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Introduction

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This book is a reference manual for the Turbo Modula-2 system, implemented for the CP/M-80 operating system running on Z80 computers. Although there are many examples throughout the book, this is not a tutorial for Modula-2 programming; a basic knowledge of Modula-2 or Pascal is assumed.

The Modula-2 language was designed in 1980 by Niklaus Wirth, who also nored Pascal. While Modula-2 provides the powerful data and statement structures of Pascal, it also incorporates a modular structure as well as basic facilities for multiprogramming applications. Turbo Modula-2 is Borland's practical implementation of Modula-2. It follows closely the definition of standard Modula-2 as defined by N. Wirth in his book, *Programming in Modula-2* (3rd Ed. New York: Springer Verlag, 1984). However, it differs from Modula-2 in two main areas: It has an easy-to-use I/0 library and optional extensions.

Because of the wide range of possible external devices, and in order to make the language truly machine-independent, the strict definition of Modula-2 does not include any input/output or low-level facilities. Turbo Modula-2, however, provides an extensive and flexible library of these facilities, which for the most part follow Wirth's suggestions.

Turbo Modula-2 also includes several constructs not mentioned in the original definition; for example, general-purpose *READ* and *WRITE* statements, string comparison and assignment, multidimensional open arrays and exception handling.

Structure of This Manual

This manual is divided into four main areas: an introduction, the module library, a look-up section, and appendices.

Chapter 1 will get you started using the Turbo Modula-2 system, walking you through such operations as copying your distribution disk and running your first program.

Chapters 2 through 7 provide a thorough description of Turbo Modula-2 programming, with a general discussion of the Modula-2 language elements and a more detailed explanation of data, statement, and program structures, as well as local and library modules. Chapters 5 and 6 serve as your guide to writing simple Modula-2 programs.

Chapters 8 and 9 cover the more advanced topics in Turbo Modula-2, including system-specific functions and extensions and low-level facilities.

Chapter 10 covers system operations, including discussion of the editor, the compiler, the linker, the librarian, and other operational features.

Chapter 11 contains the library modules, which consist of 14 modules containing over 100 procedures. You may want to read the short description of each library module now, and go back to study the specifics when you need to use a particular module.

Chapter 12 comprises Turbo Modula-2's extensive alphabetical look-up section, which contains entries of reserved words standard identifiers, and library identifiers.

The five appendices provide information on the operation of Modula-2, while also presenting some comparisons between Turbo Pascal and Turbo Modula-2. Appendix A provides the language comparisons. Appendix B details the instructions for installing Turbo Modula-2 on your system. Appendix C summarizes the compiler directives discussed in Chapter 9. Appendix D lists error messages and their definitions/diagnoses. Appendix E provides the BNF syntax diagrams of Turbo Modula-2.

Typography **T**ypography

The body of this manual is printed in a normal typeface. Special typefaces are used for the following purposes:

Alternate Alternate characters are used to illustrate program examples and screen displays.

Italics Italics are used to emphasize certain concepts and first-mentioned terms.

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Boldface Boldface is used to mark reserved words in text as well as in programming examples.

Acknowledgements

- Several programs, languages, and operating systems are referenced in this manual; the following lists them and their respective companies.
 - □ Turbo Pascal is a registered trademark of Borland International.
 - WordStar is a registered trademark of MicroPro International.
 - CP/M is a registered trademark of Digital Research Inc.
 - □ Microsoft is a registered trademark of Microsoft Corp.

Chapter 1 Getting Started

Before Use

When you receive your Turbo Modula-2 disk, complete and mail in the license agreement at the front of this manual. This agreement allows you to make as many (les as you need for your personal use and backup purposes only.

For your own protection, make a backup copy of the distribution disk with your file-copy or disk-copy program before you start using Turbo Modula-2. Make certain all files have transferred successfully, then store the original disk in a safe place. If anything happens to the backup copy, you can make a new backup copy from the original.

Files on Disk

The files you have just copied from the distribution disk to your backup disk are described here.

System Files

M2.COM The Turbo Modula-2 system file contains the M-code interpreter, the Overlay Manager, and the runtime system. Entering the command M2 on your terminal will load this file and get Turbo Modula-2 up and running.

M2.OVR Overlay file for M2.COM.

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SHELL.MCD The Turbo Modula-2 menu shell.

COMPILE.MCD The Turbo Modula-2 M-code compiler.

GENZ80.MCD The Turbo Modula-2 compiler's optional second-pass used for generating native Z80 code.

ERRMSGS.OVR	Text file containing error messages.				
LIBRARY.MCD	A library manager that combines several compiled modules into a single .LIB file.				
SYSLIB.LIB	The standard modules supplied with the Turbo Modula-2 system.				
LINK.MCD	The Turbo Modula-2 static overlay linker that is used to pro- duce stand-alone (.COM) files.				
Installation Files					
INSTM2.COM	This installation program allows you to install the Turbo Modula-2 compiler (M2.COM), as well as other .COM pro- grams produced by the linker.				
INSTM2.OVR	Installation program overlay file.				
INSTM2.DTA	Installation data file compatible with Turbo Pascal's TINST.DTA file (see Appendix B, »Installation Procedures«, for more details).				
Example Files					
*.MOD	Sample Modula-2 programs.				
Other Files					
READ.ME	If present, this file contains the latest corrections or sugges- tions on the use of the system.				
Utility Files					

REL.MCD

A Turbo Modula-2 utility that converts Microsoft REL (relocatable) object files into the .MCD format used by Turbo Modula-2.

Getting	Started
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A Turbo Modula-2 utility that counts instructions in the PROFILE.MCD various procedures of ar. M-code program. This utility can help you improve the efficiency of your Turbo Modula-2 programs.

Preparing a Work Disk

The most effective way to use Turbo Modula-2 is to have the system files on your boot disk, allowing you to use other drives for programs and data. To make your working disk, follow these steps:

- 1. Prepare a system boot disk, which will become your work disk; also include a file-copy program such as PIP. For more information on this step, consult your operating system's user manual.
- 2. Now boot your system using the work disk, and place the Turbo Modula-2 backup disk (the one you made after reading the first paragraph of this chapter) into a free disk drive.
- 3. Copy the following files from your Turbo Modula-2 backup disk to the work disk:

M2.OVR M2.COM SHELL.MCD **INSTM2.COM INSTM2.MSG** INSTM2.DTA

Now run the instaliation program by typing INSTM2 and pressing **RET** at the system prompt. This message will appear:

Install program ([RETURN] for M2.COM):

Press [RET] again and the following screen will appear:

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Modula-M2 system installation menu. Choose installation item from the following:

[S]creen installation | [C]ommand installation [M]iscellaneous | [Q]uit

Enter S, C, M, or Q:

5. Press **s** for Screen installation and pick the appropriate terminal type. For more details on installing your system, see Appendix B.

Note: For Turbo Pascal owners with custom terminals, you may substitute your Turbo Pascal terminal data file for INSTM2.DTA by copying the Pascal data file to your work disk and renaming it from TINST.DTA to INSTM2.DTA.

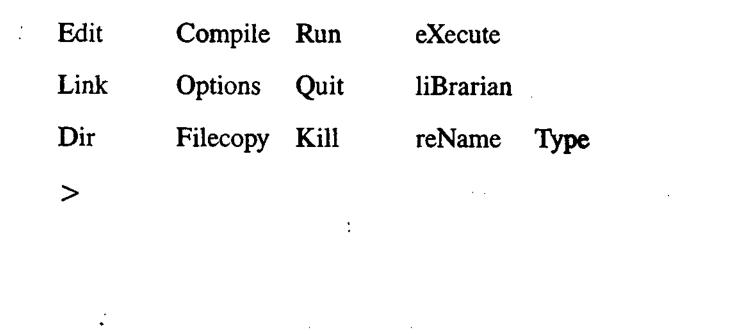
6. Now press *M* for Miscellaneous. Tell the system which drives to search in for library and work files (generally, all your drives will be included).

Note: Do not try to install the keyboard commands until you become more familiar with the editor.

- Now select a for Quit and delete the installation files from your work disk (INSTM2.*). Then delete the file-copy program we had you install in Step 1. Your bootable work disk should contain an installed copy of M2.COM, M2.OVR, and SHELL.MCD.
- 8. With your work disk in drive A and your backup disk in drive B, type M2 at the system prompt. The Turbo Modula-2 main menu will appear.

Selected drive: A

Work file:



Getting tarted

: Do not attempt to execute any menu items (except Filecopy) until all ssary files have been copied to the work disk.

9. Finish preparing your work disk, you must copy some files using Turbo dula-2. To begin, press F for Filecopy at the main menu. Then at the opy from: " prompt, type in the name of the file you want to copy; for exple:

ppy from: B:*.MCD [RET]

ress **RET** to get the "Copy to:" prompt:

lopy to: A: [RET]

Dr do it in one step, like so:

Copy from: B:ERRMSGS.OVR A: [RET]

or

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```
Copy from: B:SYSLIB.LIB A: [RET]
```

Copy the following files using any of the preceding procedures:

COMPILE.MCD SYSLIB.LIB ERRMSGS.OVR

And optionally, if there is room left on your disk, copy these files as well:

GENZ80.MCD LIBRARY.MCD LINK.MCD

REL.MCD PROFILE.MCD

(The files M2.COM, M2.OVR, and SHELL.MCD should already be on your work disk.)

At this point, it would be wise to make a backup of your work disk to avoid having to reinstall the system. Now you're ready to try out the Turbo Modula-2 compiler.

Running Turbo Modula-2

Now that you've prepared a work disk and logged onto the drive containing it, you are ready to load Turbo Modula-2 into memory. After the system prompt, type M2, press RET, and the following message will appear (but your terminal will be listed):

Turbo Mod	lula-2 Sys	tem		Version 1.00 CP/M-80, Z80
Copyrigh	t(C) 1984,	Borland International		
Terminal	: No Termi	nal Selec	ted	
This will	l be follow	red by the	main menu	:
S elected	drive: A			
Work file	e:			
Edit	Compile	Run	eXecute	
Link	O ptions	Quit	li B raria	n
Dir	Filecopy	Ki 11	reName	Туре

>

To run a program, place the backup disk containing the sample programs (*.MOD) in the B drive. At the main menu, press **C**. You will see this message:

Workfile name:

Type Hello and press **RET**. Turbo Modula-2 will now compile the sample program. The compilation terminates with the following message:

Compiled bytes: 32 M-code file A00:HELLO.MCD produced.

Now press **R** and then **RET** to run the program. The screen will look like this:

? Run MCD-file: A00:HELLO

Hello World!

>

After the prompt (>) appears in the main menu, quit Turbo Modula-2 by pressing $\boxed{\mathbf{Q}}$; this will return you to the operating system.

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Chapter 2 A Brief Tour of Turbo Modula-2

For those of you who want to learn Turbo Modula-2 quickly, or are already acquainted with some aspects of it, this chapter gets you into the thick of things in a hurry. Only a minimum of explanation is given here; to use Turbo Modula-2 to its full potential, you should refer to Chapter 10. This chapter will take you thry \cdot h the menu system and briefly explain how to use each feature.

The Menu System

To start, place your work disk in the logged drive (to make a work disk, refer to Chapter 1), then type M2 and press **RET** to bring up the following screen:

Turbo Modula-2 System	Version 1.00
	CP/M-80, Z80
Copyright(C) 1984,1985, 1986	Borland International
Terminal: No terminal selected	*
Terminal: No terminal selected This screen will be quickly followed by	

Edit Compile Run eXecute

>

ŕ

Link Options Quit liBrarian Dir Filecopy Kill reName Type

The main menu contains all of the major functions performed by Turbo Modula-2. The following section describes each element of the main menu and displays a sample screen where appropriate. (Note: The italicized items in the example indicate that you must type in your own data.) To select each item, you press the letter highlighted on your screen.

Selected drive. Use this to change the default drive; press <u>s</u> and type the letter of the drive that is to become the new default drive. You can also use this function to reset the system or to log the disk; this is handy when you need to insert a new disk to copy files to.

>S

New drive: a: ____

Work file. Sets a default file name for other menu commands to use, such as Edit, Compile, Link, and so on. You can override this default by pressing the space bar before selecting the desired menu item (see the section »Avoiding the Menus« in Chapter 10).

> W

Workfile name: Myfile

Edit. Invokes the Turbo Editor, a WordStar-like editor. This editor is similar to the Turbo Pascal editor; however, it is a »one-pass« virtual editor that limits file sizes to the disk space available rather than internal memory.

> E

Edit file: COO:MYFILE.MOD

Compile. Turbo Modula-2 is an incremental compiler, which means it saves its

state when a compile-time error is found. You can then enter the editor, correct the error and exit, at which point compilation continues at the closest block to where the error was corrected.

>C

Compile file: COO:MYFILE.MOD

Run. Runs compiled code without going through the linking step. The Run command does dynamic linking while it is reading in the support modules to run a program.

> R

Run MCD-file: COO:MYFILE

eXecute. Provides a way to run most external programs, such as STAT or even the Turbo Modula-2 installation program.

Youte COM-file: INSTM2.COM

Link. This command serves two purposes: It links separately compiled modules into a stand-alone .COM file and links specified modules so that they will load quickly when linked dynamically during the Run command. In addition, the linker provides the facility to generate overlays.

>L

Link main module: COO:MYFILE

Options. This command invokes the following Options menu:

compiler options:

```
List (OFF) Native (OFF) eXtensions (ON)
Test (OFF) Overflow (OFF) Upper=lower(OFF)
Path to search: SYSLIB
( and run-time error
Save current selection Quit
```

>

The compiler options are global; that is, they influence the entire compilation unless overridden with internal switches. You can toggle the compiler options by pressing the key for the capital (highlighted) letter in each option (for example, L for List). The following describes the function of each compiler option:

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- □ List determines if source output is displayed on the monitor during compilation.
- □ Native determines which type of code is produced, M-code or Native.
- □ eXtensions tells the compiler to issue warning messages if a program is using any of the Turbo Modula-2 extensions.
- ☐ Test determines if the compiler generates test code for array bounds and subrange checking.
- Overflow determines if the compiler generates code to check for integer overflow.
- Upper=lower tells the compiler whether or not to be case-sensitive.
- □ Path to search tells the system which library files to search when looking for external modules.
 - > P

(

New search path: SYSLIB MYLIB

□ Find run-time error helps you find the runtime error position.

> F

Module name: COO:MYFILE.MOD

Enter PC: 23

□ Save current selection allows you to save the options and search path you find most comfortable.

 \Box Quit returns you to the main menu.

Now we'll get back to describing the main menu options.

Quit. Returns you to the operating system.

liBrarian. This command prompts you for a library name and then displays the librarian menu, as shown in the following:

> B

Select library: SYSLIB

Selected library: A00:SYSLIB.LIB

Dir Include Copy

(1 Ompress Quit

The library keeps many precompiled library modules in one file. The compiled versions of the definition module and the implementation module are contained in the library as .SYM files and .MCD files, respectively.

Notice that the librarian menu has a different prompt, distinguishing the following library management utilities from the main menu's file- management routines. Again, initiate each option by pressing the capital (or highlighted) letter of its name.

Selected library prompts for a name prior to displaying the librarian menu.
 Press s to change the selected library without returning to the main menu.

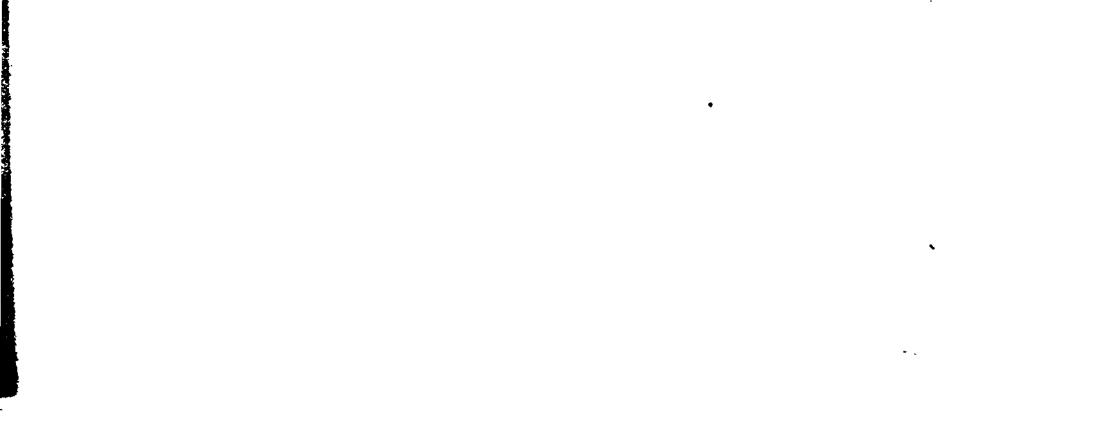
*S

Select library:

Dir lists the .SYM and .MCD files, that are stored in the selected library. In addition, it lists the size of each file and the cumulative size of all the files. *D

i.

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Directory of library: COO.SYSLIB

1:	COMLINE	.MCD	0.5K	.SYM	0.5K
2:	CONVERT	.MCD	2.OK	.SYM	1.0K
3:	DOUBLES	.MCD	3.5K	.SYM	1. 0K
4:	FILES	.MCD	3.OK	.SYM	1.5K
5:	INOUT	.MCD	1.OK	.SYM	1.0K
6:	LOADER	.MCD	2.5K	.SYM	1.0K
7:	LONGMATH	.MCD	2.OK	.SYM	0.5K
8:	MATHLIB	.MCD	1.5K	.SYM	0.5K
9:	PROCESSE	.MCD	0.5K	.SYM	0.5K
10:	STRINGS	.MCD	0.5K	.SYM	1.0K
11:	TERMINAL	.MCD	1. 0K	.SYM	1.0K
12:	TEXTS	.MCD	2.OK	.SYM	2.0K
	Total size:		39.5K	Unus ed:	8.OK

□ Include takes external files (either .SYM files or .MCD) and places them in the library.

¥Ι

Include file:

□ Copy copies files from the selected library to either another library or to a stand-alone .SYM or .MCD file.

*C

Copy module:

□ Kill erases a specified library module.

*

ЖK

Kill module:

 \Box cOmpress eliminates unnecessary space in the library files. Since this command can take some time, we recommend using it only on stable (debugged) library files.

*****0

