a jump address for a GOTO statement. The syntax of a label statement is

```
<identifier>:
```

Note that GOTO <line number> is not allowed.

```
IF BREAK THEN GOTO HALT
...
HALT:
STOP "EXECUTION BREAKED BY USER"
```

LABELS (continued)

If BREAK assumes a value of TRUE (value not equal to 0) control is transferred to the label statement. **See also GOTO.**

LEN

is a standard function. LEN(X$) returns the current length (number of characters) of the string value of X$.

LINEFEED

The command

```
LINEFEED+
```

makes the system emit a linefeed after each carriage return, when output is to the printer. The command

```
LINEFEED-
```

disables this facility, i.e. no linefeed is sent out after a carriage return. Default mode is LINEFEED-.

LIST

is a command used to display or store a whole program or a part of a program residing in workspace. The syntax of the command is:

```
LIST [<line number>[-[<line number>]]]  or
LIST -<line number>
```

where <name> is the name of a function or a procedure.

LIST (continued)

COMMAND	RESULT
LIST	List the whole program
LIST 100	List line numbered 100
LIST 100-200	List all lines between 100 and 200 inclusive
LIST -300	List all lines up to and including 300
LIST 300-	List all lines numbered 300 or greater

The LIST command may also be used to store programs on disks or tapes. The command

```
LIST "MYPROG"
```

stores a program now in main storage on disk as a program file with the name of "MYPROG". The program is stored as source code, and may therefore later be merged with another program in main storage (see ENTER). Since the LIST command handles source code directly, this version is also permitted:

```
LIST 100-200 "YOURPROG"
```

In this case line 100-200 are stored in a file named "YOURPROG".

If another device than disk unit no. 8 is used, <unit no.> must be added to the command.

A program that has been stored by the LIST command has type SEQ and may be opened as any other sequential file and read by an INPUT FILE statement. **See also PRINT FILE, ENTER, and EDIT.**

LOAD

is a command used to retrieve programs from disk or tape. Its syntax is

```
LOAD <file name> [,<unit no.>]
```

The command

```
LOAD "MAINPROG"
```

LOAD (continued)

will load the program "MAINPROG" into workspace. If you want to retrieve the program from a device other than disk unit no. 8, a unit no. must be specified:

```
LOAD "YOURPROG",1
```

will load the program "YOURPROG" from cassette into workspace. **See also CHAIN, SAVE, LIST, and ENTER.**

LOG

is a standard function. LOG(X) returns the natural logarithm of X.

MOD

is an operator that returns the remainder from integer division. **See also EXPRESSIONS.**

NEW

is a command that clears the whole workspace of program and data. Its syntax is

```
NEW
```

NEXT

The NEXT statement may be used to terminate a block of statements controlled by a FOR statement. The keyword NEXT is automatically altered into ENDFOR by the interpreter. **See also FOR.**

NOT

is a Boolean operator that denotes negation. For further explanation **see EXPRESSIONS.**

NULL

The NULL statement does nothing. Its syntax is

```
NULL
```

It might seem a bit strange or even extravagant to have a "no-op" statement like that to perform the "empty action", but it can be inserted in some special cases to satisfy the syntax of COMAL. The example below will show how.

```
FOR I:=1 TO 750 DO NULL //WAIT
```

OF

is a keyword used to terminate the CASE statement and as part of the declaration of string variables or string arrays. **See also CASE and DIM.**

OPEN

is a command or statement used to assign numbers to files for reference. Its syntax is

```
OPEN [FILE] <file number>,<file name>[,<dev. info>][,<type>]
```

<file number> is a <numeric expression> that must return a value from 2-254, <dev. info> is

```
UNIT <unit no.> [,<secondary addr>]
```

where <secondary addr> is a <numeric expression> that must return a value from 0-15. Finally <type> is READ for sequential reading, WRITE for sequential writing, APPEND for continued sequential writing, or RANDOM <record length> for reading to or writing from a direct access file (random file), where <record length> is a <numeric expression> that must return a positive value.

```
OPEN FILE 3,"MARKS",READ
```

assigns the file "MARKS" as file number 3. The keyword READ indicates that a sequential file is referred to, and that data may be retrieved from it, starting from the beginning of the file.

OPEN (continued)

```
OPEN FILE 4,"@0:MARKS",WRITE
```

The file "MARKS" is signed on as file number 4. The keyword WRITE indicates that a sequential file is referred to, and that data may be stored in it, starting from the beginning of the file. The "@0:" token indicates that if the file exists already then it may be overwritten. The same effect may be obtained by using these statements:

```
DELETE "0:MARKS"
OPEN FILE 4,"MARKS",WRITE
```

The keyword APPEND indicates that a sequential file is referred to, and that data may be stored in it, starting from the end of the existing file, thus appending more data to it.

```
OPEN FILE 6,"MARKS",APPEND
```

The file "MARKS" is signed on as file number 6.

```
OPEN FILE 3,"CLIENTS",RANDOM 250
```

With this statement the direct access file "CLIENTS" is signed on for both reading and writing. The constant 250 following the keyword RANDOM indicates that each record can be up to 250 bytes long. **See also CLOSE, READ, WRITE, PRINT, and INPUT.**

OR

is a Boolean operator that denotes disjunction. **See EXPRESSIONS.**

ORD

is a standard function. ORD(X$) returns the ASCII value of the first character held by X$.