```
Compressing library, please wait.
```

¥

 \Box Quit returns you to the main menu.

The remainder of the main menu options described here are file-management commands.

(Dir. The directory command allows you to display a full or partial directory of any disk. It accepts drive name, user areas, and wildcard file names (such as *.MOD or *.*) to build the directory listing. When a directory listing is displayed, it is shown with a number before each file name. These numbers may be used in subsequent file-management commands, such as Filecopy and Kill.

>D

Directory mask:

1:	COMPILE	. MCD	4:	LIBRARY	.MCD	7:	M2	.OVR	10:	SHELL	. MCD
2:	ERRMSGS	.OVR	5:	LINK	.MCD	8:	MYFILE	. BAK	11:	SYSLIB	.LIB
3:	GENZ80	.MCD	6:	M2	.COM	9:	MYFILE	. MOD			
Byt	es Rem ain i	ing on A:	9 6K	-							

□ Filecopy. This command will accept a drive name, a user number, and a wildcard file name as the source file. In addition, the source file may be a list or range of numbers that reference the last directory command.

Copy from : 13-5 Copy to : b:

` >F

æ*

□ Kill. This command allows you to delete disk files without leaving the shell. It also accepts drive names, user numbers, and wildcard file names, as well as a list or range of numbers referencing the last directory command. >K Kill file: *.bak Deleting DOO:MYFILE.BAK

 \Box reName. This command accepts one new file name (with optional drive and user area) for the old name and one file specification for the new name.

>N

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Rename from : myfile.mod Rename to : myfile.def

□ Type This command displays the specified file on the screen. You can pause output by pressing Ctrl S and terminate output by pressing Ctrl C.

>T

Type file: myfile.def

DEFINITIONMODULE MyFile; PROCEDUREMyProc; ENDMyFile.

Language Elements

Chapter 3 Language Elements

Language elements are the building blocks that form a program and are the fundamental units recognized by the compiler. Each element is used to build a different level of abstraction. For example, a digit is an element that can be combined with other digits to form a number that is an element at a different level of abstraction. Thus, we can continue abstracting until a level is reached where an entire program is represented by one word, such as MyProgram.

This chapter describes the elements used to assemble meaningful program statements in Turbo Modula-2. In the following section, we will look at the first level of abstraction used by Turbo Modula-2; namely, the characters that comprise symbols.

Character Set

The Turbo Modula-2 character set includes all characters that are legal in Modula-2 declarations, expressions, and statements. This set is made up of alphabetic, numeric, and special characters.

Alphabetic (uppercase and lowercase)

A to Z and a to z

Numeric

0123456789



$+ - * / = ^ < > () [] {} . , : ; & # ' "|$

Not all characters are available on all terminals; thus Turbo Modula-2 recognizes the following synonyms:

(.	for	[Left parentheses and period for left index bracket
.)	for]	Period and right parentheses for right index bracket
(:	for	{	Left parentheses and colon for left brace
:)	for	}	Colon and right parentheses for right brace
!	for	1	Exclamation mark for vertical bar

Using these available symbols, it is possible to create a great number of Modula-2 programs.

Vocabulary

The Modula-2 compiler recognizes certain groups of characters as symbols themselves, including numbers, characters, strings, delimiters, operators, and reserved words and identifiers. These symbols (or characters) comprise the se-cond level of abstraction, providing you with the means to form sentences and thus programs in Modula-2.

The Turbo Modula-2 vocabulary can be divided into five classes: numbers, strings and characters, delimiters and comments, operators, and reserved words and identifiers (user-defined, standard, and library).

Numbers

There are two types of numbers defined in Modula-2: whole numbers and real numbers. Turbo Modula-2 recognizes three subtypes of whole numbers and two subtypes of real numbers.

Whole Numbers

Turbo's three types of whole numbers may be further defined as two signed numbers and one unsigned number. The two signed whole numbers are single precision and double precision, which are INTEGER and LONGINT, respectively. The unsigned whole number is single precision and is called a CARDINAL.

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Following are the ranges for whole numbers:

Туре		Range			
INTEGER	(single-precision, signed whole num be r)	-32,768	to	32,767	
LONGINT	(double-precision, signed whole numbers)	-2,147,483,648	to	2,147,483,647	
CARDINAL	(single-precision, unsigned whole numbers)	0	to	65,535	

Single-precision integers can be formed in any of these three bases: decimal, octal, or hexadecimal (hex). Decimal numbers consist of the digits 0 to 9. Octal numbers comprise the digits 0 to 7, followed by the letter B. Hex numbers consist of the digits 0 to 9 and the letters A to F. The first character in a hexadecimal number must be a digit and the hexadecimal number must end with the letter H. The following are examples of legal and illegal single-precision whole numbers:

Legal (base)

Single	Precision	Illegal	Single Precision
1986 -10 10B 0FFFFH 1AH 62345	(Decimal) (Decimal) (Octal) (Hex) (Hex) (Decimal)	12.34 FH 08B 0F 0GH -60000	Decimal point illegal. First character must be a digit. 8 is not a legal octal digit. Requires H for hexadecimal. G is not a legal hexadecimal digit. Too small for single-precision integer.
	(Locomiul)	00000	roo small for single precision meger.

Double-precision integers, or long integers, can only be formed in decimal notation, followed by the letter L. Following are legal and illegal long integers:

Legal Double Precision Illegal Double Precision

123L123This is a normal integer.456L45.6This is a real number.120392237L0FFFFFFHOnly decimal base allowed.

Real Numbers

Single-precision and double-precision numbers are the two types of real numbers recognized by Turbo Modula-2. They are called REAL and LONGREAL, respectively.

Single-precision real numbers can be accurate up to 6 decimal points, while double-precision reals can be accurate up to 14 decimal points. The ranges of REAL and LONGREAL are as follows:

Type

Range

REAL	-6.80565E+38	to	6.80565E+38
LONGREAL -3.59538	6 26 97246D+308	to	3.59538626972 46D+308

As shown in the previous ranges, a real number contains a sequence of numeric characters, containing a decimal point with an optional *scale factor*. The scale factor is specified by the letter E or D (E for single precision and D for double precision) and an integer, beginning with an optional plus (+) or minus (-) sign. The following are samples of legal and illegal real numbers:

Legal Real Numbers

Illegal Real Numbers

12.34	Single precision	1 453	Blank space illegal
0.1E3	Equals 100.0	12	Needs decimal point
3.6E-5	Equals 0.000036	3.6E-99	Exponent too large
12.34D0	Double precision	1,423.0	Comma is illegal
0.1D3	Equals 100.0	12d-10	D and E must be uppercase
3.6D-5	Equals 0.000036	12.0D-999	Exponent too small

Strings and Characters

Strings

A *string* is a portion of text that can be handled as a single unit, such as a message to be written on the screen. Strings provide a means of manipulating text within a program. Constant strings are formed by enclosing a sequence of printable characters in either single or double quotation marks. The opening and closing quotation marks must be of the same kind, and that kind cannot occur within the string. Here are some examples of legal and illegal constant strings:

Legal Constant Strings

Illegal Constant Strings

'My name is:' 'He said, "What is the time?"' "12 34" "Hello' "She said, "The time is 4 p.m."" Quotes must match Opening quote type cannot occur within the string

Characters

A character is a single, printable ASCII symbol enclosed in matching quotes (single or double), or an octal integer (up to 377) followed by the letter C. In theory, characters occupy 1 byte of storage, and thus may take on any value beteen 0 and 255 decimal (or 377 octal). In practice, characters may occupy an entire word (2 bytes) in memory. The only time a character actually takes 1 byte is when it is declared as part of an array (arrays pack characters together). Any other declaration involving a character always results in the character occupying 2 bytes. Following are legal and illegal characters:

Legal C	Legal Characters		Illegal Characters	
"A"	The letter A	"AB"	Only one character allowed	
·*,	Asterisk	"Q'	Must have matching quotes	
15C	Carriage return	8C	8 is not an octal digit	
377C	Largest character	777C	Octal number too large for character	

When a string contains only one character enclosed in quotes, the string is considered a special case and is compatible with a character. This only applies to constant strings like "A" or '*', not character variables.

Delimiters and Comments

Delimiters

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A *delimiter* is one or more characters that separate other syntactic entities. For example:

Blanks separate identifiers and reserved words.

The vertical bar separates CASE, exception, and variant record statements.

The comma separates items in parameter lists and declarations.

The semicolon separates program statements and declarations.

*, +, -, / The mathematical symbols (or operators) also serve as delimiters between operands.

Comments A comment may appear anywhere one of the preceding delimiters is allowed. In addition, a comment may serve as a substitute for a blank space between symbols.

Comments

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Comments contain descriptive or explanatory text about a program. Since, for the most part, they are ignored by the compiler (except for compiler switches, see Chapter 10), they can contain any characters enclosed by a set of parentheses and asterisks.

Unlike Pascal, which allows either the symbol sets (* and *) or { and } to delimit comments, Modula-2 uses only (* and *) to delimit comments and uses { and } exclusively to delimit sets. Comments may be nested to any depth (limited only by memory space). They may occur anywhere a delimiter is allowed, and are treated as blanks. The following is a sample of legal and illegal comments:

Legal Comments	Illegal Comments	
(* This is a comment *)	{This isn't a comment}	Braces not allowed
(*Comments can be ne sted (* like this *) *)	(* Hi (* there *)	Missing second closing comment

Operators

Operators in Modula-2 are made up of either special symbols or reserved words. In the case of reserved words, they are always printed in uppercase letters (see "Compiler Switches," in Chapter 10) and cannot be used as identifiers. The following lists the special symbol and function of each operator:

+	Addition and set union
-	Subtraction and set difference
*	Multiplication and set intersection
/	Division and symmetric set difference
&	Logical AND
~	Logical NOT
٨	Dereferencing
:=	Assignment
=	Equality
# <>	Inequality
<	Less than
>	Greater than
<=	Less than or equal
>=	Greater than or equal
()	Parentheses
[]	Index brackets
{ }	Set braces
· · · · · · · · · · ·	Punctuation

In addition to these special symbols, the following reserved words are also operators:

AND	Logical AND
OR	Logical OR
NOT	Logical NOT
IN	Set membership
DIV	Integer division
MOD	Integer modulus

Operators are closely related to the operands they work on. In most cases, an perator will only work with certain kinds of operands; for example, to divide real numbers you must use the real division operator: 2.8/2.9. In addition, the result of an operation could be of a different type from the original operands; for example, comparing two integers results in a Boolean value: 1 = 2. (Chapter 4

discusses operators and operands in more depth.)

Reserved Words

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Reserved words in Modula-2 are symbols with a predefined and static meaning;

they cannot be used for any other purpose. They are always written in uppercase letters.

AND	ELSIF	LOOP	REPEAT
ARRAY	END	MOD	RETURN
BEGIN	EXIT	MODULE	SET
ВҮ	EXPORT	NOT	THEN
CASE	FOR	OF	TO
CONST	FROM	OR	TYPE
DEFINITION	IF	POINTER	UNTIL
DIV	IMPLEMENTATION	PROCEDURE	VAR
DO	IMPORT	QUALIFIED	WHILE
ELSE	IN	RECORD	WITH

The following Turbo Modula-2 reserved words provide useful extensions to the Modula-2 standard:

EXCEPTION FORWARD RAISE

In this manual (and other Borland manuals), all reserved words are in boldface type; however, they will not appear on your screen this way.

The preceding symbols and reserved words will be discussed in the next few chapters. For an immediate discussion of reserved words, refer to Chapter 12, "Turbo Modula-2 Reference Directory."

Identifiers

Identifiers are unique names given to constants, types, variables, procedures, and modules. Identifiers are sequences of alphabetic and numeric characters; the first character must always be a letter. Note that Turbo Modula-2 distinguishes between uppercase and lowercase letters; thus, unlike in Pascal, in Turbo Modula-2 *Varl* and *VARI* are considered two unique identifiers.

Standard Identifiers

Turbo Modula-2 has a number of predefined identifiers for special purposes. Standard identifiers are "visible" and available in all modules without explicitly importing them. The standard identifiers can be redefined, but doing so will cost you the function offered by the predefined identifier. Also, a redefined standard

Language Elements 🥣

identifier only affects the module where it is redefined, not other imported modules. (Again, note that the use of uppercase and lowercase is significant.)

ABS	DISPOSE	INT	ODD
BITSET	DOUBLE	INTEG ER	ORD
BOOLEAN	EXCL	LONG	PROC
CAP	FALSE	LONGINT	REAL
CARD	FLOAT	LONGREAL	SIZE
CARDINAL	HALT	MAX	TRUE
CHAR	HIGH	MIN	TRUNC
CHR	INC	NEW	VAL
DEC	INCL	NIL	

The following standard procedures provide extensions to the Modula-2 standard:

READ	READLN	WRITE	WRITELN
READ	readlin	MUTIE	MUTICTW

User-Defined Identifiers

Users may declare their own identifiers; however, there are two rules to follow: Identifiers must begin with an alphabetic character and may consist only of alphabetic and numeric characters; spaces, underscores, and other special characters are not allowed. The following is a sampling of legal and illegal userdefined identifiers:

Legal Identifiers	Illegal Identifiers	
MyName	My Name	
	-	Blank space illegal
Tr612	Public-Transit	Hyphen illegal
hello	lst	First character must be a letter
Modula2	LASTPRIME	Underscore illegal

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LAST_PRIME

Underscore illegal

Library Identifiers

Turbo Modula-2 contains an extensive library (in SYSLIB.LIB) with a number of predefined modules. The modules and their identifiers can be redefined, but doing so will cause you to lose the function offered by them, or at least make using them more awkward.

In one sense, library identifiers are no different than user-defined identifiers since you can create libraries with new identifiers, thus adding to the list of available library identifiers. However, there are two differences.

One is that Turbo Modula-2 provides a set of standard identifiers that are necessary for programming in Modula-2. We presume that some of these standard identifiers are in every implementation of Modula-2, while we have added others for machine-specific reasons. The second difference is that Turbo Modula-2 "comprehends" the functions of system-dependent library modules, such as *SYSTEM* and *STORAGE*. Thus, when an item is used from the machine-dependent *SYSTEM* module, the compiler already knows about it and has no need to look at additional symbol files to determine usage. Table 3-1 is a list of library identifiers.

Table 3-1

ADDRESS	EndError	Open	SpecialOps
ADR	Entier	OpenInput	Sqrt .
ALLOCATE	EOF	OpenOutput	StartProcess
Append	EOL	OpenText	StatusError
Arctan	EOLN	OpSet	STORAGE
Argument Error	EOT	OUT	String
available	ExitScreen	outName	StringError
Awaited	Exp	OUTOFMEMORY	Strings
BDOS	FILE	output	StrToCard
BIOS	Files	OVERFLOW	StrToDouble
BusyRead	FileSize	Pos	StrToInt
BYTE	FILL	PROCESS	StrToLong
Call	firstDrive	Processes	StrToReal
CAPS	Flush	progName	SYSTEM
CardToStr	FREEMEM	PromptFor	termCH

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clearEol ClearScreen ClearToEOL Close CloseInput CloseOutput CloseText CODE GetName GotoXY haltOnControlC Highlight highlightNormal HI.RESJLT Init InitScreen Random Randomize READ ReadAgain ReadByte ReadBytes ReadCard ReadChar

Terminal TEXT TextDriver TextFile TextNotOpen Texts TooLarge TooManyTexts

Language Elements -

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Col ComLine	inName InOut	ReadDouble ReadInt	TRANSFER TSIZE
commandLine	INP	ReadLine	UseError
ConnectDriver	Insert	ReadLn	WAIT
console	insertDelete	READLN	WORD
Convert	InsertLine	ReadLong	Write
Сору	IntToStr	REALOVERFLOW	WRITEBYTE
Cos	ICRESULT	ReadReal	WRITEBYTES
Create	IOTRANSFER	ReadRec	WriteCard
CreateText	legal	ReadString	WriteChar
DeadLock	Length	ReadWord	WriteDouble
DEALLOCATE	Ln	RealToStr	WriteHex
Delete	Loader	RedirectInput	WriteInt
DeleteLine	LoadError	RedirectOutput	WriteLn
DeviceError	LongMath	RELEASE	WRITELN
DiskFull	LongToStr	Rename	WriteLong
DISPOSE	MARK	ResetSys	WriteOct
Done	MathLib	SEND	WriteReal
Doubles	NEW	SetCol	WriteRec
DoubleToStr	NEWPROCESS	SetPos	WriteString
	NextPos	SIGNAL	WriteWord
	Normal	Sin	
	NoTrailer	SIZE	
	numCols		
	numRows		

For more detailed information regarding library modules, refer to Chapter 11, "The Standard Library." For information regarding the preceding library identifiers, refer to Chapter 12, "Turbo Modula-2 Reference Directory."

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Expressions

Chapter 4 Expressions

An expression is a sequence of language elements that combine to form a temporary data object with a possibly different value and type than either original element. An expression consists of operators and operands that perform certain operations when an expression is "evaluated."

In the previous chapter, we looked at the character set and vocabulary used to build Modula-2 programs. Here we'll take the next step by showing you how to form expressions with language elements, while also providing the foundation for our discussion of abstract data types in the next chapter.

Properties of an Expression

To explain expressions, let's look at a simple example from mathematics:

1 + 2

- 1. The expression consists of operands and an operator: The two operands are 1 and 2, and the operator is +.
- 2. Expressions have a result value that can be assigned or used in further expression evaluation. The preceding example has a result value of 3.
- ³(addition, the expression is considered to have a type that is determined by the result. In this example, the result type is CARDINAL.

Expressions are evaluated by applying each operator to its operands. In general,

expressions are evaluated from left to right. Operators that take precedence over others are executed first, despite the position of the operator within the expression (see the later section, "Operator Precedence").

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Operands

In Turbo Modula-2, the operands of an expression can be any *elementary type* (such as INTEGER or REAL), including function procedures that return an elementary type (such as standard function procedures *ABS*, *CHR*, or *SIZE*). However, operands within a particular expression must be of the same type; for instance, in the previous example both operands are integers. The following shows an illegal expression, one that mixes integers and reals:

3.4 + 30

The purpose of this type-checking is to make explicit the types of operands involved in the expression. Unlike Pascal and some other languages, Modula-2 in general has no implicit type conversions; however, there are ways to override this strict type-checking. The explicit conversion in the following example makes the preceding example legal:

3.4 + FLOAT(30)

The result of this expression is 33.4 and is of type REAL. Note that it is possible for the result type to be different from its operands. Consider the following:

1 = 2

Here is an expression containing integer operands and one operator. When the operator is applied to the operands, the resulting value is FALSE and the result's type is BOOLEAN.

Operators

The most distinguishing feature of an operator is the type (or types) it works on. There are four classes of operator:

Arithmetic Performs normal mathematical operations. Operations are performed on numbers, such as INTEGER and REAL.

Relational

Does a comparison of like items to obtain a BOOLEAN result of TRUE or FALSE. The items compared can be of any elementary type; for example, INTEGER, POINTER. string, and so on.

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Logical Performs the combination and the negation of BOOLEAN expressions. For example, the expression, NOT Raining AND (Today=Friday) combines the negation of *Raining* and the truth of (Today=Friday).

Set Performs bit operations on operands of type BITSET or logical set operations on user-defined SET types; for example, you may wish to mask the high bit of bytes in a WordStar document file, or you may want to include the enumerated value *Red* in a user-defined set of colors.

S. e the selection of operators is dependent on the type they're operating on, we'll defer further description of each operator until its type is introduced in Chapter 5.

Operator Precedence

When more than one operator appears in an expression, its meaning or result is dependent on the order of evaluation. Operations of highest precedence are resolved first; operations of equal precedence proceed from left to right. Operations within parentheses are of the highest priority, and thus are evaluated first. *Operator precedence* is defined as follows:

lst (Highest)	priority:	NOT, ~
2nd	priority:	*, /, DIV, MOD, AND, &
3rd	priority:	+, -, OR
4th (Lowest)	priority:	=, #, <, >, >=, >=, <>, IN

As an example, let's look at a simple mathematical expression: (

1.0 + 2.0 * 3.0

Contraction of the second s

Evaluation begins on the left with 1.0 + 2.0; however, this subexpression is not fully evaluated until the priority level of the next operator is determined. The previous table, indicates that multiplication has a higher priority than addition; thus the subexpression 2.0 * 3.0 is evaluated first, with its product added to 1.0 for a result of 7.0 (type REAL). Parentheses can alter the interpretation of operator precedence. Wheney parantheses are found in an expression, the contents within the parantheses a evaluated before being combined with any other item in the expression.

If the prior example is changed to include parantheses, as shown in the follc ing:

(1.0 + 2.0) * 3.0

then evaluation will start with the contents of the parantheses, and the sum v be multiplied by 3.0. This time the result will be 9.0 (type REAL).

Boolean expressions are evaluated almost the same as other expression However, in Boolean expressions, it is not always necessary to evaluate the enexpression in order to determine that expression's result. This is called *sha circuit evaluation*. For example, consider the following Boolean expression:

(2+4=4) **AND** (3+4=7)

To begin evaluation, we would first resolve the contents of the first parenthe (2+4=4); its result is FALSE, which is saved. The AND operator is next, because both operands to an AND must be TRUE for the entire expression to TRUE, we need only evaluate the contents of the second set of parentheses if first operand is TRUE. In this case, the first operand of the AND is FALSE the second operand to AND is not evaluated (the expression is short-circuit)

This order of evaluation is useful for certain algorithms that need to access element of an array only if the index is not a number that would cause an all bounds error. Thus, assuming you understand arrays, the following express would *not* cause a bounds error if I is 0 and the array a is undefined when equal to 0:

(I # 0) **AND** (a[I]=100)

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Other Boolean operators, such as OR, are evaluated in a similar manner. T if the first operand of an OR expression is TRUE, the second operand is evaluated. Data Structure

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Chapter 5 Data Structure

Modula-2 is often described as a language that encourages structured programming. It permits a large program to be broken down into smaller, more manageable sections that can be separately compiled into object code. Within a program, objects are structured into logical units that make them easier to manipulate.

Modula-2 has, as you might expect, many components that join to form a modern block-structured language. As Wirth has pointed out, programs are a combination of algorithmic structures and data structures. Modula-2 has welldefined constructs for expressing both structures. In this chapter, we will look at object manipulation in programs and the data structures used to describe these objects.

Data Objects

Data objects are the information a program processes. This information can be numbers, characters, or anything the program problem requires. Every data object in your Modula-2 program has the following properties:

Identifier A unique name distinguishing one data item from another. An identifier is given to most variables, any defined types, many constants, and program parts. Identifiers (except for standard identifiers) must be defined in a declaration.

Value Each data item has a value. This value may be constant and unchangeable throughout the program or the data item may take on different values at different times during the course of the program.

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Each data item has a type that determines its use. The *type* of a data item dictates the values it can be assigned and the operations that can be performed on it.

As an example, suppose your program includes the variable *Count*, which can take any whole number as a value. The variable *Count* has the following properties:

Count is the *identifier*, or unique name, of this data item.

- The value of the variable *Count* is determined at runtime by an assignment and may be changed at any point.
- \Box The *type* of *Count* is INTEGER, which means that it may receive only the values in the range -32K to 32K and that only integer math operations may be performed on it.

There are two categories of types: *unstructured* and *structured*. First, we will look at the elementary data types in Modula-2, which are predefined unstructured types. Then we will see how declarations define a data item's type, identifier, and value. Next, we will discuss user- defined unstructured types. And lastly, for more complicated objects, we will examine the building blocks Modula-2 provides tc define larger structures--structured types.

Elementary Data Types

In the previous chapter, we described some of the objects that might b manipulated in a program (numbers, strings, and so on). In addition, we showe that an object, such as a number, may have different representations called types For simple items, Modula-2 has predefined names that represent these types; fc example, INTEGER, LONGINT, REAL, and so forth. These are called elemer tary data types.

The following eight types are predefined in Modula-2. They are considere basic types and are always available. Generally, variables are declared as one (these types; however, you can also build new types from these basic types.

CHAR type: Range [OC to 377C]. Takes a single character as a value. A CHA constant is denoted by enclosing a printable ASCII character in single or doub quotation marks, or by specifying the octal value of the ASCII character follow by a C (as in the range given here). Sample CHAR values include the followin

"A" '2' "#" ' " ' 1C 377C

Data Structure

BOOLEAN type: Range [FALSE to TRUE]. Assumes one of two logical truth states denoted by the standard identifiers TRUE and FALSE. Use BOOLEAN-type variables when you expect a yes/no- or on/off-type answer. For example, "Is it raining?" has a yes/no answer that could be represented as

Raining = TRUE

or

Raining = FALSE

CARDINAL type: Range [0 to 65535]. Use CARDINAL-type variables anytime values are limited to positive whole numbers or zero, such as for a person's age or address, or lengths and distances. The type CARDINAL is used more frequently than the type INTEGER, and a CARDINAL's range is also double that of an INTEGER in the positive direction. Sample CARDINAL values:

8088 2132 0 64000

INTEGER type: Range [-32768 to 32767]. Use the INTEGER type when values are expected to drop below zero (for instance, in temperature ranges). In practice, this type is not used often since most values in programs are non-negative. Examples of INTEGER values:

8088 -2132 0

BITSET type: Range [0..15] (bit-wise). BITSET is a predefined set type (see "Set Types" later in this chapter), whose primary use is in performing bit-wise operations (such as masking) on word-length variables. BITSETs (and sets in general) has several predefined operations. Operators provided are union(+), *intersection*(-), *difference*(*), and *symmetrical difference*(/). In addition, there are standard procedures (*INCL* and *EXCL*) that are used to include and exclude any element from a set variable, and a reserved word (IN) to test whether a particular element is a member of a set element.

Sets are designated by enclosing the members in curly brackets, like this: [3,4,6]. You can visualize the type BITSET by comparing the set notation to its binary representation:

. []	= 000000000000000
<i>{</i> 4,5,6 <i>,</i> 7,12,13,14,15 <i>}</i>	= 1111000011110000
$\{0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15\}$	= 11111111111111111

In the first example, all the bits are clear which means there are no members in the set. In the second example, bits 4 through 7 and bits 12 through 15 are set (the right-most bit is bit 0). In the last example, all bits are set.

REAL type: Range [-6.80565E+38 to 6.80565E+38]. Use REAL numbers to represent objects with a fractional part or to represent numbers that are very large or very small, including money, the distance to the sun (93,000,000 miles), or measurements of temperature and time. Real numbers have 6 digits of precision; for example:

3.0E+8 98.6 0.0 2.3E-11

Turbo Modula-2 supports two types of double-precision numbers, LONGINT and LONGREAL. Double precision means the number is stored in twice the storage space as its single-precision counterpart, resulting in greater accuracy since the number is represented with more bits. Compare the ranges and number of significant digits in the single- and double-precision numbers.

LONGINT type: Range [-2147483648 to 2147483647]. Double-precision integers are used when a whole number greater than 65535 or less than -32768 is needed. For example, the size of a file may be expressed with a LONGINT as 100000L bytes. Other examples of long integers include the following:

0L 1234567889L -2000000L

LONGREAL type: Range [-3.5953862697246D+308 to

3.5953862697246D+308]. These are double-precision reals. Variables of this type have a precision of 14 digits; for example, multiplication is accurate to 14 decimal points. Use LONGREALs when numbers must be very large or require great accuracy.

Declarations

STATES TO A DESCRIPTION OF THE PARTY OF THE

In general, Modula-2 programs have a declaration part and a program part. The declaration part must contain all constant, type, and data declarations necessary Data Structure

to describe the data objects used in the program part. Data items must be defined before they are used.

Constant Declarations

Constants benefit programs in two ways: (1) They place a descriptive name where otherwise obscure numbers may be. (2) They simplify future modifications by limiting certain changes to those constant definitions that have a global effect.

A constant declaration associates an identifier with a value and a type. Constant declarations start with the reserved word CONST and are followed by any number of declarations terminated by semicolons. Each declaration statement contains an identifier followed by an equal sign, followed by a constant expression. A constant expression is an expression containing only constants.

In the following declaration, the identifier *Code* represents the value *A* and *Rate* represents the value 1.20:

CONST

Code = "A"; Rate = 1.20; Amount = 350.0 * Rate;

These values determine the type of the constant, which for *Code* is CHAR and for *Rate* is REAL. In the third expression, the identifier *Amount* represents the value obtained when the constant expression is evaluated. Notice that the identifier *Rate* must be a constant that has already been defined.

In some cases, the constant's type is not obvious; for example:

CONST

N = 100;

Is the constant N of type INTEGER or of type CARDINAL? In this case, the

answer is both. However, if N had been declared as

CONST N = 60000;

then its type would be only CARDINAL, since the value is out of the range for integers.

Type Declarations

Each data item has a type defining the possible values it can assume and the operations that can be performed on it. In addition, a item type implies its structure and how much storage the data item occupies. The type can be one of the predefined types (such as REAL or CARDINAL) or can be a user-defined type.

A type declaration begins with the reserved word **TYPE** and is followed by any number of declarations terminated by semicolons. Each declaration contains an identifier, followed by an equal sign, followed by a type identifier or statement. For example:

TYPE

Ages = CARDINAL; Time = INTEGER;

Here two new types are introduced into the program. These types can now be used to declare data items with descriptive type names. This method has the same advantage as that of naming constants: By using a descriptive name for a defined type that is to be used several times in the variable declaration, the declaration becomes more readable and easier to modify. For instance, in the previous example, you can change all variables declared as type *Time* from INTEGER to REAL by simply changing the word INTEGER to REAL.

Variable Declarations

Two things are required to describe a variable: a unique identifier and a type. The value of the variable is left undefined so it may assume different values at runtime. Modula-2 has no provision for initialization of variables at load time; all variables must be initialized at runtime.

The variable declaration defines the variable's type and identifier and optionally the location in memory where the variable will exist. The declaration begins with the reserved word VAR and is followed by any number of variable declarations terminated by semicolons. Each declaration starts with an identifier list, optionally followed by an absolute location, then by a colon, and lastly by the type

Data Structure

of the variable. The absolute location is specified by a left square bracket ([), followed by an address, and a right square bracket (]). For example:

VAR

Count: CARDINAL; SwitchOn: BOOLEAN; Screen[OCOO0H] : ScreenType;

This example defines three variables: a CARDINAL called *Count*, a BOOLEAN called *SwitchOn*, and an absolute variable called *Screen* residing at memory location 0C000H (the location must be a constant). This latter variable of type *ScreenType*. These three variables are completely defined and ready to use in a program (assuming the type *ScreenType* has been defined previously).

User-Defined Unstructured Types

We have already seen some predefined unstructured types; however, there are also user-defined unstructured types, which can be used to define variables that can hold one value at a time.

Users can define three unstructured types: *enumeration*, *subrange*, and *pointer*. In general, user-defined types may be declared directly in the variable declaration, or they may be defined as types in the type definition section.

Enumeration Types

Often, predefined types such as INTEGER or REAL are not sufficiently descriptive for certain applications. For instance, suppose you are trying to describe the four points of a compass. One solution is to decide that North is equal to 1, East 2, and so on. However, when you are reading and writing the code, you must always remember which number stands for the compass point you need. Also, the variables you are working with are declared as CARDINAL or INTEGER, which tells you nothing about how the variables should be used. Enumeration types (with

a user- defined range) provide an elegant solution to this problem. First, you define a new type:

TYPE

CompassPoints = (North, East, South, West);

Then, you may declare variables of this type, like so:

VAR

Direction: CompassPoints;

When you use the variable, you simply assign or test for the values you have defined for that type:

```
Direction := North; (* Assign the variable the value North *)
Direction >= East; (* Compare the variable to the value East *)
```

Enumeration types can also be declared directly in the variable section. Once an enumeration type is defined, the names of its values are also declared and cannot be used in another enumeration type. Here the type *Weather* can assume the values *Clear*, *Rain*, *Wind*, or *Snow*. For example,

VAR

)

```
Weather :(Clear,Rain,Wind,Snow);
Water :(Clear,Murky,Opaque);
Color :(Violet,Orange,Green,Black);
```

The use of the value *Clear* in defining *Water* would produce a compiler error because the value *Clear* has already been defined as a value assigned to *Weather*. If the second *Clear* were changed to *Transparent*, then the compiler would accept the declaration.

Enumeration types have an implied order by the way they are declared. In the first example, *Clear* is the first value of the type *Weather*, with an ordinal value of 0. The value *Snow* is greater than *Clear*, *Rain*, or *Wind*. Variables of enumeration types can be compared to find their relative rank. Thus a statement like *Clear* < *Snow* is TRUE and *Rain* > *Wind* is FALSE.

Subrange Types

- - -

The subrange type includes certain variables that can be included in one of the previously mentioned types but which never takes values outside of a restricted range. For example, toda,'s date is of the type INTEGER, but is always in the range of 1 to 31. We can state this by declaring it a subrange of the CARDINAL type. You may define subranges of INTEGER, CARDINAL, or enumeration types. Sample subrange types include the following:

TYPE

Today = [1..31]; (* CARDINAL type with range 1 to 31 *) Unusual = [Rain..Snow]; (* Subrange of Weather

To specify a subrange of positive integers, you may prefix the subrange with the word INTEGER.

VAR

Cents: INTEGER[0..100];

However, in general, the compiler will know which type is specified. If the (ange contains a negative bound, then it assumes INTEGER; otherwise, it assumes CARDINAL.

Pointer Types

Pointers point to another variable that can be of any type, including another pointer. Pointer operations include comparison and assignment, plus a special *dereferencing operator* that allows you to access the object pointed to by the pointer. Pointers are used mainly for pointing to other structured data types such as records or arrays (see "Structured Types" later in this chapter). These pointers are used to build dynamic structures such as linked lists or trees. Sample pointer types include the following:

TYPE

CharPtr	= POINTER TO CHAR;
IntPtr	= POINTER TO INTEGER;
CardPtr	= POINTER TO CARDINAL;
RealPtr	= POINTER TO REAL;
SetPtr	= POINTER TO BITSET;
(ngPtr · · · · · · · · · · · · · · · · · · ·	= POINTER TO LONGINT;
boolPtr	= POINTER TO BOOLEAN;
LRealPtr	= POINTER TO LONGREAL;
PtrPtr	= POINTER TO POINTER TO CHAR

Person = POINTER TO PERSONRECORD

The value of a pointer is an address in memory. Thus, you may assign a pointer value a 16-bit address. Assuming the following variable declarations:

VAR cp1,cp2: CharPtr;

you may make the following assignments:

```
cp1 := ADDRESS(39283); (* Assign an absolute address to cp1 *)
cp2 := cp1;
                       (* Make cp2 point to where cp1 points *)
```

Notice that the ADDRESS operator converts the CARDINAL number to a generic pointer type, which can be assigned to any pointer. (See ADDRESS in Chapter 12, "Turbo Modula-2 Reference Directory," or in the module SYSTEM.)

Dereferencing is used to access the item pointed to by a pointer. The operator used is the caret (^). To dereference a pointer, you simply append the caret to the end of the pointer's identifier. For example, to assign a character to the location pointed to by the previous declaration, you would use the following statement:

cp1 ^ := 'A';

Structured Types

A structured type is a composite of more than one data object. A structured type is analogous to a group of compartments, where each compartment may hold another structured or unstructured type.

There are two types of structures in Modula-2: arrays and records. Arrays are structured types that contain a predefined number of variables of the same type. In contrast, a record contains a fixed number of *different* types.

Both structured types can be accessed as a whole, or the parts of the structure can be accessed individually.

Array Types

Arrays have a fixed number of elements of an identical type. The type of each individual element is called the *base type* of the array. Each element of the array is accessed via an index. Arrays are declared as follows:

VAR

IntegerList: ARRAY[1..5] OF INTEGER;

IntegerList is an array of five integers. The integer elements can be accessed as IntegerList[1], IntegerList[2], and so forth, where the number in the square bracket is the index.

Arrays can be very descriptive when used in combination with enumeration and subrange types. For example, we could use arrays to record the hours of sunshine in each day of the week by using the following declarations:

TYPE

```
Hours = [1..24];
Days = (Sunday, Monday, Tuesday, Wednesday, Thursday, Friday,
Saturday);
DaysOfTheWeek = [Sunday..Saturday];
WeeklySunshine = ARRAY DaysOfTheWeek OF Hours;
```

VAR

```
Sunshine: WeeklySunshine;
```

Then to store the fact that *Monday* was gloomy and *Friday* was sunny, we would use the following:

```
Sunshine[Monday] := 1;
Sunshine[Friday] := 12;
```

Notice that each element can be accessed by an identifying index. The second item in the *Sunshine* array is accessed with the value *Monday*.

It is also possible to treat the array as a unit:

```
"AR
ThisWeek,LastWeek: WeeklySunshine;
```

With this declaration, and assuming the array LastWeek already has some values, we can make this assignment:

```
ThisWeek := LastWeek; (* More of the same weather *)
```

Multidimensional arrays (such as matrixes) are also possible. Given our previous definition of Weather, we can build a structure that will store the weather conditions for each hour of every day for a week. The declaration is as follows:

VAR

WeeksWeather: ARRAY Days OF ARRAY Hours OF Weather;

An alternative and identical declaration is

VAR

WeeksWeather: ARRAY Days, Hours OF Weather;

We can access the elements in several ways, two of which are shown here:

WeeksWeather[Sunday],[12] := Clear;

assigns Clear weather to the 12th hour on Sunday; and

WeeksWeather[Monday] := WeeksWeather[Sunday];

assigns Sunday's weather to Monday.

Record Types

While an array must consist of elements of identical type, a record may consist of elements or *fields* of different types. Each field can be accessed by a uniquante. Records are used to group different types of information into a single datype. Use record variable: to handle such information as the attributes of a perso for example, his or her name, age, address, phone number, or favorite color. The is easily done with the following record declaration:

TYPE				
Peop le =	RECORD			
	Name	:	ARRAY[130] OF CHAR;	
	Age	:	CARDINAL;	
	Address	3:	ARRAY[140] OF CHAR;	
	Phone		ARRAY 1 141 OF CHAR.	

PreferredColor: Color; END;

This is a record containing five fields: Name, Age, Address, Phone and Prej redColor. Each is a different type: three different arrays (Name, Address, & Phone), a CARDINAL, and the user-defined type Color. Each field in the rec can be accessed with the name of the variable, followed by a period and the na Data Structure

of the field to be accessed. For example, if the variable *Friend* is defined as type *People*, like so:

VAR

Friend : People;

then we can access each field as follows:

Friend.Name	:= 'Jon';
Friend.Age	:= 23;
Friend.Address	:= '234 Anywhere Drive';
Friend.Phone	:= '333-3456';
Friend.PreferredColor	:= Blue;

We can also nest records two different ways. We can include the nested record directly in the record definition.

TYPE

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```
People = RECORD
Name : RECORD
First,
Middle,
Last: ARRAY[1..15] OF CHAR;
END:
Age : CARDINAL;
END;
```

Or we can declare the type separately and nest it using the new type's name:

TYPE	•		• • •	
Nam es	= RECORD			
	First,			

Middle, Last: ARRAY[1..15] OF CHAR; END;

People = RECORD
 Name : Names;
 Age : CARDINAL;
 END;

VAR

```
Person: People;
BEGIN
Person.Name.First[1] = 'L'; (* first initial *)
Person.Name.Middle[1] = 'J'; (* middle initial *)
Person.Name.Last[1] = 'G'; (* last initial *)
END
```

Notice that we can now access the initials of a name by selecting the Name field with each of the nested fields (*First, Middle, Last*), and then index into the first character of each array.

Variant Records

A record type can also have one or **more** dynamic variant parts. The variant is selected by the value of a *tag field*.

```
Employee = RECORD
```

```
Name: ARRAY[1..20] OFCHAR;
Age: CARDINAL;
CASE OwnHome: BOOLEAN OF
TRUE: Payment : CARDINAL;
        OwnedSince : Date
        i
FALSE:Rent: CARDINAL
END;
```

In the preceding record, there are two fixed fields, *Name* and *Age*, and a varian part consisting of one or two fields, depending on the value of the tag fiel *OwnHome*. If *OwnHome* is TRUE, then the fields *Payment* and *OwnedSince* ar presumed to exist and the *Rent* field should not be accessed. If *OwnHome* is

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FALSE, then only the *Rent* field should be accessed.

Note: It is possible to access any of the fields regardless of the value of the ta field; it is up to the programmer to ensure that variant fields are only accesse when the tag field has the correct value.

Sometimes you may not want to specify a tag field. In this case, the tag fie

```
Data Structure
```

can be omitted, producing a record with fields that overlap one another. The colon and type must be present to indicate that no tag field was chosen.

```
TYPE
HiLo = RECORD
        CASE : BOOLEAN OF
         TRUE: byte: ARRAY[0..1] OFCHAR;
         FALSE: All: CARDINAL;
        END
       END;
```

VAR

```
MyWord : HiLo;
```

The variable MyWord of type HiLo can be accessed as follows:

```
MyWord.byte[1]:= A'; (* Assign character 'A' to the low byte *)
MyWord.All := 65; (* Assign the CARDINAL 65 to the entire word *)
```

Set Types

A set type defines a collection of related members. The members may be of any scalar type. Within a particular set, all members are of the same type and must have an ordinal value between 0 and 15. For example,

TYPE

```
Color = (Red, Green, Blue);
Digits = SET OF [0..9];
Colors = SET OF Color;
```

The set *Digits* has members that are a subrange of type CARDINAL. The members of Digits have ordinal values ranging from 0 to 9. Colors is a set consisting of members of an enumerated type. The members have ordinal values ranging from 0 to 2.

The value of a set variable is the collection of members that it contains at any point in time. Operations on sets include assignment and comparison, as well as some special set operations. If we define set variables like this:

VAR ColSet1,ColSet2: Colors;

we can make the following statements:

```
ColSet1 := Colors{Red,Blue};
ColSet2 := Colors[Red,Green];
```

Thus, a variable of type *Colors* may take as a value any combination of the three members; for example, [Red,Blue], [Blue], [Green,Blue], and { }, which is the empty set.

Notice that the type of the set must prefix the constant set. If no prefix is present, the type of the set is assumed to be BITSET. The same operations applicable to BITSET are valid for user-defined sets (see BITSET in Chapter 12). Thus, we have the following:

```
ColSet1 + ColSet2= Colors{Red,Green,Blue}ColSet1 - ColSet2= Colors{Blue}ColSet1 * ColSet2= Colors{Red}ColSet1 / ColSet2= Colors{Green,Blue}ColSet1 - ColSet1= Colors{ColSet1 / Colors{Green}= Colors{
```

Procedure Types

Procedure types are an advanced language feature included here for completeness. Thus, you may wish first to read more about procedures and parameters (ir Chapter 6), and then come back to procedure types.

Procedures can be assigned to a variable in order to be passed as arguments to other procedures. A procedure-type declaration specifies the number and type o its parameters and an optional function result. The following is a sample pro cedure type:

TYPE

(

Proc1 = PROCEDURE (CARDINAL, VAR INTEGER);

This is a procedure type with two arguments. The first argument is a valu

Data Structure

parameter of type CARDINAL and the second is a variable parameter of type IN-TEGER. For example, suppose P is a procedure variable of type *Procl*; declared as

VAR

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P: Proc1;

The procedure variable P can take two arguments: one a CARDINAL, the other an INTEGER variable, and only in that order. The variable P could then be passed as an argument to another procedure.

A procedure variable may only take on the value of a globally defined procedure (see "Procedure Declarations" in Chapter 6) with an identical parameter list. For example, the variable P may take the value of procedures declared as follows:

PROCEDURE Test(:CARDINAL; VAR i:INTEGER);
BEGIN
END Test;

or

PROCEDURE Fees(accountNo:CARDINAL; VAR Balance:INTEGER);
BEGIN
END Fees;

The assignment operation is the only operation allowed on procedure variables.

P := Test; P := Fees;

Assuming that *Fees* is assigned to *P* and that *CurrentBalance* is declared as an INTEGER variable, the procedure *Fees* can be called as follows:

P(121,CurrentBalance);

The most useful aspect of procedure variables is passing them as parameters to algorithms accessing complicated data structures (such as tree traversal procedures). The benefit is that many different operations can be performed on each element of the data structure, but only one data- access routine need be written to do so.