OTHERWISE

The OTHERWISE statement is used in the CASE structure to indicate a default case. **See CASE.**

PASS

is a command to pass strings to the CBM disk. The strings are interpreted as commands by the disk operating system (see your disk manual for disk commands). Its syntax is

PASS <string expression>

PASS "N0:CONNIE'S DISK,01" passes a format command to the disk

PEEK

is a standard function. PEEK(X) returns the contents of a memory location X (X in the range 0-65535) in decimal representation.

POKE

is a statement or command to assign values to specified locations in memory. Its syntax is:

POKE <location>,<contents>

where <location> is a <numeric expression> that must return a value from 0-65535, and <contents> is a <numeric expression> that must return a value from 0-255 (one byte).

POKE 650,128 makes C64 keys repeat

PRINT

The PRINT (may be entered as ;) statement or command outputs data to the data screen or the printer. Its syntax is

PRINT [<output list>] [<print end>]

where <output list> is

<print element> {<print separator>
<print element>}

PRINT (continued)

The <print element> is an <expression> or the TAB function, and <print separator> is either a comma (,) or a semicolon (;). If a semicolon is used an extra space is output between one <print element> and the next; if a comma is used no extra spaces are output unless otherwise stated in a ZONE statement (see ZONE). The <print end> is the same as <print separator>.

```
PRINT "THIS IS THE ",3,". TIME"
```

outputs

```
THIS IS THE 3. TIME
```

The same output results from

```
PRINT "THIS IS THE";3,". TIME"
```

The next statement:

```
PRINT "THE NAME OF THE ",NO,". PUPIL IS ",NAME$(NO)
```

may output the following

```
THE NAME OF THE 5. PUPIL IS ROY MANNING
```

The same output may be produced by

```
PRINT "THE NAME OF THE";
PRINT NO,". PUPIL IS";
PRINT NAME$(NO)
```

Note the use of semicolon as <print end> in this case. If comma is used you get

```
PRINT "THE NAME OF THE ",
PRINT NO,". PUPIL IS ",
PRINT NAME$(NO)
```

PRINT FILE

is used to store data on disk or tape. Its syntax is

```
PRINT FILE <file no.>[,<rec. no.>]: <print list>
  [<print end>]
```

<print list> and <print end> are as specified for PRINT, <rec. no.> is a <numeric expression>. A file that has been created using PRINT FILE is of type SEQ and data from it may be retrieved by means of INPUT FILE.

```
OPEN FILE 4,"PERSONS",UNIT 1, WRITE
FOR NO:=1 TO MAXNO DO
  PRINT FILE 4: NAME$(NO)
  PRINT FILE 4: ADDR$(NO)
  PRINT FILE 4: PAYCD(NO)
ENDFOR NO
CLOSE
```

The program stores data sequentially on a cassette in the file signed on as number 4. The data thus stored may be retrieved by means of the following:

```
OPEN FILE 6,"PERSONS",UNIT 1, READ
FOR J:=1 TO MAX DO
  INPUT FILE 6: NAME$(J)
  INPUT FILE 6: ADDR$(J)
  INPUT FILE 6: PAYCD(J)
ENDFOR J
CLOSE
```

Normally PRINT FILE and INPUT FILE are only used for sequential data files on cassette. **See also READ FILE, WRITE FILE, and OPEN FILE.**

PRINT USING

The PRINT USING statement is used when formatted output of numbers is required. The syntax is

```
PRINT USING <format info>: <using list>
  [<print end>]
```

PRINT USING (continued)

where <format info> is a <string expression> and <print end> is as specified for PRINT. The <using list> is

<numeric expression> {,<numeric expression>}

The <format info> can contain texts and format fields. A format field is a string that serves as a model for the printout of numeric values. The hash mark (#) reserves a digit place, the dot (.) specifies the location of the decimal point, if any, and a minus sign can be introduced to be displayed if the value of the number is negative.

```
PRINT USING "  ###     ####.##": A,B
```

If A equals 23.6 and B equals 234.567 the following output is produced:

```
 24     234.57
```

If A is equal to 1234 and B has a value of 546 the following output is produced:

```
***     546.00
```

with the three *'s indicating that there is an overflow in the format.

```
PRINT USING "THE ROOT IS: -##.##": -B/2/A
```

If B is equal to 15.748 and A is equal to 7.2 the statement produces the following output:

```
THE ROOT IS: -1.09
```

If B equals 234.67 and A is equal -23.3 the statement produces this output:

```
THE ROOT IS:  5.04
```

PROCEDURES AND PARAMETERS

The PROC statement is used as the first statement - or head - of any user-defined procedure. The syntax of a procedure is

```
PROC <procedure identifier> <head appendix>
  <procedure body>
ENDPROC [<procedure identifier>]
```

The <head appendix> is specified as

```
[(<formal parameter list>)] [CLOSED]
```

The <procedure identifier> is an <identifier>, the <procedure body> is made up of COMAL statements. The <procedure identifier> following ENDPROC is supplied automatically by the system during prepass if not entered by the programmer.