Statements

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Chapter 6 **Statements**

In the previous chapter we discussed how to define data with constant, variable, and type declarations. Now we'll provide you with the remaining item you'll need to write your program. the statement.

Statements provide a means to handle data and define the flow of control. Modula-2 program statements can be divided into four classes: assignment, conditional, repetitive, and procedural (which includes procedure calls and a special flow of control statements). Each statement type will be examined in detail, but first we'll talk about programs in general in Modula-2.

In Modula-2, programs are called modules. Every main program begins with the reserved word MODULE, followed by the name of the program and a semicolon. The module statement is followed by a series of declaration statements that include the data declarations discussed in the last chapter (namely constant, type, and variable declarations), and possibly external and procedure declarations (discussed in the following chapter and at the end of this chapter, respectively).

The following sample program outlines the general form of a Modula-2 program:

```
MODULE Skeleton;
(* External Declarations (Next Chapter) *)
```

JONST

```
(* Constant Declarations (Last Chapter) *)
TYPE
```

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(* Type Declarations (Last Chapter) *) VAR

(* Variable Declarations (Last Chapter) *)

(* Procedure Declarations (This Chapter) *)

BEGIN

```
(* Program statements (This Chapter) *)
END Skeleton.
```

The program body follows the declaration section, and contains statements separated by semicolons. The statements are within a block enclosed by the reserved words BEGIN and END, followed by the name of the program and a period. Modula-2 statements can be divided into the following classes:

- Assignment Assignments are made to variables, resulting in a change in the value that the variable holds. The source of the assignment may be any expression that has the same resulting type as the destination. A simple assignment may look like this: X := 4.
- Conditional This class groups statements together so that they are executed only if a specified condition is TRUE; for example, »If it's raining, then....« This group includes the IF and CASE statements.
- Repetitive Looping statements group one or more statements that are to be executed a number of times. For example, a loop may »Switch a light on and off ten times.« This group includes the FOR, WHILE, REPEAT, and LOOP statements.
- Procedural These statements call and control subroutines. They include procedure calls and the RETURN statement, which affects the flow of control in procedures.

Assignment Statements

A simple assignment statement replaces the current value of a variable with the result of an expression. The expression may be as simple as a constant or another variable, or it may be a complicated mathematical expression containing con-

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stants, variables, and functions. For example:

MODULE Assignment; CONST Pi = 3.14159;

Statements

VAR

```
X,Y: CARDINAL;
CircleArea,Radius,Z : REAL;
```

BEGIN

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```
(* simple *)
X := 2;
Y := X + 1;
Z := 3.23;
```

```
(* complex *)
CircleArea := 2.0 * Pi * Radius;
Z := (CircleArea*(45.2/29.3)+Z*(Z+2.0))/Pi;
END Assignment;
```

The result of the expression on the right must be assignment compatible with the variable on the left. In the first two examples, the expressions result in type CARDINAL; thus X and Y must be of type CARDINAL. The second set of expressions have REAL results; thus *CircleArea* and Z are of type REAL.

Note that := is the assignment operator and should be read as \rightarrow becomes (or gets), as in I becomes I+1, or I gets I+2.

WITH Statements

The WITH statement is used to alter the scope of identifiers, and is often used with assignment statements (though it is not itself an assignment statement). WITH is used with record variables, eliminating the need to name the record identifier for each field accessed within the WITH block. The WITH statement takes the following form:

WITH record identifier DO Statement sequence

END

This statement improves code readability when you are assigning values to fields of record variables, because the code reflects the immediate action of assignment to individual fields without the clutter of additional identifiers. For example:

```
MODULE WithStatement;
TYPE
Months = (Jan, Feb, Mar, Apr, May, Jun, July, Aug, Sep, Oct, Nov, Dec);
Date
        = RECORD
           Day: [1..31];
           Month:Months;
Year:CARDINAL
          END;
Person= RECORD
                       : ARRAY[0..30] OFCHAR;
            Name
                       : CARDINAL;
            Age
            Height
                       : REAL;
            BirthDay
                       : Date;
          END;
VAR
```

Friend: ARRAY [1..2] OF Person;

BEGIN

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```
Friend[1].Name := 'Rodney';
Friend[1].Age := 28;
Friend[1].Height := 5.5;
Friend[1].BirthDay.Day:= 3;
Friend[1].BirthDay.Month:= Dec;
Friend[1].BirthDay.Year:= 1958;
WITHFriend[2] DO
Name := 'Judith';
Age := 32;
Height := 5.4;
WITH BirthDay DO
Day:= 27;
Month:= Oct;
Year:= 1954;
END
```

END

ENDWithStatement.

The first record, *Friend* [1], receives values by simple assignment. Note that for every field accessed the name of the record is present. The second record is accessed using the WITH statement. Notice that the structure of the code reflects the structure of the data. The change in scope is accentuated by the indentation used to code the WITH statement.

Conditional Statements

IF Statements

The IF statement executes a different statement sequence depending on the result of a Boolean expression. The IF statement has the form

```
IF BOOLEAN expression THEN
 Statement sequence
(ELSIF BOOLEAN expression THEN
 Statement sequence]
FELSE
 Statement sequence]
END
```

The ELSIF (else if) and ELSE parts are optional. If the Boolean expression following the IF is TRUE, the first statement sequence is executed and control continues with the first statement after the END. If the first expression is FALSE and the ELSIF part is present, then its Boolean expression is evaluated. If it is TRUE, then its statement sequence is executed; otherwise, the next ELSIF is evaluated. There may be any number of ELSIF parts after the IF THEN, including none. If all expressions are FALSE, then the ELSE part, if present, is executed. For example:

```
MODULE If Then ElsifElse;
```

VAR

```
SwitchOn, PowerOn: BOOLEAN;
Status : (OK, Danger, Emergency);
```

BEGIN

```
(* Statements that set Boolean flags *)
IF SwitchOn AND PowerOn THEN
  Status := OK
```

ELSIF NOT SwitchOn THEN

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```
Status := Danger
```

ELSE

Status := Emergency END;

(* Other statements *) END IfThenElsifElse.

After the Boolean flags have been set, the expression following the IF is evaluated. If it is TRUE, then *Status* gets *OK* and execution continues after the END; otherwise, the ELSIF expression is evaluated. If it is TRUE, then *Status* gets *Danger*. However, if the ELSIF expression is FALSE, the ELSE is executed and *Status* is set to *Emergency*. After either the IF part, the ELSIF part, or the ELSE part is executed, control continues with the first statement after the END

CASE Statements

The CASE statement executes a different statement sequence according to th value of an expression. The result of the expression is compared against value in a constant list (a list of constants separated by commas) until a match is foun or there are no constants left. A CASE statement may have several constant lists each associated with a statement sequence and separated by vertical bars.

The elements of the constant lists must be of the same type as the expressio following the CASE. The CASE statement takes the form

```
CASE expression OF
Constant List : statement sequence
Constant List : statement sequence
.
.
.
.
FISE
statement sequence
```

END

where a particular statement sequence is executed if the expression results a value contained in the constant list. The optional ELSE part is executed if nor of the constants match the expression. If none of the constants match the expre sion and there is no ELSE part, the behavior of the code is dependent on the se ting of the TEST switch when the source was compiled (see »Compiler Optio and Switches,« in Chapter 10). If TEST is ON, then the exception CaseSelectE ror is generated. If TEST is OFF, then execution continues with the instruction after the END that corresponds to the CASE. For example:

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Statements

```
MODULE Cases;
 VAR
        : (Freezing, Cold, Cool, Perfect, Warm, Hot, Searing);
  Temp
 HeaterOn,
 AirConditionerON : BOOLEAN;
 BEGIN
  (* Statements which set Temp *)
  CASE Temp OF
 Freezing..Cool
                   : HeaterOn := TRUE
   Perfect, Warm, Hot : HeaterOn := FALSE
  ELSE(* must be Searing *)
   HeaterOn := FALSE;
   AirConditionerON := TRUE;
  END
 END Cases.
```

This example executes one of three statement sequences depending on the value of *Temp*. If *Temp* has a value between *Freezing* and *Cool*, then the heater is turned on. If the value is between *Perfect* and *Hot*, then the heater is turned off. However, *Temp* may take on a value that is in neither constant list. In that case, the ELSE part of the CASE statement is executed and the heater is turned off and the air conditioner is turned on.

Note: The CASE statement is for situations where the lists of constants have adjacent ordinal values. When conditional execution is dependent on nonadjacent values, the IF THEN ELSIF statement should be used; otherwise, nonadjacent values used in CASE statements will generate a relatively large amount of code.

Repetitive Statements

FOR Statements

The FOR statement encloses a sequence of statements that is repeated a fixed number of times. The FOR statement takes the form

```
FORVar:= First TO Last BY Step DO
```

statement sequence

END

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where Var is a variable called the *control variable*, First is the initial value of Last is the final value of Var, and Step is the increment added to Var for each ite tion. First, Last, and Var can be any ordinal type, but they must all be of the sa type.

The statement sequence is repeatedly executed and the control variable cremented until the control variable equals or exceeds the value of *Last*. For exple:

MODULE ForLoop; CONST

```
Increment = 0.1;
```

VAR

```
I:CARDINAL;
```

Result:REAL;

BEGIN

```
FOR I:= 0 TO 10 BY 2 DO
```

```
Result:= Result + Increment
```

END

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END ForLoop.

This example repeats the statement sequence six times, with I equal to values 0, 2, 4, 6, 8, and 10. If the optional step value is omitted, then it is assurt to be 1. The step can also be negative; for example:

MODULE ForLoopCountDown VAR Time,Add:INTEGER; BEGIN FORTime:= 3 TO -3 BY -1 DO Add:= 2 * Time END END ForLoopCountDown.

Note that the control variable can take part in the statement sequence but can be altered by it.

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WHILE Statements

The WHILE statement repeats a statement sequence until a Boolean expression yields a FALSE result. The WHILE statement takes the form

WHILE Boolean expression DO statement sequence END

where the statement sequence is repeatedly executed when the Boolean expression is TRUE. For example:

```
MODULE WhileLoop;
VAR
Control:CARDINAL;
BEGIN
Control:= 4;
WHILE Control>0 DO
Control:= Control - 1
END
END WhileLoop.
```

This example repeats the statement sequence until Control is equal to 0.

Note that the Boolean expression is evaluated before the statement sequence; therefore, it is possible that the statement sequence will not be executed. In the preceding example, this would be true if *Control* was set to 0 instead of 4. Also note that the values that make up the control expression must be affected by some part of the loop, otherwise the loop will never end.

REPEAT Statements

The REPEAT statement replicates a statement sequence until a Boolean expression yields TRUE. The REPEAT statement differs from the WHILE statement in that the expression is evaluated *after* the statement sequence; therefore, the statement sequence is always executed at least once. The REPEAT statement has the form

REPEAT

statement sequence UNTIL Boolean expression

where the statement sequence is repeatedly executed until the expression is TRUE. For example:

```
MODULE RepeatLoop;
VAR
N: REAL;
BEGIN
N := 1.0;
REPEAT
N := 2.0 * N;
UNTILN > 100.0;
END RepeatLoop.
```

This loop repeats until the value of N is greater than 100.

LOOP Statements

The LOOP statement repeats a statement sequence until terminated by an EXIT statement. The LOOP statement has the form

LOOP

```
statement sequence
```

This statement is generally used when the termination condition can only be determined in the middle of the loop. Since Modula-2 has no GOTO statement, the EXIT statement is used to terminate the loop and continue control at the statement after the END.

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EXIT Statements

The EXIT statement specifies termination of a LOOP statement. A common example of this occurs in sequential processing, where a data object is obtained and then processed. In this instance, a problem can occur if the program can only test if the object was obtained successfully *after* the statement to obtain it. Thus, there must be a test directly after the *Obtain* statement to see if it was successful. If

it was not, no further processing can be done and control must be passed around the processing statements and go to the statement after the loop. The following example simulates this situation with arrays:

```
MODULE LoopLoop;
TYPE
DataObject = RECORD
Name : ARRAY[0..30] OFCHAR;
Age : CARDINAL
END;
```

VAR

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```
Record: ARRAY[1..10] OFDataObject;
WorkRecord : DataObject;
```

BEGIN

```
I := 0;
Record[10].Name := 'LastRecord';
LOOP
I := I + 1;
WorkRecord := Record[I];
```

```
IFWorkRecord.Name = 'LastRecord' THEN EXIT END;
```

```
(* statements to process the record *)
```

END

END LoopLoop.

This example presents a more common problem with sequential file processing: The flag in the *Name* field represents the end-of-file condition; thus, the records are continually read and processed until the end-of-file condition is TRUE. At this point the EXIT statement is executed and control continued after the loop's END.

More than one EXIT can be present in a loop. However, if there are too many XIT statements, it is difficult to understand the meaning of the loop and to determine when and where it will terminate.

Procedural Statements

Procedures are named subroutines and subroutines are pieces of code declared elsewhere and invoked by name. In the following, we will look at how a procedure is called and how it is defined.

Procedure Calls

A procedure call is an identifier, optionally followed by a parameter list. The identifier represents a sequence of statements defined elsewhere. When a procedure call is encountered in a statement sequence, the flow of control is transfer red to the statements that that identifier represents. A procedure call may have parameters specified by listing variables or constants, which are separated by commas and enclosed in parentheses. These are called *actual parameters*. The following example shows three procedure calls in the body of the module:

MODULE ProcedureCall;

```
(* Statements that define the procedure Read *)
```

VAR

Number,

Count	:	CARDINAL		
First	:	INTEGER;		

BEGIN

```
Read(Number); Read(Count); INC(First);
END ProcedureCall.
```

The first *Read* statement has one actual parameter, *Number*. This parameter can be different each time the procedure is invoked, as with the second procedure cal of *Read*, where *Count* is the actual parameter.

Note that there must be a declaration statement defining *Read*. However, thi is not so with the third procedure call in the example, (INC(First);). This is because it is a standard procedure, predefined in Modula-2 and callable from anywhere without explicit declarations. (There is a list of standard procedures a the end of this chapter.)

Procedure Declarations

Procedure declarations allow the programmer to define a statement sequence once and use it many times. Procedures allow a series of actions to be abstracted into a single meaningful name. For example, it could take hundreds of lines of code to implement the following procedure calls:

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ReadChar; AccessFile; WriteScreen;

However, these three statements abstract the lines of code into names that describe the action the code performs. (This lends itself to the concept of information hiding: The details of each procedure are not relevant to the immediate code; they are hidden in the declarations of each procedure.)

As mentioned at the beginning of this chapter, the declaration section of a module may contain procedure declarations. Each procedure declaration starts with the reserved word **PROCEDURE** and is followed by the procedure's identifier name, an optional parameter list, an optional function result type, and a semicolon. Next is a declaration section that contains constant, type, variable, and possibly additional procedure declarations. The following example shows a skeleton procedure declaration:

```
PROCEDURE Skeleton((* parameter declarations *));
CONST
```

```
(* Constant Declarations *)
```

TYPE

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```
(* Type Declarations *)
```

VAR

(* Variable Declarations *)

(* Procedure Declarations *)

BEGIN

```
(* Program Statements *)
END Skeleton;
```

Notice the similarities between this procedure skeleton and the module skeleton at the beginning of this chapter. Both have a declaration section and a body, which is convenient when you need to convert a stand- alone program to a subroutine. The following example shows how procedures are declared and how they can be called repeatedly:

MODULE ProcedureDeclaration; VAR

x: CARDINAL;

PROCEDURE ExampleProcedure; BEGIN

x := x + 1;

END ExampleProcedure;

BEGIN

```
x := 0;
ExampleProcedure;
ExampleProcedure;
ExampleProcedure;
END ProcedureDeclaration.
```

The module *ProcedureDeclaration* has defined one procedure called *ExampleProcedure*. The body of the module calls it three times, incrementing x by 1 each time the procedure is invoked.

Parameters

Procedure declarations may have parameters that are passed to the procedure in a procedure call. The parameters are specified in the procedure statement after the procedure identifier, and enclosed in parentheses. This is called a *parameter declaration*.

The parameter declaration defines the names and types of each parameter, which are its *formal parameters*. For example:

PROCEDURE foo(a,b,c: INTEGER; d: CARDINAL; e: REAL);

Notice that parameters of the same type may be grouped together, as in variable declarations. Each group of parameters is separated by semicolons. In addition to name and type, the declaration determines the kind of parameter that is being passed.

There are two kinds of parameters: variable parameters and value parameters. Variable parameters link actual and formal identifiers, and are identified by prefixing a group of parameters with the reserved word VAR. Value parameters pass a value as an initial condition to a formal identifier. Since VAR does not appear in the preceding declaration, all of the parameters are value parameters.

To explain the difference between variable and value parameters, let's look at the procedure call. When a procedure call passes a parameter to a subroutine, the program may or may not want the variable it passes to be changed. If it does not, the formal parameter should be declared as a value parameter. But if the call is

Statements 5 8 1

expecting the procedure to do some work on the variable and return the new value, then the formal parameter should be a variable parameter.

When a value parameter is passed, a copy of the value is made. Any reference to that parameter will affect only the copy and not the original; thus, constants as well as variables may be passed as value parameters. For example:

MODULE ValParameters;

PROCEDURE Power(VAR A:REAL;I:CARDINAL); VAR Temp: REAL; BEGIN Temp:= 1.0; WHILE I > 0 DO Temp:= Temp * A; I := I - 1END; A := Temp; END Power; VAR x : **REAL**; e : CARDINAL; BEGIN x := 10.0; e := 2; Power(x,e); (* Raise 10 to the 2nd power *) (* Now x = 100.0 *)Power(x,3); (* Raise 100 to the 3rd power *) (* Now x = 1000000.0 *)END ValParameters.

(The reserved word VAR in the procedure heading declares A to be a variable parameter; the cardinal I is a value parameter.)

In the first call, the value parameter is the variable *e* set to the value 2. Notice that the value of I is changed. This will not be reflected in the value of e; it will remain the same. In the second call, the constant 3 is passed as a value parameter. A copy of this value is made within the procedure, thus it may be treated as a variable within the procedure.

When a variable parameter is passed, the address of the variable is passed. Thus, any reference to that parameter is to the original copy. For this reason, constants cannot be passed as variable parameters.

The following example shows the use of variable parameters:

```
MODULE VarParameters;
```

```
PROCEDURE Swap(VAR I,J: INTEGER);
VAR
Temp: INTEGER;
BEGIN
Temp:= I;
I:= J;
J:= Temp;
```

END Swap;

VAR

The integers I and J are formal parameters. The formal parameters are used inside a procedure in place of the external actual parameters (a, b, c) in the example.

In the first call to Swap, a and b are aliases for I and J, respectively, which allows the procedure to change the values that a and b contain. The procedure interchanges the values of I and J, as well as the values of the external variables a and b. The second call then interchanges c and a, whereby c ends up with b's original value, a gets the value of c, and b holds the original value of a.

Open Array Parameters

Modula-2 has a special feature that allows an array of unspecified size to be passec as a parameter to procedures. These are called *open array parameters*. They are specified in the parameter declaration list in the following form:

ARRAY OF T

where T is the type of the item in the array. The lower bound of the array is always 0, and the upper bound is determined by a call to the standard procedure HIGH. HIGH returns the highest legal index value based on the declaration of the array that was passed, but which has been adjusted so that the lower bound is zero. For example, consider this module:

MODULE OpenArrays;

TYPE

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Employee = **RECORD**

Name Age

: ARRAY[0..20] OF CHAR; : CARDINAL; : REAL; Wage

END;

VAR

```
: ARRAY[1..20] OF Employee;
AllEmployees
CurrentEmployees : ARRAY[0..9] OF Employee;
```

PROCEDURE PrintEmployeeRecords(VAR e: ARRAY OF Employee); VAR

```
I: CARDINAL;
```

BEGIN

```
FOR I := 0 TO HIGH(e) DO
WITH e[I] DO
```

WRITELN(Name,Age:10,Wage:5:2);

END

END

END PrintEmployeeRecords;

VAR

I: CARDINAL;

BEGIN

```
FOR I := 1 TO 20 DO
 WITH AllEmployees[I] DO
  Name := 'Hilary';
  Age := 11;
 Wage := 3.35;
 END
END;
```

```
FOR I := 0 TO 9 DO
WITH CurrentEmployees[I] DO
Name := 'Nate';
Age := 2;
Wage := 3.35;
END
END;
PrintEmployeeRecords(AllEmployees);
PrintEmployeeRecords(CurrentEmployees);
END OpenArrays.
```

The procedure *PrintEmployeeRecords* will accept and correctly print the two Employee arrays even though they have different bounds. Note that the function *HIGH* gives the highest legally accessible item in the array.

Although *HIGH* provides the largest index, you may still need another way to determine how full the array is. For instance, it is often useful to define procedures that have open arrays of characters, because you need to pass strings of differing length to the same algorithm. However, the character arrays may not be completely filled when passed to the open array; thus, *HIGH* points to the end of the array rather than the end of the string. Modula-2 appends a null character (0C) if a constant string is passed to a procedure with an open array. Thus, the procedure can determine the actual length by scanning for the null character.

With open arrays of other types that may not be completely filled, you must provide some mechanism for the procedure to determine the last valid item in the array. This may be a flag record or an additional parameter that gives the count.

There is an even more powerful version of an open array that allows you to pass any type to a procedure; for more details, refer to Chapter 8. Turbo Modula-2 allows multidimensional open-array parameters, specified as

M: ARRAY OF ARRAY OF T

The high bound of the first dimension is HIGH(M) and the high bound of the second dimension is HIGH(M[0]). Thus you may find the high bound of the *n*th dimension by passing HIGH the array with *n*-1 subscripts.

Function Procedures

As mentioned earlier, a procedure may return a result. This is called a *function procedure*. A call to a function procedure is either an expression or part of an expression. The types of values they return must be defined in the procedure statement, as follows:

PROCEDURE Foo(): INTEGER;

This procedure heading defines a function that returns a value of type IN-TFGER. Note that even though there are no parameters, the empty parameter list $n^{(1)}$ be present. This is true for both formal and actual parameter lists. For example, if the preceding function is used to assign a value to an integer variable, then it will look like this:

IntVar := Foo();

With the empty parameter list, it is clear whether an identifier occurring in an expression is a variable or a function procedure. This is not a problem with normal parameterless procedures, because they cannot occur in expressions.

As an example, we will change the *Power* procedure we used earlier to a function:

MODULE FunctionProcedure;

ENI);	
RE	TURN	Temp;
END	Powe	er;

VAR

x: REAL; e: CARDINAL; BEGIN x := 10.0; e := 2; x := Power(x,e); (* Raise 10 to the 2nd power *) (* Now x = 100.0 *) x := Power(x,3); (* Raise 100 to the 3rd power *) (* Now x = 100000.0 *) END FunctionProcedure.

The FunctionProcedure example has the same outcome as the procedure Power example, but the methods are different. The parameter declaration for A has been changed from a variable parameter to a value parameter. Thus, the actur parameter is not changed by the body of the function, but by the assignment stat ment in the body of the module. Another difference is that the function Power h an explicit RETURN statement to define the result and terminate the procedur

In general, it is a good practice to have only value parameters in a function pr cedure. When a function's variable parameter or global variable is changed with the course of the function call, it is called a side effect.

RETURN Statements

The value returned by a function procedure is explicitly named by a RETUR statement. This statement takes the form

RETURN value;

where *value* is an expression with the same resulting type as the function pr cedure. Thus, in an earlier example, the statement

RETURN Temp;

specifies the result of the function. The **RETURN** statement may also be us in normal procedures with no statement after **RETURN**. In a normal procedur the **RETURN** statement has the same effect as if the procedure had come to t final END statement. This permits procedures to be exited at any point. As w

the EXIT statement previously described, too many RETURN statements in a procedure make it difficult to understand.

Examples of **RETURN** statements:

```
RETURN ; (* normal procedure *)
RETURN 26; (* function procedure returning an Integer *)
```

Nested Procedures

As shown in the skeleton procedure, the declaration section can also include additional procedure declarations called *nested procedures*, or *local procedures*. (The procedures described earlier are global procedures.) The following is an example of a nested procedure:

MODULE NestedProcedures;

PROCEDURE LevelOne;

PROCEDURE LevelTwo;

PROCEDURE LevelThree; BEGIN END LevelThree;

BEGIN (* LevelTwo procedure body *)
END LevelTwo;

PROCEDURE AnotherLevelTwo; BEGIN END AnotherLevelTwo;

BEGIN (* LevelOne procedure body *)

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END LevelOne;

BEGIN (* Module body *) END NestedProcedures.

This example defines four procedures: one is global (procedure *LevelOne*), and the remaining three are nested. Two are considered local to the procedure

LevelOne; they are LevelTwo and AnotherLevelTwo. The procedure LevelTwo a local procedure called LevelThree. At certain points in this program, only tain procedure identifiers are available to be called. This is because proced restrict the visibility of identifiers declared within them. This is referred to as scope of an identifier.

Scope of Visibility

Here we present the rules for the *scope of visibility* of an identifier for a cedure. The rules for modules are slightly different and are presented in the chapter.

The procedure in which an identifier is declared defines the scope of visit for that identifier. For procedures, the rules are as follows:

 \Box An identifier exists while the declaring procedure is active.

- □ An identifier is visible within the declaring procedure after the identifi declared and it is also visible within nested procedures unless redeclare a nested procedure. The new identifier exists until the redeclaring proce is inactive, then the identifier reverts to the original declaration condit
- □ All identifiers that are visible outside of the procedure are also visible in the procedure, unless redeclared in that procedure.

For example consider the following module:

MODULE ProcedureScope;

```
PROCEDURE A;
VAR
i,j: CARDINAL;
```

```
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```

PROCEDURE B; VAR j: REAL; BEGIN (* i and j (the REAL) are visible here *) END B;

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PROCEDURE C; BEGIN END C;	(*	i and	j	(the	CARDINAL)	are	visible	here	*)
BEGIN END A;	(*	i and	j	(the	CARDINAL)	are	visible	here	*)

BEGIN END ProcedureScope.

An identifier declared in A is visible in A, B, C, and all the procedures nested within B and C. On the other hand, an identifier declared in procedure B is visible only in B and any of B's nested procedures, but not in A or C.

Notice that the identifier j is declared in both A and B. The A version of j (the CARDINAL) is visible throughout A, C, and the procedures nested in C. In procedure B, the A version is invisible, being replaced by the B version of j (the REAL). The B version is therefore visible in B and all the procedures nested in B.

FORWARD Statements

The original definition of Modula-2 specified that identifiers declared at the same level have the same scope. Thus a procedure declared textually at the top of a program could call a procedure that was declared later in the text. This was possible because the first Modula-2 compilers were multipass compilers (in most cases four passes) that could resolve an undeclared reference on a subsequent pass.

Turbo Modula-2 and Wirth's latest compilers are one-pass, recursive-decent compilers, which means there must be additional syntax to allow a single pass. This is done with the FORWARD statement. Its syntax and usage is similar to that of Pascal's. To use the FORWARD statement, simply copy the entire procedure heading, including the parameter list and the optional function result, to the location where it is needed. Then append the FORWARD statement and a semicolon. You need not change the procedure at all. The syntax is as follows:

PROCEDURE indentifier (parameter list) :result type ; FORWARD ;

This statement is required for algorithms involving mutual recursion, where one procedure calls another, which then calls the first. For example:

MODULE MutualRecursion;

PROCEDURE One; FORWARD ;
PROCEDURE Two;
BEGIN
WRITELN('Procedure Two'); READLN;
One;
END Two;

BEGIN

WRITELN('Procedure Two'); READLN;
One;
END Two;

PROCEDURE One; BEGIN WRITELN('Procedure One'); READLN; Two; END One;

BEGIN

One; END MutualRecursion.

Thus, the FORWARD statement is a way of extending the scope of a pr cedure's identifier, making it available over a larger program area.

Standard Procedures

Modula-2 includes several predefined procedures that are visible anywhere with a program; in other words, the identifiers do not require importing into a modul (To see examples of these procedures, turn to the respective entries in Chapter 12

The following is a list of all standard procedures in Modula-2:

ABS(X) Absolute value of variable X
CAP(Ch) Uppercase of letters Ch
CARD(X) Conversion of X to CARDINAL
CHR(X) The character with ordinal number X
DEC(X) Replace X by its predecessor

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Replace X by its Nth predecessor
Exclude element I from set S
Conversion of X to REAL
Halt program execution
Upper index of array A
Replace X by its successor $(X := X + 1)$
Replace X by its Nth successor $(X := X + N)$
Include element I in set S
Conversion of X to REAL
Halt program execution
Upper index of array A
Replace X by its successor $(X := X + 1)$
Replace X by its Nth successor $(X := X + N)$
Include element I in set S
Conversion to INTEGER
Conversion to LONGINT
Largest element of type T
Smallest element of type T
Returns Boolean TRUE if X is odd
Ordinal number of X in its type
Returns the size in bytes of variable X
Returns the size in bytes of type T
Truncate real X to CARDINAL
Value with ordinal number X and type T

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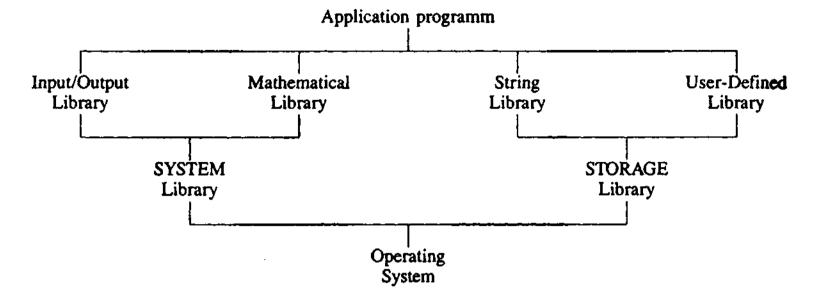
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Figure 7-1: Hierarchy of Modula-2 Program



The application program is the main module, requiring the services of the *Ir* put/Output, Mathematical, String, and User-defined Library modules. Thes modules in turn may require the services of the so-called, »low- level« module (SYSTEM and STORAGE Libraries), which in turn require the services of th underlying operating system.

Each library module is a self-contained unit that is compiled separately. Use can build their own library modules and use them as if they were provided by th Modula-2 system. When a main module uses library procedures, the facilities that library are linked to the main program. In general, this process is the san for both predefined and user-defined modules.

As in any hierarchy, the application program may bypass the intermedia modules to use the services of the low-level modules.

When a module requires the services of a library module, it must explicitly st this as the first item in its declaration section. This is done with the **IMPOI** declaration, which can take the following forms:

FROM < module name > **IMPORT** < identifier list > ;

or

IMPORT < identifier list>;

The first form names a library module after the reserved word FROM, the names the identifiers it requires from that module after the reserved word I PORT. The identifier list is terminated with a semicolon.

Modules

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Chapter 7 Modules

In Modula-2, the module is a syntactical construct that serves to encapsulate certain parts of a program, letting the outside world see only identifiers that are explicitly made visible. Up till now, all the sample modules we have seen have been stand-alone programs, or main modules (which are analogous to entire Pascal proms). Typically, though, Modula-2 programs are made up of many modules, where each support module contains a small amount of code to do its part.

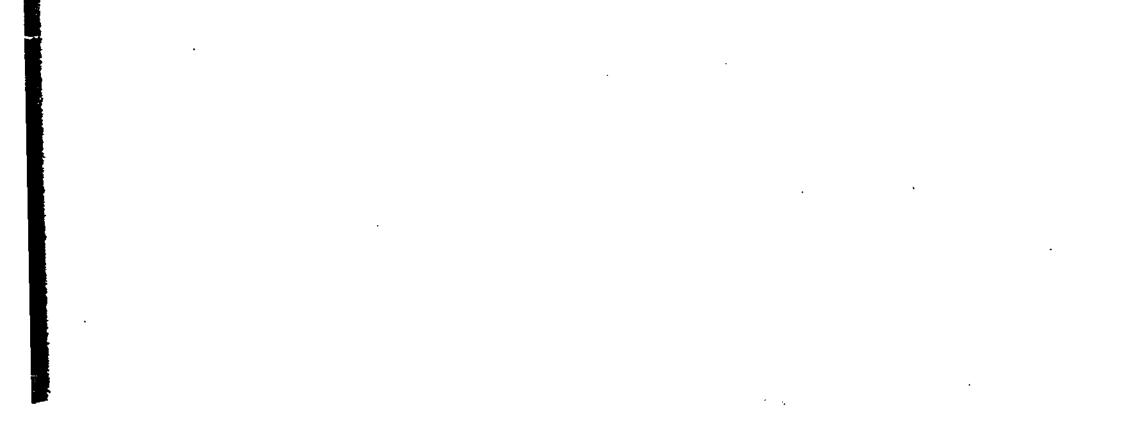
In the Turbo Modula-2 system, the smallest modules have less than 100 lines, the most complex ones nearly 1,500. (The upper limit also mirrors the memory limitations of the computer we're working on [Z80].) How large should a module be? There is no general rule. The task is to break the problem into natural pieces and to have little interconnection between the parts. The amount of interconnection is mirrored by the size of import and export lists; the smaller the lists, the better.

In this chapter, we'll examine the types of modules that can be used in Modula-2.

The Main Module

The main module defines a program. When a main module is running, it usually requires the services of library modules and the underlying operating system. \therefore these may be viewed as disjoint units (only minimal connection), we may $\log \kappa$ at a Modula-2 program as hierarchically structured, as shown in Figure 7-1.

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The second form imports all identifiers made available by the module specified after the reserved word **IMPORT** and followed by a semicolon. However, unlike the first form, use of imported identifiers requires qualification. This means that any identifiers used from this module must be prefixed with the module name, as follows:

ModuleName.IdentiferName

Typically, this form is used when identifiers imported from different modules have the same name. Thus, the module name specifies which identifier is intended. The following example shows the use of the two forms of the IMPORT statement:

```
MODULE ImportLists;
```

FROM Terminal IMPORT WriteChar, WriteString, WriteLn, ReadChar; IMPORT Texts;

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ch: CHAR; num: INTEGER;

BEGIN

```
WriteString('Enter a character: ');
ReadChar(ch); WriteLn;
WriteString('The character you entered was " ');
WriteChar(ch);
WriteString(' " . '); WriteLn;
```

Texts.WriteLn(Texts.output); Texts.WriteString(Texts.output, 'Enter an integer and') Texts.WriteString(Texts.output, 'press return: '); Texts.ReadInt(Texts.input,num); Texts.WriteString(Texts.output, 'The number you entered was '); Texts.WriteInt(Texts.output,num,2); Texts.WriteInt(Texts.output); END ImportLists.

The facilities of the two library modules *Terminal* and *Texts* are used in the program ImportLists. Individual identifiers are imported from the module *Terminal*: *WriteString*, *WriteChar*, *ReadChar*, and *WriteLn*. All facilities from the module Texts are made available, though they must be qualified. The identifiers used from Texts are output, input, WriteLn, WriteString, ReadInt, and WriteInt. Notice that some procedures are available in both modules, which is why the module Texts was imported as a whole and then its identifiers qualified. (For more details on the operations of Texts and Terminal, refer to Chapter 11, "The Standard Library," or the specific procedures in Chapter 12.)

Library Modules

Library modules have two advantages over stand-alone modules: *information hiding* and *module decoupling*.

In Modula-2, library modules hide the operation and details from the module user; information needed to use the library facilities is separate from the implementation details.

In the preceding example, we needed to know the types and number of parameters of the *WriteString* procedure in order to use it in the module *Terminal*. The declaration

tells us that the procedure *WriteString* takes an array of characters and prints them to the screen. This information is contained in a *definition module* (explained in the next section). Thus by looking at the definition module, we can determine how to use its facilities.

In addition to information hiding, library modules allow the details of operations to be changed without affecting modules that depend on its definition. This is called module decoupling. This feature of Modula-2 aids in the development of large programs by minimizing recompilation after code changes. Thus, if a library module is made more efficient, users (or »clients«) of that module will only notice the increase in efficiency and will not need to recompile (unless producing a .COM file) or change their source code. A client need only recompile or change source code when the actual definition (and therefore meaning) of a module changes.

Definition and Implementation Modules

Modula-2 formalizes the separation of a module's definition and its implementation with these two modules: the definition module and the implementation module. Every library module consists of one definition module and one implementation module.

The definition module contains all the declarations of the library module that are to be made public, which may include constants, types, variables, and procedures. These declarations do not contain code, but instead contain the interface needed to use the procedures they export, along with comments that describe how ne exported identifiers should be used. Definition modules take the following form, beginning with the reserved words DEFINITION MODULE:

DEFINITION MODULE < module name> ;

< Import Sections > < Export Sections >

END < module name > .

where Import Sections declare any external identifiers needed to define exported objects and procedures. The Export Sections include the constant, type, variable, and procedure declarations that define identifiers exported by this library module.

Note: Definition modules may not contain an EXPORT list (see »Local Modules, « later in this chapter). All identifiers appearing in the definition module are automatically exported.

The following definition module is an example of a library module that provides andom-number facilities:

DEFINITION MODULE RandomNumbers;

(* This module provides a reproducible set of random numbers. *)

PROCEDURE Randomize(NewSeed: Cardinal);

(* Randomize sets the internal seed to the specified value, thus allowing a random sequence to be reproduced when the same value is passed to Randomize.

*****)

PROCEDURE Random(): REAL;

(* The Random function returns a random real between 0 and 1 *)

END RandomNumbers.

This module provides information about the use of the random-number facilities its implementation provides. By reading this Modula-2 text, clients may incorporate random numbers into their programs without writing their own random-number generator or understanding how it works. The corresponding implementation module hides all the details from the client.

The implementation module holds the code that performs the actions stated in the definition module. Objects declared in the definition module are visible in the implementation module. Thus, constants, types, and variables should not be redeclared in the implementation module; doing so will cause a duplicate definition error during compilation. Also, the procedure heading declared in the definition module must be identical to the procedure heading in the implementation module or the compiler will flag the implementation's procedure in error as »Two different declarations of same procedure.«

Implementation modules must define all procedures mentioned in the definition module or the compiler will flag unresolved identifiers.

Implementation modules can be considered identical to main modules with two exceptions. The first is the form of declaration, as shown in the following:

IMPLEMENTATION MODULE < module name> ;

- (* Import Declarations *)
- (* Data Declarations *)
- (* Procedure and Module Declarations *)

BEGIN

(* Initialization Code *)
end <module name> .

Note that the module name must be the same one used in the definition module.

The second exception is the optional initialization code, which follows the reserved word **BEGIN**. This code is used primarily to set up variables before any procedure is called or any variable is accessed. Thus, you are guaranteed that this initialization code will be executed before the client modules use any function provided by the library module.

If the initialization code is not present, then the reserved word BEGIN is optional. Of course, the reserved word END, followed by the module name and a period, must be present.

The following module implements the previously defined module Random-Numbers:

IMPLEMENTATION MODULE RandomNumbers;

```
CONST
multiplier = 100;
 modulus = 257;
VAR
 Seed: CARDINAL;
PROCEDURE Randomize(NewSeed: CARDINAL);
BEGIN
 Seed := NewSeed MOD modulus;
END Randomize;
PROCEDURE RANDOM(): REAL;
BEGIN
 Seed := (Seed * multiplier) MOD modulus;
 RETURN FLOAT(Seed) / FLOAT(modulus);
END Random;
BEGIN
 Randomize(1986)
```

END RandomNumbers.

To complete the examples presented in this section, we can define a main module that imports the facilities of *RandomNumbers*:

MODULE PrintRandomNumbers; FROM RandomNumbers IMPORT Randomize, Random; FROM Texts IMPORT output, WriteReal, WriteLn;

VAR

Count: CARDINAL;

BEGIN

```
FOR Count := 1 TO 10 DO
WriteReal(output,Random(),5,3); WriteLn(output);
```

END

```
END PrintRandomNumbers.
```

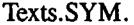
As mentioned earlier, most Modula-2 programs are made up of several modules. The preceding module depends on two library modules, each made up of two modules (a definition and an implementation module). We have defined the two modules required for random numbers, and thus have the source to both. However, the module *Texts* is a standard library module provided by Turbe Modula-2. This means the source code is not available, though the definition module is listed in the next chapter. So how does the program know the interface and code? This information is stored in compiled form; there is one file for the definition module and one for the implementation module.

Compiled Modules

When a definition module is compiled, the result is stored in a symbol file with the extension .SYM. This file is basically a symbol table containing the names and types of exported identifiers. When the compiler is resolving the import lis of a module, it looks in this file to obtain information about the imported iden tifiers. This information is then inserted into the working symbol table of the module being compiled.

Thus, the compiler can tell if an externally declared identifier is being used cor rectly, at least in a syntactic sense. This concept is referred to as type-checking across compilation units. To compile a module that imports identifiers, the com piler must have access to the identifier's corresponding .SYM file. For example if there is an import from a module named *Texts*, then there must be a file named Texts.

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When an implementation module is compiled, its result is stored in a specia code file with the extension .MCD. This file contains the code that is linked in when a program is either loaded or linked.

For convenience, Turbo Modula-2 provides a library manager that groups th

Modules

.SYM and .MCD files of various library modules into one file with the extension .LIB. For example, all of the standard library modules provided with Turbo Modula-2 are in the library file called SYSLIB.LIB. (For more information on the library manager, refer to Chapter 10, »System Operations.«).

Opaque Export

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Sometimes library modules must ensure that variables of an exported type are only manipulated by procedures of the library module itself.

Consider a module that exports a file type. One approach is to export the whole structure of this record, making all fields accessible to user programs. If, however, a program updates such descriptor records, chaos may ensue (in the file example, valuable information on disk may be destroyed). In such cases, we would like to hide the fields of the record.