The <formal parameter list> is specified as

```
<formal parameter> {,<formal parameter>}
```

where a <formal parameter> could be either

```
[REF] <variable identifier>  or
REF <variable identifier>({,})
```

If the keyword REF is used before a parameter it is passed by reference, otherwise it is passed by value. Arrays of any type can only be passed by reference.

Example: A procedure that starts with this statement

```
PROC TRY(I,J)
```

called with:

```
TRY(FIRST,LAST)
```

PROCEDURES AND PARAMETERS (continued)

In this case the identifiers I and J in the procedure head are formal parameters, and a value is assigned to each of them when the procedure is called. The identifiers FIRST and LAST referred to in the calling statement are actual parameters and must be defined whenever the statement comes to be executed. During the procedure call, I is assigned the value of FIRST (the value of FIRST is "passed" to I), and J is assigned the value of LAST. Since actual values are passed, I and J are also called value parameters.

But there is more to it. I and J will be treated as local variables to the procedure TRY, and that means that they will not be known to the "world" outside the procedure, and therefore they will not be confused with variables I and J, if any, in other parts of the program. Also when the procedure is finished any trace of local variables is removed.

Actual parameters to be passed by value may be constants, variables, or expressions, as long as they are ready to "deliver a value" on request, i.e. whenever a call is invoked. The procedure TRY might be called by statements like

```
TRY(1,9)   or   TRY(P-1,P+L-1)
```

```
PROC BACKWARDS(W$)
  LN:=LEN(W$); B$:=""
  FOR I:=LN TO 1 STEP -1 DO B$:+W$(I)
ENDPROC BACKWARDS
```

The above procedure is called from these mainlines:

```
DIM B$ OF 30
INPUT "ENTER WORD (MAX. 30 CHAR.): ": B$
BACKWARDS(B$)
PRINT B$
```

PROCEDURES AND PARAMETERS (continued)

The value of B$ is passed to W$ during the call. Note that W$ is not declared explicitly. When a string variable is used as a formal parameter it is automatically given the length necessary to hold the actual string value passed to it. When the procedure is finished the part of memory occupied by W$ is set free.
A procedure is headed

```
PROC WRITERECORD(R,N$,REF M())
```

and is called by

```
WRITERECORD(STUDENTNO,NAME$,MARKS)
```

In this example R and N$ are formal value parameters, and during the call they are assigned the values of STUDENTNO and NAME$, respectively. The

```
REF M()
```

denotes a formal parameter M that is called by reference. The string "()" following M indicates that M must refer to a one dimensional array. If the call is to be legal, MARKS must be the name of a one dimensional array. With a reference parameter no assignment takes place during the call, but the formal parameter in question is simply used by the procedure as a "nickname" for the actual parameter. So in this case MARKS will actually "suffer" from anything WRITERECORD does to M. The following metaphor might help you to remember what a reference parameter is: A boy named JEREMY is called JIM at home - i.e. locally. If JIM is overfed by his mother the world will see JEREMY grow fat. The procedure WRITERECORD might also be headed

```
PROC WRITERECORD(R,REF N$,REF M())
```

The only difference from the former heading is that N$ is now a parameter to be called by reference. N$ will only refer to NAME$ and no assignment takes place. This of course speeds up the process and saves storage.

PROCEDURES AND PARAMETERS (continued)

A procedure with this heading is given

```
PROC PRINTOUT(REF TABLE(,))
```

The string "(,)" following the name TABLE indicate that TABLE must refer to a two dimensional numerical array. By analogy the string "(,,)" would indicate reference to a three dimensional array, and so forth.

```
PROC BACKWARDS(REF W$) CLOSED
  LN:=LEN(W$)
  DIM B$ OF LN
  FOR I:=LN TO 1 STEP -1 DO B$:+W$(I)
  W$:=B$
ENDPROC BACKWARDS
//
DIM B$ OF 30
INPUT "WORD (MAX. 30 CHAR.): ": B$
BACKWARDS(B$)
PRINT B$
```

The string B$ declared in the procedure has nothing to do with the string B$ declared in the mainline program, since the procedure is closed. In fact W$ is taking over the part of "outer B$". **See also FUNC and CLOSED.**

RANDOM

is a keyword used to indicate that a file is opened for random access. **See OPEN FILE.**

READ

The READ statement is used to retrieve data from a data queue set up in DATA statements. Its syntax is

```
READ <variable identifier>
       {,<variable identifier>}
```

As data elements are read a data pointer is moved to point to the next element. When the last element in the queue has been read a built-in Boolean function EOD (End-Of-Data) returns a value of TRUE. **See STANDARD FUNCTIONS.**