To avoid such problems, Modula-2 offers *opaque export*. This means a name of a type is exported without giving its structure (the actual structure is given in the corresponding implementation module). Thus, user programs may declare variables of that type, but the only operations applied to them will be the provided library procedures. The following example may help clarify this:

DEFINITION MODULE Files; **TYPE**

FILE;

PROCEDURE Open(VAR f: FILE; filename: ARRAY OF CHAR);

(* Other declarations *)

END Files.

MODULE OpaqueExport; FROM Files IMPORT FILE, Open;

.

VAR

f : FILE;

BEGIN

Open(f, "A:TESTDATA.DAT")

END OpaqueExport.

Since the definition module *Files* does not provide information about the type FILE the user program cannot apply any operations to it, except for those explicitly provided by Files (which in this case is Open).

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When compiling the example *OpaqueExport*, the compiler must know the space requirements of the variables of opaque types, which in this case is FILE. However, it can only inspect the definition module. Therefore, to be able to find out the space needs of opaque-type variables, a restriction must be imposed on opaque export: Only pointer types can be exported in opaque mode.

Local Modules

The remaining module type in Modula-2 is a local module, one that is nested within either a main module or an implementation module. Local modules serve to hide details of some task or object from the surrounding environment. Since they are nested, they cannot be separately compiled. Additionally, they have special scope rules.

Local modules may be declared anywhere a procedure declaration is permitted. Thus, local modules may appear in the declaration section of either a module (main, implementation, or local) or a procedure. In general, modules and their contents are static, meaning they exist throughout the duration of the program that surrounds them. There is one exception: When a module is declared local to a procedure, then the module exists only while the enclosing procedure is active.

A local module declaration is similar to a main module and takes the following form:

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MODULE < module name> ;

- (* Import Declarations *)
- (* Export Declarations *)
- (* Data Declarations *)
- (* Procedure and Module Declarations *)

Modules

BEGIN

```
(* Initialization Code *)
END < module name> ;
```

Its export declaration is what makes it different from other modules. These declarations cause the listed identifiers to become visible in the surrounding environment. Both import and export declarations cause the scope of identifiers to be altered in both the external and internal environment of the local module.

Scope and Local Modules

Unlike procedure walls, local module walls are not only opaque from the outside but also from the inside. Identifiers that are to be used within a local module must be imported (via an import declaration), and identifiers declared inside a local module that must be visible outside must be exported (via an export declaration). The rules for importing and exporting are completely symmetrical:

- □ An identifier exists while the declaring module is active. The declaring module is active while its surrounding environment is active.
- \Box An identifier is only visible in a local module if declared by the module or imported from the surrounding scope.
- \Box An identifier declared in a local module is only visible within the module, unless explicitly exported.

The form of import declaration for local modules is identical to that for other kinds of modules. The major difference is that any identifier in the surrounding scope may be imported; thus, you may find import lists grouping many different identifiers from many different sources within the same list.

The export declaration that makes identifiers visible outside the local module has the following form:



EXPORT < identifier list> ;

where the identifier list may contain constants, types, variables, and procedures. The identifier list is prefixed with the reserved word EXPORT and terminated with a semicolon. An export declaration introduces an identifier to the next highest scope. For example, an export declaration in a local module would introduce an identifier to the surrounding environment. And an import declaration would introduce an identifier into the local module from the next highest scope.

This modular separation hides many details from the programmer and protects the abstraction of the data structure, which is defined in the local module.

The following stack example demonstrates this:

```
MODULE LocalModules;
FROM Terminal IMPORT WriteString, WriteLn;
TYPE
StackElement = CARDINAL;
```

```
MODULE AbstractStack;
IMPORT StackElement, WriteString, WriteLn;
EXPORT Push, Pop;
```

CONST

```
StackSize = 100;
```

VAR

```
SP : [0..StackSize]; (* The stack pointer *)
Stack : ARRAY [0..StackSize-1] OF StackElement;
```

```
PROCEDURE Push(item : StackElement);
```

BEGIN

```
IF SP < StackSize THEN
Stack[SP] ;= item;</pre>
```

```
INC(SP);
```

ELSE

```
WriteString('ERROR: Stack overflow.'); WriteLn; HALT;
```

END

END Push;

PROCEDURE Pop(VAR item: StackElement); BEGIN

IF SP > 0 THEN
DEC(SP);
item := Stack[SP]

ELSE

```
WriteString('ERROR: Stack underflow'); WriteLn; HALT;
```

END

END Pop;

```
BEGIN (* initialization *)
SP := 0;
END AbstractStack;
```

VAR

```
i: CARDINAL;
( `IN (* main program for LocalModules *)
   Push(2);
   Pop(i);
   IF i = 2 THEN WriteString('The stack worked!') END
   END LocalModules.
```

Since the stack pointer variable SP is not exported, it is not visible outside the module. Note that all objects declared outside of the module must be imported if they are used. The only exception to this rule are standard identifiers, such as INTEGER, BOOLEAN, ORD, and so forth. Notice the use of the standard procedure HALT to stop execution when a stack error occurs.

There is a further facility to restrict the number of visible identifiers: qualified export. If we had written

```
MODULE AbstractStack;
IMPORT ...
EXPORT QUALIFIED Push, Pop;
```

(in the procedures *Push* and *pop* would have to be denoted by Abstract-Suck.Push and AbstractStack.Pop, respectively, in the surrounding scope.

Since it is sometimes difficult to avoid name clashes of different modules' identifiers, qualified export allows you to clarify ambiguous names. Note that identifiers exported from library modules are always exported in a qualified mode, but the qualification is usually overridden with the FROM statement.

Local modules may also overrride the qualified statement by importing with the **FROM** clause. This allows local modules to share data without cluttering the next

highest scope with unnecessary identifier names. The following example demonstrates QUALIFIED exports:

MODULE t;

```
MODULE one;
EXPORT QUALIFIED a;
MODULE two;
EXPORT QUALIFIED a;
```

VAR

```
a: CARDINAL;
BEGIN
a := 4;
END two;
```

```
MODULE three;
FROM two IMPORT a;
BEGIN
a := 5;
END three;
```

BEGIN

```
WRITELN('one',two.a);
END one;
```

BEGIN

```
WRITELN(one.a);
END t.
```

Note: In the main body of module one, the identifier a must be qualified; however, it is not qualified in the body of module three.

Chapter 8 Low-Level Facilities

Modula-2 is a strongly typed language, an aspect that greatly contributes to its programming safety, yet one that is often too restrictive for system programming. Low-level facilities are the avenue to system programming in Modula-2. They include type-transfer functions, special types of the pseudomodule *SYSTEM*, abute addresses, and coroutines and interrupts. It is helpful to restrict their use to small sections of code grouped into one module, so that when the program is moved to another system only the one module need be changed.

Before we begin discussing low-level facilities, though, we should consider some of the decisions that were made in implementing Turbo Modula-2. These decisions have a direct impact on certain low-level facilities, such as type-transfer functions and SYSTEM types. The general philosophy at Borland is small and fast; thus we have restrictions like word alignment of variables and benefits such as register variables.

Register variables are used whenever possible. Programmers can hand-optimize procedures by declaring important variables in the first four words of local storage. Only simple variables of unstructured types are chosen as register variables. If there are not four words of storage declared in a procedure, then the procedure's parameters are placed in registers. Consider the following procedure:

```
PROCEDURE RegVars(x,y: CARDINAL);
VAR
   i,j,amount: CARDINAL;
   AGIN
END RegVars;
```

In this procedure, three words of local storage (i, j, amount) and one word of parameters (x) would be allocated to the registers as follows:

xsits in BCamountsits in DEjsits in BC'isits in DE'

A consequence of using register variables is that while a variable sits in a register that variable will have no address. We impose the following restriction: Simple variables of unstructured type are not accepted by ADR.

Of course, these variables do not have to be kept in registers during the entire procedure. For example, they may be placed in memory if a procedure is called. However, if a procedure has no procedure calls, then the register variables will not be moved to memory, and the procedure can be very efficient and fast.

Word alignment provides both advantages and disadvantages. Word alignment means placing all variables on word boundaries, and the variables that require less than a word of storage are allocated a full word anyway. Thus, a character that needs only 1 byte of storage is allocated one word.

The reason for allocating variables in a word-aligned fashion is that it makes M-code and the M-code interpreter highly efficient and small. Since the M-code interpreter is part of the runtime system (always present), it makes sense to use M-code for non-time-critical operations. This is because M-code takes up approximately one-third the space of native (machine) code, allowing more code to be fit into Z80 memory space. Turbo Modula-2 allows a single program to be made up of both M-code and native code modules so that very large and efficient programs can be written.

The choice to use an efficient M-code interpreter, however, does impose certain restrictions on accessing memory. To keep the interpreter efficient, it may only access entire words at a time. Thus variables are word aligned, which leads to the following restrictions:

□ Byte-sized array elements cannot be substituted for VAR parameters.

 \Box Byte-sized array elements cannot be arguments for *INC* or *DEC*.

Notice these restrictions are only for byte-sized array elements. This is because byte-sized array elements are not word aligned, they are packed. This is apparent when contrasting arrays and records. A record variable that contains two character fields will always occupy two words of storage. An array that is declared to contain two character elements is always packed into 2 bytes (one word).

When considering certain low-level facilities, keep in mind that variables are usually word aligned. Word alignment impacts transfer functions that involve characters and bytes and the SYSTEM type BYTE.

Type-Transfer Functions

Modula-2 offers facilities to relax strict type-checking, forsaking some portability for the ability to perform system programming.

For this purpose, type identifiers are used as function names. The type- transfer function allows programs to explicitly override the type-checking of the compiler. Type-transfer functions are not meant to perform any computation or manipulation. They merely change the interpretation of the bit pattern contained in their argument.

ince the machine representations of types are entirely implementation dependent, so are the correspondences between representations. Modula-2 does not, for example, define which bit pattern corresponds to the integer value 15. Therefore, the use of type-transfer functions makes a program nonportable.

Type-transfer functions can only be applied to simple types. Moreover, type transfers are only allowed between types that occupy the same amount of storage. Since different systems may have types of different sizes, the applicability of type-transfer functions depends upon the implementation.

In Turbo Modula-2 implementation on Z80 computers, simple types have three sizes: REAL and LONGINT occupy 4 bytes, LONGREAL occupies 8 bytes, and the rest (including pointers, set, characters, and subranges) occupy 2 bytes. Because of the nature of the M-code interpreter, all data objects in Turbo Modula-2 are word aligned. This means that a single character declaration allocates one word, not 1 byte. Further, a record structure consisting of two characters occupies 4 bytes. Only arrays are packed so that characters are in an adjacent byte. Thus, an ARRAY[0.1] OF CHAR occupies only one word.

'pe-transfer functions are illustrated in the following module:

MODULE TypeTransfer;

VAR

- ch : CHAR;
- c : CARDINAL;
- i : INTEGER;
- b : BOOLEAN;
- s : BITSET;

r : REAL;

1 : LONGINT;

BEGIN

```
ch:= CHAR(c);
s := BITSET(i)*BITSET(b); (* bitwise AND operator *)
r := REAL(1);
END TypeTransfer.
```

This module shows the use of type-transfer functions. The first line in the body allows the CARDINAL c to be assigned to the CHAR ch. The second line transfers two different types into type BITSET, performs a set operation, and then assigns the resulting set to the variable s. The last line transfers the LONGINT I to a REAL. No physical conversion takes place in any transfer; the bits of the variables remain the same, but are viewed in a different way.

Type Transfer and Type Conversion

There is a difference to note between type-transfer functions and type conversions. While conversions try to preserve meaning, changing the bit patterns if necessary, type-transfer functions leave the bit pattern unchanged but interpret it differently. For example, in the type conversion call

LONG(1.0) = 1L

the real value is truncated and converted to type LONGINT. But in the type-transfer call

LONGINT(1.0) = 1065353216

the bit pattern standing for the real value 1.0 is interpreted as a LONGINT number.

In addition, type-transfer functions perform no checking. The statement

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b := BOOLEAN(3)

where b is declared as a BOOLEAN, will compile and execute without any error messages. Execution may, of course, lead to somewhat strange results.

In some cases it may appear as if there is no difference between a type- transfer

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function and a type-conversion function. Consider the following code:

```
PROCEDURE TransferAndConversion(i: INTEGER);
VAR
c : CARDINAL;
BEGIN
c := CARDINAL(i); (* Type transfer *)
c := CARD(i); (* Type conversion *)
END TransferAndConversion;
```

As long as the value of i is positive, the two statements will have the same mean g and effect. However, if the value of i is -1, the first statement will execute fine, but the value that c receives may not be what you think (65535). And if i is -1, the second statement will cause a runtime error because the conversion is impossible using CARD--you cannot convert a negative number to a CARDINAL value.

If you intend to look at the same bits in a different way, then you need the lowlevel facilities of type-transfer functions.

Low-Level Types and the Pseudomodule System

Besides type-transfer functions, there are the special types BYTE, WORD, and AD-DRESS exported by the pseudomodule SYSTEM (so-called because it does not really reside in a library module).

Type WORD is compatible with all types that occupy one machine word of storage. Since objects of type WORD are considered to have no specific interpretation, no operations (except assignment) may be applied to them. Type-transfer functions must be used to indicate the desired interpretation.

There is also the type *BYTE*, which is compatible with 8-bit types such as CHAR. Like *WORD*, the assignment operation is the only one that may be applied to variables of type *BYTE*. Note that whether a variable of type *BYTE* takes only 1 byte or 2 bytes of memory is dependent on the declaration used (see the beginning of this chapter).

The type ADDRESS is compatible with all pointer types and has the declaration

TYPE

ADDRESS = POINTER TO WORD

In contrast to type WORD, arithmetic operators may be applied to operand of type ADDRESS; such operands will behave like CARDINAL operands. Thi feature is especially useful for storage management algorithms (also called pointe arithmetic). The resulting type from pointer arithmetic is ADDRESS.

All knowledge about the pseudomodule SYSTEM is built into the compiler Although there is no actual implementation module that corresponds to the defini tion module of SYSTEM, you may use SYSTEM as if it were defined as the defini tion module presented in Chapter 11, "The Standard Library.«

Untyped Parameters

Modula-2 allows a procedure to declare a parameter that will accept any typ passed to it. This is called an *untyped parameter*. Untyped parameters have the following type declaration form:

PROCEDURE Foo(chunk: **ARRAY OF WORD**);

Notice that the untyped parameter declaration is similar to an open array parameter declaration. The difference is that it uses the low-level type WORD ex ported from the pseudomodule SYSTEM.

Untyped parameters are functionally different from open array parameters in that they accept any type of variable as an actual parameter, not just arrays of on type. You may pass either a single character or a large record structure to a pro cedure with an untyped parameter. For example:

```
MODULE UntypedParameters;
FROM SYSTEM IMPORT WORD;
```

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PROCEDURE HowBigIs(chunk: ARRAY OF WORD); BEGIN

WRITELN('Size is ',SIZE(chunk):3,' High is ',HIGH(chunk):3); END HowBigIs;

VAR

- c : CARDINAL;
- r : REAL;
- s : ARRAY [0..20] OF CHAR;
- t : RECORD
 - a,b,c,d: LONGREAL;

END;

BEGIN

```
WRITE('CARDINAL : '); HowBigIs(c);
WRITE('REAL : '); HowBigIs(r);
WRITE('String literal : '); HowBigIs('This is a string');
s := 'This is a string';
WRITE('String variable : '); HowBigIs(s);
WRITE('Record variable : '); HowBigIs(t);
END UntypedParameters.
```

The following are the results of this program:

CARDINAL	:	Size	is	2	High	is	0
REAL	:	Size	is	4	High	is	1
String literal	:	Size	is	16	High	is	7
String variable	e :	Size	is	22	High	is	10
Record variable	e :	Size	is	32	High	is	15

The standard function SIZE gives you the number of bytes that were passed, and the standard function HIGH tells you the index of the last valid word in the open array.

Absolute Addresses

Modula-2 has a facility to explicitly specify the address of a variable and thus erride the space allocation scheme used by the Modula-2 system. This is especially useful for memory-mapped I/O devices. In the example that follows, a memory-mapped video screen is declared to reside at address 0C000H:

screen[0C000H] : ARRAY [0..31],[0..127] OF CHAR;

The desired address is specified in brackets after the variable identifier; in every other respect, this is a normal variable declaration. The programmer must ensure

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correct and consistent use of such variables. Declaring the previous scree variable on a computer with a different screen would lead to chaos.

A useful application of this facility is to define an array that stretches acros all memory. Using the low-level types WORD and BYTE, we can define an arra from the start to finish of memory, like so:

```
VAR
Mem [1]:RECORD
CASE : BOOLEAN OF
TRUE: b : ARRAY [1..65535] OF BYTE |
FALSE: w: ARRAY [1..32767] OF WORD |
END;
```

Memory locations can be accessed like this:

```
Mem.b[10] := 0C;
Mem.w[CARDINAL(ADR(SomeDataRecordOrArray))+SomeOffset] := 39201;
```

Note that you cannot define an absolute variable at location 0. However, the second byte of a word defined at location 0FFFF resides at location 0.

Coroutines and Interrupts

The pseudomodule SYSTEM provides certain mechanisms to implement *conoutines* and *interrupt handlers*, in a high-level manner. These facilities an machine-specific but are presumed to be in all implementations of Modula-2. The actual synchronization and scheduling of processes must be done by support modules. As an example, the standard library module *Processes* offers one possible implementation of coroutines; there are many other ways.

Coroutines

Coroutines can be created by calling the procedure NEWPROCESS exported by SYSTEM. Switching between coroutines must be done explicitly by calling the procedure TRANSFER. Both the source and destination coroutines have to be identified in the TRANSFER statement.

Low-Level Facilities~

Programs using coroutines can be thought of as consisting of several programs, each with their own program counters. Each program corresponds to a coroutine: One is always active, the others are sleeping or frozen. *TRANSFER* freezes the currently active coroutine and activates another one. Unlike procedures, when a coroutine is reactivated it will always continue processing from the point where it was frozen. In contrast, when a procedure is activated, processing always starts at the beginning.

Note that more than one coroutine may use the same procedure. However, each coroutine must have its own *PROCESS* variable and its own work space. This allows several processes to share the same code.

Interrupts

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Usually, an interrupt is an unscheduled jump to some special code triggered by a hardware condition, although, software may also trigger interrupts. The code that receives control *after* an interrupt is called an *interrupt handler*. It services the interrupt and then returns control to the interrupted program.

In Modula-2, interrupts are considered coroutine transfers and interrupt handlers are coroutines. When an interrupt occurs, the currently executing code is suspended, and an unscheduled transfer to the coroutine waiting to service that interrupt takes place. When the interrupt handler is finished, control is returned to the suspended code by using a special transfer statement, *IOTRANSFER*, exported from the pseudomodule *SYSTEM*. This procedure not only acts as a coroutine transfer but also initializes (or re-initializes) the interrupt vector for the next interrupt.

Of course, the coroutine waiting for an interrupt must somehow notify the system which interrupt it wants. For this purpose, interrupt vectors are used. (The Z80 CPU uses this scheme when it is in interrupt mode 2.) Note that it is up to the programmer to ensure that the processor is in the correct interrupt mode and that the interrupt jump table is in the correct location.

Note that the CP/M operating system is not reentrant, making it difficult to use

interrupts. To guarantee proper functioning, be certain the operating system is not active when user interrupts are possible.

Chapter 9 **Turbo Modula-2 Extensions**

Turbo Modula-2 offers several extensions to Wirth's definition that are not covered by standard Modula-2, such as general-purpose READ and WRITE statements, string comparison and assignment, multidimensional open arrays, and exception handling. These extensions can be suppressed with the embedded compiler option (* -X- *), or from the Options menu. If this option is turned off, the compiler will flag all extensions with a warning message.

Input and Output Extensions

Although the various input/output modules provide procedures for reading and writing data to external devices, Turbo Modula-2 defines four new statements that allow a simplified approach to input/output: READ, WRITE, READLN, and WRITELN.

The four statements provide you with a quick way to do output. The following program shows some of the many possible uses for these extensions.

MODULE READWRITE; **VAR** aNumber: CARDINAL; aCharacter: CHAR;

BEGIN

```
/RITELN('The READ and WRITE statements',' take any number ',
       'of arguments');
WRITE('Enter a number and a character: ');
READ(aNumber, aCharacter);
```

```
WRITE('You may even mix types. The number is ',aNumber);
WRITELN(' The character is ',aCharacter);
WRITELN('Number may be formatted, as in Pascal ');
WRITELN('The number 3 in a field of length of 4: " ',3:4, ' " ');
WRITELN('A real number ',34.556:10:2);
END READWRITE.
```

READ and WRITE extensions have essentially the same function as the Pascal equivalents: They eliminate the need to use Modula-2's precise library pr cedures.

During compilation, the READ and WRITE statements are translated into cal to the appropriate input/output procedures from the library module Texts. Using these statements replaces the need to import the specific procedure from the Tex module.

For a more thorough discussion of these statements, refer to the module Tex in Chapter 11, "The Standard Library."

String Extensions

Standard Modula-2 allows the assignment of arrays only if both sides are of t same type, and it completely forbids comparisons of arrays. In Turbo Modulaassignments and comparisons of strings are allowed. A string is any variab whose type is an array with elements of type CHAR. The starting and endin bounds do not matter; strings are assigned and compared as if both strings invol ed start at the same lower bound.

The end of a string is denoted either by the end of the array (if the array is con pletely filled) or by the null character OC. Any two strings can be assigned to ea other, even if they are defined as different lengths or start at different bound

Additionally, any two strings can be compared using the relational operators = < >, #, <, >, <=, or >=.

Multidimensional Open Arrays

Turbo Modula-2 allows open array parameters to be of any dimension. This exte sion is invaluable for programs that use matrixes. The standard procedure HIC will return the highest bound for each dimension. The next higher bound is four by passing HIGH the variable with »[0]« appended (see Chapter 6, »Open Arr

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Parameters«).

Error-Handling Extensions

Program errors can be divided into the following three types:

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Compiler-time errors	Syntax errors discovered by the compiler (for example, a missing semicolon or a misspelling)
I/O errors	Problems occurring during input/output operations (for example, file not on disk or file not open)
Runtime errors	Errors occurring while executing a program (for exam- ple, division by zero or integer type passing out of range)

Compiler errors are corrected before the program can be run. However, I/O and runtime errors are only apparent while executing a program.

Should an error occur while running a program, the computer has two options: (1) to write an error message on the screen and halt the program, or (2) to send an error signal to the program.

The first option is fine for simple programs, but could have disastrous results in real-time applications. The second method requires that the running program test some kind of flag after each operation capable of producing an error. This can clutter up the program's logic and reduce efficiency, particularly if the tested condition occurs only in rare circumstances.

As an example, consider a disk-write operation. Testing for a full disk after each disk write is clearly inconvenient. On the other hand, halting the program unconditionally prevents the running program from reacting to this error.

Pascal solves this problem by using a compiler option that determines the program's reaction to I/O errors. However, this is not possible in Modula-2 since disk writes are performed in a library module not within the control of the compiler. It is evident that a system consisting of several largely independent modules needs 'ome way to signal error conditions.

Exceptions serve this purpose well. We do suggest, however, that you use exceptions only if there is no other appropriate way to handle errors. In general, their use should be confined to the signaling of errors across module boundaries. (There are a number of predefined exceptions in Appendix D.)

Syntax and Semantics of Exception Handling

An exception consists of three parts: the exception declaration, which defines the

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exception identifier and uses the reserved word EXCEPTION; the except handler, which is the programmed response to the error condition; and the RA. statement, which calls the exception.

An advantage of exception handling is that handlers are present statically in program text, near the location they are needed. In comparison to other eri handling methods, exception handlers are much clearer. They also follow nested structure of the Modula-2 language itself.

Declaration of Exceptions

An exception declaration contains the reserved word EXCEPTION, followed a list of identifiers. Exception declarations have the following form:

```
EXCEPTION < identifier list> ;
```

And the following example is taken from the module Files:

EXCEPTION

EndError, StatusError, UseError, DeviceError, DiskFull;

All of the usual scope rules of Modula-2 apply here. Exception identifiers be exported and imported like normal Modula-2 identifiers.

Raising Exceptions

Exceptions are raised when the program detects an error condition; for example when the module Files has detected that the disk is full. Raising an exception v transfer control to an exception handler that is provided by either the user or system.

A program may raise an exception with the reserved word RAISE, followed the exception identifier and optionally by a string. The RAISE statement ta the form

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RAISE < exception identifier> , < string> ;

This next example is taken from the standard module MathLib.

Turbo Modula-2 ______xtensions

IF x < 0.0 THEN

```
RAISE ArgumentError, 'Negative argument for Sqrt';
END ;
```

When an exception is raised, the system looks in the current procedure for a matching exception handler. If none is found, the calling procedure is examined, then the caller of that procedure, and so on, until a matching exception handler is found. This handler is then executed, and the procedure containing the handler is exited. If no handler is found, the system prints the exception identifier's name and the optional message string.

There is an alternate form of the RAISE statement that is only allowed within exception handlers. It is the reserved word RAISE by itself, as shown in the following:

RAISE;

This has the effect of passing an exception through one handler and on to the next in the calling chain.

Exception Handlers

Exception handlers are written at the end of procedures and modules to handle exceptions issued by a RAISE statement. The syntax is similar to the familiar CASE statement. Exception handlers have the following form:

EXCEPTION

```
<vertical bar>
<exception identifier list> : <statement sequence>
<vertical bar>
<exception identifier list> : <statement sequence>
```

ELSE

<statement sequence>

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END <procedure identifier> ;

Exception handlers consist of the reserved word EXCEPTION, followed by any number of exception cases. Each exception case is separated by a vertical bar, and each consists of a list of exception identifiers followed by a colon and a statement sequence. In addition, an ELSE part is executed if the raised exception is not any of the exception identifier lists.

In the following example, pretend you are running a program-controlled las experiment and want to guarantee that the experiment turns off in all cases.

```
MODULE LaserExperiment;
IMPORT MathLib;
```

MODULE GuardedMath;
FROM MathLib IMPORT Exp;
EXPORT ExpG, UndefinedExp;
EXCEPTION UndefinedExp; (* Excep

(* Exception Declaration *)

PROCEDURE ExpG(X,Y:REAL):REAL;

BEGIN

```
IF (1.E-10<X> AND (X<1.E10) THEN RETURN Y/X
ELSE RAISE UndefinedExp (* Signal an error *)
END
END ExpG;</pre>
```

END GuardedMath;

(* Procedure Declarations *)

BEGIN

SetUpExperiment;
PerformExperiment;

TurnOffLaser; ShutDownLab; PrintOutResults; (* Normal termination *)

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EXCEPTION (* Exception Handler *) Undefined Exp: WRITELN("WARNING: Bad Math"); TurnOffLaser; ShutDownLab; DumpProgramVars; ELSE

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er

TurnOffLaser; ShutDownLab;

END LaserExperiment.

There is one explicit exception raised in a special exponentiation routine. The exception handler in the main body of code has two clauses: one to catch the exception explicitly raised in ExpG, the other to catch all other possibilities.

If no exception handler is present for a given exception condition, the RAISE statement writes the exception identifier and an optional message to the screen, and halts the program. For example:

RAISE ZeroDivision;

would react to an error by printing the following message:

ZeroDivision in module Division Press "C" for calling chain >

If a more comprehensive error message is desired, an additional string can be included in the RAISE statement. The string can be a literal or any variable whose type is an array with elements of type CHAR. The string will be printed below the exception name, like so:

DiskFull in module MYPROG While processing file OUTDATA Press "C" for calling chain >

A program can respond to an exception by appending a handler to the end of the program unit where an exception may be raised. Such a program unit can be a procedure or the main program. When an exception is raised, normal execution is suspended and the corresponding exception handler is invoked; that is, the handler is executed instead of the rest of the program unit.

Exception Propagation

A scheme requiring an exception handler in the program unit where the exception is raised is really not very useful. After all, you need exceptions to signal your program that an error has occurred in a called library module. There must be some way to propagate exceptions. If the procedure that raises an exception does not contain a handler for it, the procedure is aborted completely and its caller is searched for a handler.

If the calling procedure also does not contain a handler, the search is continued in the procedure that called the caller, and so on. This continues until a handler for the raised exception is found, or until the main program (or a coroutine) is reached. Note that the order in which procedures are searched for exception handlers duplicates the order in which they are displayed in the calling chain.

If a handler for a raised exception is found in the calling chain, it is invoked and thus replaces the rest of the procedure containing the handler. If all statements in the handler are executed, the procedure returns. Note that a program cannot be restarted at the point where the exception is raised. This restriction makes the exception-handling mechanism relatively safe. The restriction is not severe, since an exception can easily be converted into a flag that indicates an unsuccessful operation.

A handler for an exception can of course raise an exception itself. In this case, the exception is always propagated to the next procedure in the calling sequence thus preventing an infinite loop where every time an exception is handled, another is raised. To propagate the handler exception to higher-level procedures, a handler can raise the handled exception again by using the short form of the **RAISE** state ment. If the following statement is found in some exception handler, the handled exception is propagated to the calling procedure (or module):

EXCEPTION

```
EndError,DeviceError: Close(infile); RAISE
END ReadFile;
```

If a library module should signal an exception, it must first be declared wit an exception declaration. An exception declaration can be given anywhere in

program where constant, variable, or type declarations would be legal. And lik other identifiers, exceptions can be exported and imported.

Many of the library modules export exception identifiers that can be incomporated into programming error handlers. For example, the following program reads data input from the keyboard and writes it to disk. The exception DiskFu

is declared in the module *Files* and raised when the disk is full (Texts is implemented with Files).

```
MODULE DataWrite;
 FROM Files IMPORT DiskFull;
 FROM Texts IMPORT TEXT, OpenText, CloseText;
 FROM Comline IMPORT PromptFor;
VAR Value: CARDINAL;
 DataFile: TEXT;
 Str: ARRAY [0..30] OF CHAR;
BEGIN
str:= "Input value (99 to stop): ";
(* Request filename and open file *)
PromptFor("Data file name: ",DataName);
OpenText(DataFile,DataName);
(* Request data from keyboard and write to file *)
 WRITELN(Str);
 READ(Value);
 WHILE Value # 99 DO
  WRITE(DataFile,Value);
  WRITELN(Str);
  READ(Value2);
 END;
(* Close completed file *)
  CloseText(DataFile);
(*If disk full, die *)
EXCEPTION
 DiskFull: WRITELN( "DISKFULL - YOU JUST LOST ALL YOUR INPUT");
END DataWrite.
```



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Chapter 10 System Operations

Turbo Modula-2 is a menu-driven package similar to Turbo Pascal. However, Turbo Modula-2 is a more complex system, containing more menu options and operating differently than Turbo Pascal.

In this chapter, we'll take a look at the basic system operations of Turbo Modula-2. As shown in Chapter 2, the Turbo Modula-2 main menu looks like this:

Selected drive: A

Work file:

Edit	Compile	Run	eXecute
Link	O ptions	Quit	liBrarian
Dir	Filecopy	Kill	reName Type >

The first two items on the main menu (Selected drive and Work file) are default values used by the other menu items.

Selected drive

Allows you to log a drive as the default disk drive. This command has the side iffect of resetting the drive that is specified, so the BDOS read- only error is avoided. (This command is the same as Turbo Pascal's L command.)

Work file

Work file is a file name or partial file name that can be prompted with certain menu commands, such as Compile, Link, Run, Edit, and Find runtime error. It is essentially a default user response in which the user can either specify a whole file name (like A:MYMOD) or a partial string (like B:). These default responses can be overridden; see the section in this chapter, *Avoiding the Menus.*

The Run and eXecute commands are used to execute runnable files from within the shell. The remaining menu items are used for file management. (Note: Each item is initiated by pressing the item's capital letter.)

File-Management Utilities

The following five file-management commands provide most of the file facilities you will need when writing Modula-2 programs. Whenever these commands accept a drive specifier, you may also specify a user area. It takes the form

DU:filename.ext

where D stands for the drive letter (A through P) and U stands for a user area (0 through 32). Hard disk users will find this facility invaluable for isolating different projects in different user areas.

Dir

A:TEXTS.*

A10:**

Lets you display a directory. You can mask certain file names by specifying an ambiguous file name at the mask prompt. In addition, the Dir command lists the remaining space on the disk from which the directory is read.

You can use question marks (?) and asterisks (*) as »wild cards« in the mask. A question mark represents an arbitrary letter (including none) and an asterisk represents an arbitrary string. Here are some examples of allowed directory masks:

A:	Lists	the	names	of	all	files	on	disk	drive	A:

B:*.SYM Lists the names of all files having extension .SYM on drive B:

Lists the names of all files with the file name TEXTS, regardless of extension

T????.* Lists the names of all files on the logged drive whose file name begins with a T and has five letters or less

Lists the names of all files on drive A: in user area 10

System Operations

If you enter nothing after the prompt and press \square then the names of all files on the currently logged disk drive are displayed.

The files are listed by number, which you can use to refer to individual files or groups of files in the Filecopy and Kill commands. Groups of files are specified as a range, for example, 4-9 or 1-20. If there are more file names than will fit on the screen, you will receive the following prompt:

"C" to continue >

Press **C** to continue the directory listings; pressing any other key will stop it.

Filecopy

Allows you to copy a file to another file. The source can be specified either as a complete or ambiguous file name, or as file numbers; the two methods cannot be mixed. The files can be referred to by number only if a Dir command has been performed. As an example, if copying files by numbers:

> D

Directory	mask:	a:				·			
1: PIPES	.DEF	4:	PIPES	.SYM	7:	PIPETEST	.MOD	10:T2	.MOD
2: PIPES	.MCD	5:	PIPETEST	.BAK	8:	Т	.MOD	11:T3	.MOD
3: PIPES	.MOD	6:	PIPETEST	.MCD	9:	T1	.MOD	12: TYPETRAN	.MOD
Bytes Remain	ing on A	A: 14	45K						
						-			
	•								
>F									
Copy from: 1	2 8-11								

Copy to : c:			
Copying A00:PIPES	.DEF		
Copying A00:PIPES	.MCD		
pying A00:T	.MOD		
copying A00:T1	.MOD		
Copying A00:T2	.MOD		

.MOD

Copying A00:T3

Kill

>

Allows you to delete a file. The files may be referred to by their number if a Dir command has been performed. When Killing by number, you are prompted for

each deletion. If you specify only a mask (ambiguous file name), then you ar not prompted at all. For instance, look at this example of Killing by numbers

>D

Directory mask: B:

1: SAMPLE .DEF

2: SAMPLE .MCD

3: SAMPLE .MOD

4: SAMPLE .SYM

Bytes Remaining on B: 75K

>K

```
Kill file: 2 4
Delete BOO:SAMPLE.MCD (Y/N)? Y
Delete BOO:SAMPLE.SYM (Y/N)? N
```

Note that since CP/M allows numbers as file names, the Kill commar distinguishes between names and file numbers by insisting that a space be place before file names that consist of numbers (this also applies to Filecopy).

reName

Allows you to change the name of a file. You may only change one name at a tim A warning is given if you overwrite another file. For example:

>N

Rename from: sample.mod Rename to : sample.mud

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Type

Allows you to display the contents of a file on the screen without leaving Tur Modula-2 or using its editor. (This works the same as CP/M's TYPE utility.) Pre CTRL S to pause and CTRL C to stop. For example: > T

Type file: sample.mod

MODULE sample;

END sample.

Options

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Provides you with a collection of infrequently used but occasionally useful options. If you press (o) (for Options), the following submenu will appear:

compiler options:

List	(ON)	Native	(OFF)	eXtensions	(ON)
Test	(OFF)	O verflow	(OFF)	Upper=lower	(OFF)

Path to search: SYSLIB

Find run-time error

Save current selection Quit

>

The first six items on the option menu are compiler switches, which affect the way source code is compiled. These switches are global in that they affect the whole file; however, they are overridden if the source being compiled has embedded switches.

Each of the six switches has an embedded counterpart. A brief description of each is given here. (For a complete description of the following compiler switches and how to use embedded compiler switches, refer to the section in this chapter,

»Compiler Options and Switches.« A brief description is also given in Appendix **C**.)

□ List toggles compiler listing on and off.

 \Box Native toggles native code generation on and off.

□ eXtensions allows or disallows Turbo Modula-2 extensions.

Test toggles bounds-checking by assignment-compatible assignments assignments (for more information see »Compiler Options and Switches,« later in this chapter).

Overflow toggles INTEGER overflow-checking.

 \Box Upper=lower toggles case sensitivity on and off in identifiers.

Path to search

This entry holds the names of the libraries files that will be searched to find separately compiled imported modules. Library files are created with the librarian (see the section, »The Librarian,« later in this chapter). This option contains the entry SYSLIB, which refers to the file SYSLIB.LIB that contains the standard library modules.

Find runtime error

This utility helps you find bugs that occur at runtime. By accepting a module name and a PC number, it can determine where a program has stopped. The module name and PC number are obtained from the calling chain that is displayed when the error occurs. (For details on the calling chain, refer to the section Appendix E, »The Calling Chain.«)

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Save current selection

This option selects the current switch settings and library path as the new default setting. The current selections are made permanent by writing them to the M2.COM file; thus, this file must always be available.

Quit

This selection returns you to the main menu.

Avoiding the Menus

A menu-driven shell makes life a lot easier for beginners, but for experienced users it can sometimes be tiresome. Therefore, we have included a way to circumvent the menu scheme. If you answer the menu prompt with the space bar, you are allowed to enter the full selection sequence, optionally followed by additional arguments on the same line. After the selected command is executed, you are again placed in the menu where the blank was entered. The following examples demonstrate this:

> C B:MYPROG

Compiles the file B:MYPROG.MOD at once. It is equivalent to this dialogue:

> W

Work File: B:MYPROG

> C

Compile file: B:MYPROG

This next example shows how prompts are avoided:

> D B:

lists the directory of drive B, as the following dialogue would

>D

Directory mask: B:

This method only works on the main menu; you cannot, for example, toggle the native code generation option with the string > ON.

The Turbo Editor

The built-in editor is a screen editor specifically designed for creating progratext. If you are familiar with Turbo Pascal or WordStar, you'll need little instruction in the use of the editor. The Turbo editor includes some extensions, plus you can install your own commands on top of the WordStar commands (described Appendix B, »Installation Procedures«) and the WordStar commands will remainsable.

Using the Turbo editor is simple: After you have defined a work file and presser $\begin{bmatrix} E \end{bmatrix}$ (for Edit), the menu will disappear and the editor is activated. the work file exists on the logged drive, it is loaded and the first page of text displayed. If it is a new file, the screen is blank, apart from the status line at the top.

To terminate a line, press the key. When you have filled the screen with text, the top line will scroll off the screen, out of view. You may page back ar forth in your text with the editing commands described later in this section.

First, let's take a look at the information the status line provides at the top the screen.

X:FILENAME.TYP. Shows the drive, user area, and name of the file beir edited.

Line n. Shows the line number that contains the cursor, counting from the sta of the file.

Col n. Shows the column number that contains the cursor, counting from the less side of the screen.

Char n. Shows the character number that contains the cursor, counting from the beginning of the file.

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Insert. Indicates that characters entered on the keyboard are inserted at the curso position. Existing text in front of the cursor is pushed to the right. The inserted on/off command, $Curl \lor v$, switches this message to *Overwrite*, which means text entered on the keyboard overwrites characters under the cursor, instead of being inserted.

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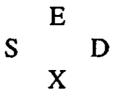
1

Indent. Indicates that auto-indentation is active. It may be switched off with the auto-indent on/off command, [Ctr] [a] [1], in which case this space on the status line is blank.

Operating The Editor

This editor is a full-screen editor, which means you can move the cursor anywhere on the screen and begin writing. This is done by using a special group of control characters: pressing the Ctrl key while simultaneously pressing any of the keys, A, S, D, F, E, R, X, or C

The characters are arranged on the keyboard in a manner that logically indicates their use. For example, in the following display:



E will move the cursor up, Ctrl X pressing Ctrl moves it down, Ctri S moves it to the left, and Ctri D moves it to the right. If your keyboard has repeating key capability, you may hold down the Ctr key and one of these four keys to move the cursor rapidly across the screen.

Editing Commands

The editor accepts and uses many editing commands that move the cursor, page through the text, find and replace text strings, and so on. These commands can be grouped into the following categories:

- □ Cursor movement commands
- □ Extended movement commands
- □ Insert and delete commands
- □ Block commands
- \Box Find and replace commands

□ Miscellaneous commands

Each group contains logically related commands that are described in the following sections. (A summary of the commands is provided in Table 10-1.) The following descriptions consist of a command definition, followed by the default keystrokes used to activate the command. If you would like to redefine the commands, refer to »Installation of Editing Commands« in Appendix B.