READ (continued)

The data pointer may be reset to the beginning of a queue by means of the RESTORE statement. **See RESTORE.**

```
READ NAME$,TEL
...
DATA "JOHN NELSON",34
```

After the READ statement has been executed, NAME$ is assigned the value "JOHN NELSON" and TEL is set to 34. Note that a string constant must be read by a string variable, and a numeric constant must be read by a numeric variable. The types of the variables in the READ statement must be in accordance with the types of the constants in the queue.

```
NO:=1
REPEAT
  READ NAME$(NO),TEL(NO)
  NO:+1
  PRINT NAME$(NO);
  PRINT "HAS TEL.NO.";TEL(NO)
UNTIL EOD
...
DATA "MAX ANDERSSON",34,"PETER CRAWFORD",45
DATA "ANNI BERSTEIN",12,"LIZA MATZON",56
```

See also DATA.

READ FILE

The READ FILE statement is used to retrieve data from sequential and random access files stored by using the WRITE FILE statement (see WRITE FILE). Its syntax is

```
READ FILE <file no.> [,<record no.>]:
  <variable list>
```

where <file no.> and <record no.> are both <numeric expression>.

READ FILE (continued)

Note that a variable on the <variable list> may refer to an array, and in that case a whole array of data can be retrieved in a single execution of a READ FILE statement

```
DIM NAME$(100) OF 30
READ FILE 2: NAME$
```

Values for the whole array NAME$ is retrieved from the sequential file signed on as file number 2.

```
READ FILE 4,RECNO: NAME$,OWNER$,DEST$,CARGO'NO
```

The statement reads from record no. RECNO in the file opened as no. 4. **See also OPEN, PRINT, INPUT, and CLOSE.**

REF

A keyword used to mark formal parameters to be called by reference. **See PROCEDURES AND PARAMETERS and FUNC.**

REM

The keyword REM is used to initiate comments. The interpreter converts it into the symbol "//". A comment may be placed on a line of its own (like a REM statement in BASIC) or at the end of any other statement, and is initiated with the symbol "//".

```
IF CH$ IN VOWELS$ THEN //IS IT A VOWEL?
  COUNT'VOWELS:+1
ELSE //MUST BE A CONSONANT
  COUNT'CONSONANTS:+1
ENDIF //LETTER
```

RENUM

is a command used to change or adjust line numbers. Its syntax is

```
RENUM [<line number>] [,<increment>]
```

RENUM (continued)

```
RENUM
```

causes the line numbers to become: 10, 20, 30, etc.

```
RENUM 100
```

causes the line numbers to become: 100, 110, 120, etc.

```
RENUM 150,5
```

causes the line numbers to become: 150, 155, 160, 165, etc.

```
RENUM ,2
```

causes the line numbers to become: 10, 12, 14, 16, etc.

REPEAT

A REPEAT statement initiates a REPEAT loop. The syntax of the REPEAT loop and the REPEAT and UNTIL statements is given in this diagram

```
REPEAT
  <statement list>
UNTIL <numeric expression>
```

The program section given by <statement list> is executed repetitively until the <numeric expression> returns a value of TRUE (i.e. numeric non-zero).

```
REPEAT
  READ NAME$,TEL
  FOUND:=(THISNAME$=NAME$)
UNTIL FOUND OR EOD
```

RESTORE

is a statement that resets the data pointer to the first element in a data queue. Its syntax is

```
RESTORE
```

See also DATA and READ.

RETURN

The RETURN statement is used to return a value from a function, or to return from a procedure before the ENDPROC statement is reached. Its syntax is

```
RETURN [<numeric expression>]
```

```
FUNC MAX(X,Y)
  IF X<=Y THEN
    RETURN Y
  ELSE
    RETURN X
  ENDIF
ENDFUNC MAX

FUNC GCD(A,B)
  IF (A MOD B)=0 THEN
    RETURN B
  ELSE
    RETURN GCD(B,A MOD B)
  ENDIF
ENDFUNC GCD
```

Note that the function is calling itself recursively. **See also FUNC and PROCEDURES AND PARAMETERS.**

RND

is a standard function. RND(X,Y), X and Y integers and X less than Y, returns a random integer in the range from X to Y. RND(Y) returns a random real number in the range from 0 to 1. If Y is negative the same sequence of random numbers is always displayed, but if Y is non-negative a new random start is implied.

RUN

The RUN command invokes a prepass of the program in workspace (unless the program has already been prepassed and no changes have been made in it) and then starts execution of it. See also CHAIN. Its syntax is

```
RUN
```

SAVE

is a command to store programs on diskette or tape. Its syntax is

```
SAVE <file name> [<unit no.>]
```

Programs stored by using SAVE may be retrieved by LOAD or CHAIN.

```
SAVE "AUNTIE"
```

stores the program presently in workspace on a diskette in unit no. 8.

```
SAVE "UNCLE",1
```

stores the program presently in workspace on a tape in unit no. 1. **See also LOAD, CHAIN, LIST, and ENTER.**

SELECT [OUTPUT]

is a command or a statement used to direct printout to the screen or the printer. Its syntax is

```
SELECT [OUTPUT] <device>
```

where <device> is "LP:" (Line Printer) or "DS:" (Data Screen). The default output device is the screen.

```
PRINT "I AM HERE."
PRINT "WHERE ARE YOU?"
SELECT "LP:"
PRINT "I AM HERE BESIDE YOU."
SELECT "DS:"
PRINT "THANKS, PRINTER."
```

The two first texts are displayed on the screen, the third one is sent out on the printer, and the fourth one appears on the screen.

SETEXEC

is a command to make the interpreter list the keyword EXEC when listing a program (see EXEC). Its syntax is

```
SETEXEC <sign>
```

where <sign> is + or -.

```
SETEXEC+      makes COMAL list the keyword EXEC
SETEXEC-      causes EXEC to be supressed
```

The default mode is SETEXEC-. If you are in SETEXEC+ mode the keyword EXEC is inserted automatically by the system. This means that you never need to type in EXEC. On the other hand if you are in SETEXEC- mode you are allowed to type in the EXEC. The interpreter will then simply ignore it.

Note. The reason for having this command in C64 COMAL is one of compatibility. In earlier version of COMAL the EXEC was compulsory, and some people might still like to have it. **See also EXEC.**

SETMSG

is a command used to suppress the error messages. Its syntax is

```
SETMSG <sign>
```

where <sign> is + or -. Default mode is SETMSG+.

Error messages are held in a file on the diskette to save main storage. This means that you will have to wait about 3 seconds to get a message on the screen. To a trained programmer this could be annoying. Therefore the option to switch the messages off is given with SETMSG. If in SETMSG- mode a prompt like

```
ERROR 12
```

is displayed with the cursor placed on the estimated location of the error.

SGN

is a standard function. SGN(X) returns the sign of X: -1 if X is positive, 0 if X is equal to zero, and 1 if X is positive.

SIN

is a standard function. SIN(X) returns the sine of X (X in radians).

SIZE

The SIZE command print the size of free memory in bytes. Its syntax is

```
SIZE
```

SQR

is a standard function. SQR(X) returns the square root of X (X non-negative).

STANDARD FUNCTIONS

ABS(X)	returns the absolute value of X.
ATN(X)	returns the arctangent in radians of X.
CHR$(X)	returns the character whose ASCII value is X.
COS(X)	returns the cosine of X (X in radians).
EOD	returns a value of TRUE (numeric 1) if the last element in the data queue has been read, otherwise a value of FALSE (numeric 0) is returned.
EOF(X)	returns a value of TRUE (numeric 1) if the end-of-file mark in a sequential file opened as file number X has been encountered, otherwise a value of FALSE (numeric 0) is returned.
ESC	returns a value of TRUE (numeric 1) if the STOP key is depressed, otherwise it returns a value of FALSE (numeric 0).
EXP(X)	returns the value of e (nat. log. base) to the power of X (thus being the inverse of nat. log.)
KEY$	returns the first ASCII character in the keyboard buffer. If no key has been depressed, a CHR$(0) is returned.
INT(X)	returns the integer part of X, i.e. the greatest integer less than or equal to X.
LEN(X$)	returns the current length, i.e. number of characters, of the string value of X$.
LOG(X)	returns the natural logarithm of X, X positive.
ORD(X$)	returns the ASCII value of the first character held by X$.
PEEK X	returns the contents of memory location X (X in the range 0-65535) in decimal representation.
RND(X,Y)	returns a random integer in the range from X to Y, X and Y integers and X less than Y.
RND(X)	returns a random real in the range from 0 to 1. If X is negative the same sequence is always generated, otherwise a random start is implied.
SGN(X)	returns the sign of X: -1 if X is positive, 0 if X is equal to zero, and 1 if X is positive.

STANDARD FUNCTIONS (continued)

SIN(X)	returns the sine of X (X in radians).
SQR(X)	returns the square root of X (X non-negative).
TAN(X)	returns the tangent of X (X in radians).

STATUS

is a command that makes the system display the disk operative system status and switches off the error indicator.

STEP

is a keyword that may be used in FOR statements to indicate an optional counter variable increment. **See FOR.**

STOP

is a statement to stop program execution. Its syntax is

```
STOP
```

STRING HANDLING, SUBSTRINGS

A string variable must always be declared. For example

```
DIM NAME$ OF 30
```

declares a string variable NAME$ that may hold up to 30 characters. If a string array is declared, the maximum length of the components must also be specified. For example

```
DIM ADDRESS$(100,3) OF 20
```

declares a two dimensional string array, where each component may hold up to 20 characters.

STRING HANDLING, SUBSTRINGS (continued)

Formal parameters of type string have no predeclared length. Thus in

```
PROC PACK(N$)
```

the parameter N$ is automatically given the length necessary to hold the string value passed to it.

A substring is specified by giving the position of the first and last character in it. If for example NAME$ has the value: "RICHARD PAWSON", then

```
NAME$(9:14)
```

returns the string "PAWSON".

If the string SPACE$ is declared (DIM) to a length of 60 characters, the assignment

```
SPACE$(1:60):=""
```

fills SPACE$ with blanks.

In the string NAME$, the expression NAME$(5) is equal to NAME$(5:5), i.e. if the substring is only one character long, you only have to give the position of that character.

Also note that substring assignment is allowed in CBM COMAL. If the following statements are executed

```
DIM ADDRESS$ OF 80
ADDRESS$(1:80):=""
ADDRESS$(21:40):=HOUSE$
```

the current value of HOUSE$ is stored in ADDRESS$ on positions 21-40. If the value of HOUSE$ has a length of more than 20 characters surplus characters are lost.

STRING HANDLING, SUBSTRINGS (continued)

If a substring of an array component is to be pointed out, the component is first indicated and after that the substring. If TEL$(23) has a value of

```
"HARRY HENDERSON     3456"
```

then the string expression

```
TEL$(23)(21:24)
```

returns the value "3456".

SYS

is a statement that invokes a subroutine call (JSR). Its syntax is

```
SYS <memory location>
```

where <memory location> is a <numeric expression> that must return a value in the range 0-65535.

TAB

In a PRINT statement the TAB function may be used to set the next print position. The argument of the TAB function must be positive and not greater than 32767. If a value greater than 80 (line length) results it is first divided by 80, and the remainder is used. Non-integer values are truncated before use. If the TAB function evaluates to a position prior to the current one, the line is shifted before the tabulation is effected.

```
PRINT "  MATHEMATICS:",TAB(20),2
```

produces this printout

```
MATHEMATICS:     2
```

with "2" printed in column 20.

TAB (continued)

```
PRINT "  MATHEMATICS:",TAB(5),2
```

produces this printout

```
MATHEMATICS:
  2
```

The example demonstrates that if the TAB function returns a position prior to the current one, the line is shifted first. **See also PRINT.**

TAN

is a standard function. TAN(X) returns the tangent of X (X in radians).

THEN

is a keyword used to terminate an IF statement. **See IF.**

TO

is a keyword used in the FOR statement to separate <initial value> from <final value>. **See FOR.**

TRAP

is a statement or a command used to enable or disable the functioning of the STOP key. Its syntax is

```
TRAP ESC <sign>
```

where <sign> is one of the characters + or -. Default mode is TRAP ESC+.

TRAP (continued)

After the statement or command

```
TRAP ESC-
```

has been encountered by the interpreter, depressing the STOP key will have no effect on program execution, but the function ESC (see ESC) returns the value TRUE (numeric 1). The command or statement

```
TRAP ESC+
```

brings the STOP key back to normal mode of operation.

TRUE

is a predefined constant with the numeric value 1. **See also FALSE.**

UNIT

is a keyword used in OPEN FILE statements when a certain external device must be indicated. Default unit is always disk unit no. 8. **See OPEN FILE.**

UNTIL

is a statement used to terminate the block of statements in a REPEAT-UNTIL loop. **See REPEAT.**

USING

is a keyword used with PRINT to give a formatted output of numerical values. **See PRINT USING.**

WHEN

is a statement used to initiate a block of statements in the CASE structure. **See CASE.**

WHILE

is the leading statement in the WHILE loop structure. The syntax of the WHILE loop and the statements that control it is

```
WHILE <numeric expression> [DO]
  <statement list>
ENDWHILE
```

The block of statements in the <statement list> is executed repetitively as long as - i.e. while - the expression following the WHILE keyword is evaluated to TRUE. When the expression evaluates to FALSE, control is transferred to the statement following the ENDWHILE statement.

If the <statement list> contains only one statement a short form of the WHILE loop may be used. Its syntax is

```
WHILE <numerical expression> DO <statement>
```

In this case no ENDWHILE statement is needed - nor allowed - to terminate the loop.

```
TAKEIN("NAME")
WHILE NOT OK DO
  ERROR("NAME")
  TAKEIN("NAME")
ENDWHILE
```

```
WHILE X<A(I) DO I:+1
```

is functionally equivalent to

```
WHILE X<A(I) DO
  I:+1
ENDWHILE
```

WRITE FILE

is a statement used to store data in a sequential or random access file. Its syntax is

```
WRITE FILE <file no.> [,<record no.>]:
   <variable list>
```

where <file no.> is a <numeric expression> that must return an integer in the range 2-254 (the COMAL System uses numbers 1 and 255), and <record no.> is a <numeric expression> that must return a positive integer.

Data stored using the WRITE FILE statement may be retrieved with the READ FILE statement but not with the INPUT FILE statement.

```
WRITE FILE 2: NAME$,ADDRESS$,PAYCODE
```

writes sequentially the values of the variables on the list to file number 2.

```
WRITE FILE 4,NO: NAME$,ADDR$,DEPTNO
```

writes the values of the variables on the list to file number 4, in the record given by the value of NO.

Note. WRITE FILE and READ FILE cannot be used with files stored on cassette.

ZONE

is a system state variable that defines the width of the print zones. The value of ZONE may be set with this statement

```
ZONE <zone width>
```

where <zone width> is a non-negative <numerical expression>. Default value of ZONE is zero.

```
ZONE 10
PRINT 1,2,3
PRINT "----5----0----5----0----5"
```

produces the following output:

```
1         2         3
----5----0----5----0----5
```

```
ZONE 20
PRINT "PRICE PER POUND:",PRICE
```

If PRICE has the value 1.5 this printout is submitted

```
PRICE PER POUND:    1.5
```

```
PRINT ZONE
```

displays the present value of ZONE.

BACK

Syntax: BACK <distance>

This statement/command moves the turtle <distance> screen units backwards. If the pen is down (see PENDOWN), a line is drawn using the present PENCOLOR. **See PENCOLOR.**

BACKGROUND

Syntax: BACKGROUND <color>

where <color> returns an integer value from 0 to 15 (see COMMODORE 64 USER'S GUIDE, page 61). The statement/command sets the background to the color given by the value of <color>. When in hi-res graphics the instruction is not executed, until COMAL has met a CLEAR statement/command. **See CLEAR.**

BORDER

Syntax: BORDER <color>

Sets the border to the color given by the value of <color>. **See also BACKGROUND.**

CLEAR

Syntax: CLEAR

Clears the graphics screen.

DRAWTO

Syntax: DRAWTO <x>,<y>

Draws a line from the present position of the pen to the position (<x>,<y>). The present color of the pen is used.

FILL

Syntax: FILL <x>,<y>

Fills the closed area containg the position (<x>,<y>) with the present color of the pen. **See PENCOLOR.** The bound of a closed area is thus defined: A boundary point is one that has a color different from that of the background or a point on the edge of the present frame. **See FRAME.**

FRAME

Syntax: FRAME <xmin>,<xmax>,<ymin>,<ymax>

Defines the frame within which the pen is active. No drawing takes place in points whose coordinates are outside the frame the lower left corner of which is given by (<xmin>,<ymin>), and whose upper right corner is (<xmax>,<ymax>). However the turtle is still displayed outside the frame. Default frame covers the whole graphics screen, i.e. you have

<xmin>::=0 <xmax>::=319 <ymin>::=0 <ymax>::=199

FULLSCREEN

Syntax: FULLSCREEN

Shows the whole of the graphics screen, i.e. no text window is displayed on the upper two lines of the physical screen (unlike SPLITSCREEN).

HIDETURTLE

Syntax: HIDETURTLE

The turtle is no longer shown on the graphics screen. This makes some graphics faster.

HOME

Syntax: HOME

Places the turtle in the position (160,99) head vertically upward (zero direction).

LEFT

Syntax: LEFT <angle>

The turtle turns its head <angle> degrees to the left (counter clockwise).

MOVETO

Syntax: MOVETO <x>,<y>

Moves the turtle without drawing from its present position to the position (<x>,<y>).

PENCOLOR

Syntax: PENCOLOR <color>

Sets the color used for drawing, i.e. the color of the pen. This is also the color of the cursor and turtle, and the color in which text is displayed on the text screen. Normally <color> is an integer from 0 to 15. **See BACKGROUND.**

PENDOWN

Syntax: PENDOWN

The turtle's pen is now active, i.e. the turtle leaves a trace as long as its movements are inside the present frame and the pen's color is different from that of the background. **See PENCOLOR.**

PENUP

Syntax: PENUP

The turtle's pen is lifted, i.e. it no longer leaves a trace on the screen. However note that DRAWTO and PLOT work even if PENUP is set.

PLOT

Syntax: PLOT <x>,<y>

Displays the position (<x>,<y>) in the present color of the pen.

PLOTTEXT

Syntax: PLOTTEXT <x>,<y>,<text>

The text given by the string expression <text> is displayed on the graphics screen such that the lower left corner of the first character of <text> is placed at the position (<x>,<y>). However note that the applied coordinates are set to the greatest multiple of 8 less than or equal to the given values. Texts can only be displayed in hi-res graphics mode.

RIGHT

Syntax: RIGHT <angle>

makes the turtle turn its head <angle> degrees to the right (clockwise).

SETGRAPHIC

Syntax: SETGRAPHIC <type>

Initializes the graphics systems and makes the graphics screen visible. On COMMODORE 64 you have two graphic modes:

High resolution graphics: <type>=0
Multicolor graphics: <type>=1

In high resolution graphics you have 320*200 pixels at your disposal. The whole of the graphics screen is split up in 40*25 blocks, each of which holds 8*8 pixels. Each individual block only allows two colors to be applied at a time. One of these colors is the background. The other color is defined as soon as a pixel in the block is set. If on a later occasion a pixel inside a block is set with a different color the whole block changes to the latter one.

In multicolor graphics the resolution in the horizontal direction is only half the one in hi-res, i.e. you now have 160*200 pixels at your disposal. Again the screen is divided in 40*25 blocks, but each of them only holds 8*4 pixels. However each block can hold up to four different colors one of which is the background.

SETHEADING

Syntax: SETHEADING <direction>

The turtle turns its head to point at <direction> degrees clockwise from zero (which is vertically upward).

SETTEXT

Syntax: SETTEXT

Hides the graphics screen and shows the text screen. However the graphics instructions still work on the hidden graphics screen. The result of graphics activities can easily be revealed by using the SETGRAPHIC command.

SHOWTURTLE

Syntax: SHOWTURTLE

Makes the turtle visible on the graphics screen. When COMAL is started a default SHOWTURTLE is executed, i.e. from start the turtle is shown on the graphics screen. **See HIDETURTLE.**

SPLITSCREEN

Syntax: SPLITSCREEN

A window into the text screen is displayed on the top two lines of the physical screen. **See FULLSCREEN.**

TURTLESIZE

Syntax: TURTLESIZE <size>

Defines the size of the turtle. The value of <size> is an integer from 0 to 10. Default value of <size> is 10.

DATACOLLISION

Syntax: DATACOLLISION(<sprite>,<read>)

This function returns a value of TRUE, if sprite no. <sprite> collides with graphics information, i.e. a non-background sprite pixel is also a non-background graphics pixel. The collision detection is automatically done by the video chip each time a sprite is drawn. If <read> has a value of TRUE (1), a collision is registered as soon as it takes place, i.e. the function returns a value of TRUE at that moment. If <read> is set to FALSE (0), it is registered when a collision has happened already. In this case the function returns the value TRUE, if sprite no. <sprite> has collided with some other graphics information earlier.

DEFINE

Syntax: DEFINE <image no.>,<definition>

where <image no.> is an integer from 0-47, and <definition> is a string expression that returns the 64 characters which defines the image. You can have a pool of 48 images (47 if a turtle is used) and each of these can be used as a model for any one of the 8 (7 if a turtle is used) sprites that may perform on the screen at the same time. Not all of the 48 images need to be defined, and later on more than one sprite can be modelled after the same image.

HIDESPRITE

Syntax: HIDESPRITE <sprite>

Sprite no. <sprite> is no longer displayed on the screen.

IDENTIFY

Syntax: IDENTIFY <sprite>,<image no.>

Sprite no. <sprite> is modelled after <image no.> Imagine you have a cupboard filled with drawings of differet shapes numbered 0-47. Each time the IDENTIFY statement is used, a drawing is taken out of the cupboard and we have a shape after that drawing act on the screen as sprite no. <sprite>. The <sprite> must be an integer from 0 to 7. If used the turtle acts as number 7.

PRIORITY

Syntax: PRIORITY <sprite>,<p>

If <p> is TRUE, the pixels in sprite no. <sprite> will have lower priority than the graphics pixels, i.e. the sprite will appear underneath the graphics. If <p> is FALSE, the sprite will have higher priority than the graphics. The priority among the sprites is fixed: A sprite with a lower number has a higher priority. Thus sprite no. 0 has a higher priority than sprite no. 1 etc.

SPRITEBACK

Syntax: SPRITEBACK <color-1>,<color-2>

where <color-1> and <color-2> are integers from 0 to 15. The statement defines the two common colors to be used with multicolor sprites.

SPRITECOLLISION

Syntax: SPRITECOLLISION(<sprite>,<read>)

A function that returns the value TRUE, if and only if sprite no. <sprite> has collided with another sprite. About <read> **see DATACOLLISION.**

SPRITECOLOR

Syntax: SPRITECOLOR <sprite>,<color>

Defines the color of sprite no. <sprite> to become <color> (0-15).

SPRITEPOS

Syntax: SPRITEPOS <sprite>,<x>,<y>

Positions sprite no. <sprite> such that the upper left corner appears at the position (<x>,<y>), <x> in 0-319, <y> in 0-199.

SPRITESIZE

Syntax: SPRITESIZE <sprite>,<x>,<y>

If <x> is TRUE (1), sprite no. <sprite> is expanded to double width, if <y> is TRUE, the sprite is expanded to double height. The resolution is not affected by the expansions.

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COMAL Keywords

Sprites

COMAL

Easier than BASIC, more powerful than basic, COMAL (COMmon Algorithmic Language) was developed for learning programming.

COMAL gives many error messages as lines are entered — no more waiting until a program is run before finding a type mismatch or syntax error.

COMAL has structures that make writing legible programs easy (multiple line IF statements; IF, THEN, ELSEIF, ELSE; PROCEDURES and FUNCTIONS that can be invoked just by their names; REPEAT, UNTIL; WHILE, ENDWHILE, etc.) while retaining most of the commands of BASIC

Variables in COMAL can have up to 78 characters so you can easily see what the program is doing: VOLUME'REGISTER:=54296 is easier to understand than V = 54296.

COMAL 0.14 for the Commodore 64 has the graphics commands that Commodore forgot; defining and using sprites is easy; and it even has the TURTLE graphics that LOGO is famous for.

Is COMAL the language that will replace BASIC? Try it and find out!

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