Table 10-1 Summary of Turbo Editor Commands

Cursor Movement Commands

Character left
Character right
Word left
Word right
Line up
Line down
Scroll up
Scroll down
Page up
Page down

Ctrl	S
Ctrl	D
Ctrl	A
Ctrl	F
Сти	E
Ctrf	X
Ctrl	W
Ctrl	Z
hťĴ	R
Ctrl	C

Extended Movement Commands

Left on line
Right on line
Top of window
Bottom of window
To top of file
To end of file
To beginning of block
To end of block
To last cursor position

Insert and Delete Commands

Insert mode on/off
Delete left character
Delete character under cursor
Delete right word
Insert line
Delete line
Delete to end of line
Delete line up to cursor position
- •

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Ctrl		S
Ctrl	Q	
Ctrl	Q	Ε
Ctrl	Q	
Ctrl	Q	R
Ctrl	Q	С
Ctrl	Q	В
Ctrl	Q	K
Ctrl	Q	P

Ctrl	V	
Del		
Ctrl	G	
Ctrl	T	
Ctrl	N	
Ctrl	Y	
Ctrl	Q	Y
Ctrl	Q	H

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Cursor Movement Commands

Block Commands

Mark block begin Mark block end Hide block Copy block Move block Delete block Read block from disk

Ctri	B	K	КВ
Ctrl	K	K	K K
Ctrl	H	K	КН
Ctrl	С	K	КС
Ctrl	V	K	Κ
Ctrl	Y	K	ΚΥ
Ctrl	R	K	KR
Ctrl	W	K	ĸw
	K H C V	K K K K K K K K K K K K K K K K K K K	K K K K K K K K K K K K K K K K K K K

Find and Replace Commands

Find Find and replace Repeat last find

Ctrl	Q	F
Ctrl	Q	A
Ctrl		-

Miscellaneous Editing Commands

Delete file on disk Save file, exit Save, edit Quit, no save Tab Auto-indent on/off Control character prefix Abort operation

K	J
K	D
K	
K	Q
Q	
Ρ	
U	
	K

-sor Movement Commands

Character left

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CTRL

S

Moves the cursor one character to the left nondestructively (without affecting any characters). When at the start of the line, the cursor will move to the end of the previous line.

Character right



Moves the cursor one character to the right nondestructively (without affecting

any characters). When the last character on the line is reached, the cursor will move to the first character on the next line.

Word left

Moves the cursor to the beginning of the word to the left.

Word right

Moves the cursor to the beginning of the word to the right.

Line up

Moves the cursor to the preceding line. If there is no character in the current column, the cursor is moved to the end of the line.

Line down

Moves the cursor to the proceeding line. If there is no character in the curren column, the cursor is moved to the end of the line.

Scroll up

Scrolls the file up one line toward the beginning of the file (the entire scree) scrolls down).

Scroll down

Scrolls the file down one line toward the end of the file (the entire screen scroll up).

Page up

Moves the cursor one page up

CTRL A

F

CTRL

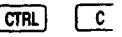
CTRL Ε

CTRL X

CTRL ₩

CTRL Ζ

Page down



R

CTRL

Moves the cursor one page down.

Extended Movement Commands

The editor provides commands to quickly move to either end of a line, to the beginning and end of the text, and to the previous cursor position. These commands require two control characters to be entered simultaneously: press \boxed{CTRL} \boxed{Q} and then one of the control characters, \boxed{S} , \boxed{D} , \boxed{E} , \boxed{X} \boxed{R} , or \boxed{C} . Their keyboard arrangement repeats the pattern previously shown.

E R S D X C

Left on line

Moves the cursor to the far left of the screen (column 1).

Right on line

Moves the cursor to the far right (the end) of the current line.

Top of window

Moves the cursor to the top of the screen.

Bottom of window

Moves the cursor to the bottom of the screen.

Top of file

Moves to the first character in the file unless the top of the file has been paged out, in which case the cursor is moved to the first character in the buffer. To move to the start of a file that has had the beginning paged out, you must use $\Box R$ K S, which also saves any changes the were made. If you don't want to save your changes, you must quit (K Q) and restart the editor.

	 <u> </u>	
CTRL	Q	R

CTRL

CTRL

CTRL

CTRL

Q |

Q

Q

Q

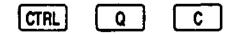
S

D

E

X

End of file



Moves to the last character in the file.

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Beginning of block	CTRL	Q	B
Moves the cursor to the block-begin marker set with [CTRL]	K	В.	
End of block	CTRL	٩	K
Moves the cursor to the block-end marker set with CTRL (commands only work if a block is fully marked.)	K	K.	(Bloc
Last cursor position	CTRL	Q	P
Moves to the last position of the cursor. This command is par a find or find/replace operation has been executed and you'd		•	

Insert and Delete Commands

last position before its execution.

Insert mode on/off

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When you write text, you may choose between two entry modes: *Insert* and O_{V_i} write. The current mode is indicated in the status line. The CTRL V co: mand allows you to switch between these modes.

Insert mode inserts characters at the cursor position; existing text to the right the cursor will move to the right as you write new text.

Overwrite mode may be chosen if you wish to replace old text with new te Characters entered will overwrite any characters under the cursor.

Delete left character

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Deletes the character to the left of the cursor. This can also be used to rem line breaks.



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Delete character under cursor



CTRL

۰V

Deletes the character under the cursor.

Delete right word

Deletes the word or part of the word to the right of the cursor. It may also be used to remove line breaks.

Insert line

Inserts a new line at the cursor position.

Delete line

Deletes the line containing the cursor. No provision exists to restore a deleted line, so use this cautiously.

Delete to end of line

Deletes all text from the cursor position to the end of the line.

Block Commands

All block commands are extended commands (that is, the standard command definition consists of two characters). You can use them to move, delete, or copy whole chunks of text, and to perform certain file operations.

A block of text (which you determine) is marked by placing a block-begin marker at the first character and a block-end marker after the last character of the desired text.

The marked block may be copied, moved, deleted, or even written to a disk file. There are also commands to read or write an external disk file into or out of the editor as a block.

Mark block begin

Marks the beginning of a block. The marker itself is not visible on the screen, and the block only becomes visibly marked if the block-end marker is set. (This only applies if your terminal has highlight capabilities.)



CTRL	

CTRL	Q	<u> </u>	



Deletes

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Mark block end

Marks the end of a block. As stated previously, the marker itself is not visible on the screen; it is only visible if the block-begin marker is also set.

Hide block

Causes the visual marking of a block to be switched off and removes block markers. After this command, no block markers are visible and all block commands are invalid.

Copy block

Copies a previously marked block to the cursor position. The original block is left unchanged, and the markers are placed around the new copy of the block.

Move block

Moves a previously marked block from its original position to the cursor position. The markers remain around the block in its new position. If no block is marked, nothing happens.

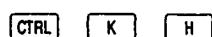
Delete block

Deletes the previously marked block. No provision exists to restore a deleted block, so use this cautiously.

Read block from disk

Reads a file into the current text at the cursor position, exactly as if it were a bloch that was moved or copied. The text read in from the disk is marked as a block

When using this command, you are prompted to give the name of the file to b read (after which you must press]. The file specified may be any legal fil name; no default extension is supplied.



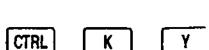
K

CTRL

CTRL



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Write block to disk

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Writes a previously marked block to a file. The block is left unchanged, and the markers remain in place. When this command is issued, you are prompted for the theorem of the second se

name of the file to write to. If the file specified already exists, you are asked if you want to continue before the existing file is overwritten. If no block is marked, you will get an error message.

The file specified may be any legal file name; no default extension is supplied.

Find and Replace Commands

These commands allow you to search for a string of characters or replace one string with another, which is useful when correcting a repetitive error.

Find

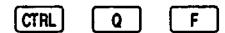
Lets you search for any string of up to 30 characters. When you enter this command, the status line is cleared and you are prompted for a search string. Enter the string you desire and terminate by pressing \square .

Search strings may be edited with the Character left, Character right, Word left, and Word right commands. To recall the previous search string, press [CTRL] L when prompted for the new string. A search operation may be aborted with the Abort command, [CTRL] U.

The search string may contain any characters, even control characters. Enter control characters into the search string by using a CTRL P prefix. For example, to enter a Control-A, hold down the CTRL key and press P, then press A. Thus you may include a line break in a search string by including Control-M/Control-J (press CTRL P M and CTRL P J, respectively.

When the search string is specified, you are requested for search options. The following options are available:

U Ignores uppercase/lowercase. Uppercase and lowercase alphabetic characters are regarded as equal.



- W Searches for whole words only; skips matching patterns that are embedded in other words.
- B Searches backward.

digits Finds the *n*th occurrence of a search string.

For example:

- BU Searches backward and ignores uppercase/lowercase. 'Block' will match both 'blockhead' and 'BLOCKADE'.
- W Searches for whole words only. The search string 'term' will only match the word 'term', not the word 'terminal'.
- **B5** Searches backward and finds the fifth occurrence.

Terminate the list of options (if any) by pressing \square ; the search will then begin. If the text contains a target matching the search string, the cursor is positioned at the end of the target, unless you're searching backward, in which case the cursor is positioned at the start of the target.

The search operation may be repeated by the Repeat-Last-Find command, CTRL .

Find and replace

Lets you search for any string of up to 30 characters and replace it with any other string of up to 30 characters.

When you enter this command, the status line is cleared and you are prompted for a search string. Enter the string you require and terminate by pressing Again, however, control characters entered into the search string must use a P prefix. (See the previous example in the »Find« section.)

As mentioned in the »Find« section, search strings may be edited with the Character left, Character right, Word left, and Word right commands. (Refer to the »Find« section for more information.)

When the search string is specified, you are asked to enter the string that wil replace the search string. You can enter up to 30 characters; control-character en try and editing is performed as stated previously. If you press \square , the targe string will not be replaced but will be deleted.

Finally you are prompted for options. The find-and-replace options include the following:

- G Global search and replace; searches and replaces in the entire text, starting at the current cursor position.
- N Replaces every item without asking *Replace (Y/N)* for each occurrence of the search string.
- U Ignores uppercase/lowercase; uppercase and lowercase alphabetic characters are considered equal.
- W Searches and replaces whole words only; skips matching patterns that are embedded in other words.

For example:

GWU Find and replace whole words in the remaining text. Ignore uppercase/lowercase.

Terminate the list of options (if any) by pressing \Box ; the search- and-replace operation will begin. If found (and the N option is not specified), the cursor is positioned at the end of the target and you are asked

Replace (Y/N)?

You may abort the search-and-replace operation at this point with the Abort command, $\boxed{\text{CTRL}}$ $\boxed{\text{U}}$.

The search-and-replace operation may be repeated by the Repeat-Last-Find command, [CTRL] [L].

Repeat last find



Repeats the latest find-and-replace operation exactly as if all information had been reentered.

Miscellaneous Editing Commands

This section lists the commands that do not fall into any of the earlier categories.

D

Save and quit

Saves the text file and also gives the original file (if any) the last name .BAK. You are then returned to the Turbo Modula-2 shell.

Tab

Unlike Turbo Pascal, tab positions are fixed to multiples of eight; however, Modula-2 contains the same Autotab feature present in Turbo Pascal.

Indent on/off

The indent feature provides automatic indentation. When active, the indentation of the current line is repeated on each following line. To change this indentation, use the space bar and - keys to select the new column.

When indent is active, the message INDENT is displayed in the status line; when passive, the message is removed. Autotab is active by default.

Save and edit

Saves the file and remains in the editor. Press CTRL Q P to return to where you issued the command.

Quit/no save

Terminates the editor. If changes were made to the text, you are prompted as to whether or not you want to abandon the edited file. Press \boxed{Y} for yes; otherwise, press any other key.

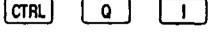
Delete file

Allows you to delete files from within the editor. This is handy if you run out of disk space after entering lots of text you want to save.

CTRL

CTRL

TAB



S CTRL

K

Q

J

CTRL

CTRL

Abort operation



Pressing CTRL U will let you abort any command whenever it pauses for input.

The Librarian

A typical Modula-2 development system uses a large number of files. There are four files for each library file: two that define it and two that make it usable. It is typical in Modula-2 to write and debug a library routine once and then use it many times. Thus it is the it is the second two files that must be kept around. These are the .SYM and .MCD files, which hold the compiled definition and the compiled code, respectively.

The liBrarian makes the storage of these files easier by allowing you to keep many .SYM and .MCD files in a CP/M file called a library file. Thus, if you lop 10 library modules for your general use, you can store the compiled versions in one file instead of 20.

So, the compiler, the program loader, and the linker all need to know which libraries should be searched for files. This information is given in the search path. As mentioned earlier, the search path can be changed in the Options submenu, which initially consists only of the entry SYSLIB.

Searching Libraries

After a library has been created, the modules included in the library will be invisible to the system until the name of the new library is entered in the »Path to search« selection of the Options submenu.

Libraries are manipulated via the liBrarian, which is selected by pressing **B** in the main menu. The liBrarian first prompts the user to select which library to work on:

```
>B
(
```

If you enter MYLIB.LIB, then the following menu will appear:

Selected library: A:MYLIB.LIB

Dir Include Copy

Kill cOmpress quit

You may enter your selection from this menu after the * prompt. The choice have the following effects:

Include A CP/M file is included in the specified library. Only the CP/M extensions .MCD or .SYM are allowed. Displays all the modules already included in the use Dir library; includes size information. Moves files out of the library, either by copying them into Copy another library or to a CP/M file. If the destination nam has a drive code, it is considered to be a CP/M file name without a drive code, the name specifies the destinatio library. Kill Terminates a module's existence inside the used library Copies all files in a library in such a way that there ar **cO**mpress no unused »holes.« This command is used quite rarely since it takes a lot of time. Select Selects another library. Quit Returns the user to the main menu.

The Compiler

The Turbo Modula-2 compiler translates a Modula-2 program (the *source*) int a sequence of instructions (the M-code) that form the code of a virtual machine They are optimized for compactness, to make possible execution of large programs in the limited address space of 8-bit computers.

The Z80 processor cannot execute M-code directly; instead, every instructic is executed by a special program, the M-code Interpreter. In comparison to directly interpreted language like BASIC, M-code operates much faster. In mo applications, it approaches machine speed but needs less memory. For those case where speed is critical, there is a native code option that tells the compiler to pre-

System Operations

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duce Z80 machine code. (For more on this topic, see the section, »Compiler Options and Switches, « later in this chapter.)

The translated program is called an *object program*. The source can only be read by the programmer, while the instructions of an object program can only be executed by the computer. The translation proceeds in a single pass through the source program; in other words, Turbo Modula-2 uses a one-pass compiler for generating M-code. When native code is desired, an additional pass is executed.

The Turbo Modula-2 compiler serves another purpose: If several modules are designed to work together, the programmer must first prepare one or more definition modules. A definition module contains information about parts of the corresponding implementation module that can be used by other modules. The compiler translates the definition module's information into a symbol file. These files do not contain M-code instruction; they merely reference parts of the corresponding implementation module. Whether a program's text constitutes a definition module or not is decided by the reserved word DEFINITION in the header line of the module. (Definition modules usually have the extension .DEF in their file name.)

Operating the Compiler

Before a source program is compiled, its program text is written using the editor and then stored on disk. You will have usually provided Turbo Modula-2 with a work-file name for this purpose. The compiler is started from the Turbo Modula-2 shell by pressing \boxed{c} . Assuming a work-file name of DEMO and a default disk drive of B, Turbo Modula-2 will respond by prompting you with the message: Compile file:B:DEMO. You can confirm this by pressing \boxed{d} .

Source programs usually have the extension .MOD. This extension can be omitted in the file name, and the compiler will append it automatically.

Note: If a source file has no extension at all, the file name cannot be entered as is, a since the compiler will then look for a file with the extension .MOD. This problem is solved by appending a single period (.) to the file name. Also note that the Turbo Modula-2 editor assumes the default extension .MOD.

Once the name of the source is entered, the compiler starts execution. It continuously reads the source from disk and, if the List option is on, displays the translated portion of the source on the screen. When compilation is finished, the object file is written to the disk where the source resides. You can override thi convention by including a drive code (letter plus a colon) on the command line somewhere after the name of the source. For example, Compile file:B:DEMO A translates B:DEMO.MOD into A:DEMO.MCD.

The generated file now assumes the same name as the source file. If it is a object module, it is given the extension .MCD; if it is a symbol file, it assume the type SYM.

The Listing

During translation the compiler can produce a listing of the compiled program text. The listing can be switched on and off in the Options submenu. When switch ed on, it is usually displayed continuously on the screen, constantly updating you about how far the compiler has proceeded in the source text. The listing can b redirected to a disk file or to any of CP/M's logical output devices, such as the printer, by including a redirection argument n the command line after the Compilcommand. Remember that an argument for output redirection consists of the > symbol, followed by the name of the desired output medium. For example:

```
Compile file:B:POWERS > B:DEMO.LST
```

creates a file B:DEMO.LST and sends the listing to this file.

A program listing could like this:

```
| (* $U- *)
MODULE Powers;
| FROM Texts IMPORT Done, input;
FROM SYSTEM IMPORT ADR, MOVE, WORD;
PROCEDURE Power(x: REAL; i: INTEGER): REAL;
  VAR t: REAL;
| BEGIN
```

154

- t:=1.0' 0
- WHILE i > 0 DO 9
- t := * x; 12
- 211 i := i 1;
- 251 END;
- 271 **RETURN** t

System Operations

```
271 END Power;
 ---- Size = 31
    | PROCEDURE GetNum(s: ARRAY OF CHAR; VAR n: ARRAY OF WORD);
    | VAR rec: RECORD
                CASE : BOOLEAN OF
                   TRUE
                          : r: REAL;
                1
    I I FALSE
                           : c: INTEGER;
                END
           END;
    | BEGIN
   0
     WITH rec DO
  11
        REPEAT
         WRITE(s);
  11
         IF SIZE(n) = SIZE(REAL) THEN
  161
          READLN(r); MOVE(ADR(r),ADR(n),SIZE(r))
  221
  331
         ELSE
          READLN(c); MOVE(ADR(c), ADR(n), SIZE(c))
  381
  471
         END
  501
        UNTIL Done(input)
  501 END
  571 END GetNum;
      Size = 59
    ł
    VAR
       x: REAL; n: INTEGER;
    BEGIN
       LOOP
   0
   21
        WRITELN;
        GetNum("X= ",x);
   8
        GetNum("N= ",n);
  18
  281
        IF n < 0 THEN EXIT END ;
8888.
```

.

.

- 34| WRITELN(x :8:4, " to the power of ", n :0,"
 - = ",Power(x,n):8:4);
- 91 **END**
- 91 END Powers.
- --- Size = 94

End of source reached. Compiled bytes: 208 M-code file DOO:POWERS.MCD produced.

Besides displaying the program text, this listing offers other information. After each procedure and each module, the line Size = indicates the length in bytes of the M-code that was generated. The line Compiled bytes: indicates the tota length of the M-code generated by the compiler.

The left margin of the source program text is marked by a column of vertica bars. The numbers at the left of the bars are only given on lines that actually generate M-code. They indicate the amount (in bytes) of M-code that is generated between the start of the procedure or module and the current line. These numbers form a coordinate system (procedure name and offset) that allows you to find the location of an error should one occur during execution. Notice that this offset is only correct with M-code. If the native code generation switch has been toggled on, these numbers are meaningless.

If a program's execution fails, the calling chain specifies the offset of the poin of error from the enclosing procedure or module. This offset corresponds (in the case of M-code) directly to the numbers in the compiler listing, thereby indicating the error's location in the source. You can demonstrate this effect by entering and compiling the previous program example. If you then run the program and presen input that is too large, the program will fail.

In the case of native code, the offset from the calling chain of a runtime erro corresponds to the set of numbers given during the second native code pass of the compiler. The numbers will look like this:

End of source reached.

NAME	START	len
POWER	4	102

GETNUM110240POWERS354313

Compiled bytes: 675

Native-code file DOO.POWERS.MCD produced

s, a runtime error with offset = 53 refers to the second line:

POWER 4 102

since 53 is within the first 106 bytes of the file. Since the procedure power is 102 bytes in length, you know the error occurred about halfway through the procedure. An easier method to finding runtime errors is to use the Find runtime error utility provided in the compiler Options menu (described earlier).

The primary use for the numbers in the listing is to determine the size of procedure and modules. This is helpful when using overlays. Normally you will want to keep the listing option off; using the List option reduces compiler speed by about 30 percent.

Error Correction

The Turbo Modula-2 compiler provides for an interactive error-correction scheme. If an error is detected during the compiler run (for example, a syntax error or a type mismatch), the compiler stops and displays the type of error and the point at which it occurred. You are given the option of loading the source immediately into the editor for correction or stopping the compiler. When correction is completed, the compiler takes over again, resuming its work near where you corrected the error (usually at the start of the same line). This is all done automatically, without having to use the Edit and Compile commands everytime an error occurs. The correction cycle is explained further in the following example.

Assume that the ninth line (labeled by the byte offset 12) of the program listing in the preceding section reads t = t * x instead of t := t * x. This line is now illegal, since assignment must be expressed by := instead of =. The compiler will translate up to the first illegal line, displaying all processed lines in the listing. When it detects an error, it lists the currently processed line in full before giving a message and stopping. With the List option on, it would look like this:

```
1 (* $U- *)
1 MODULE Powers;
```

```
PROCEDURE Power(x: REAL; i: INTEGER): REAL;
VAR t: REAL;
BEGIN
```

The caret (^) points to the last symbol read before detection of the error. Y can abort the compiler run by pressing \bigcirc , or you can correct the error pressing \bigcirc . If you select \boxdot , the editor is started for correction, yc program is loaded automatically, and the cursor is positioned at the place whe the error was detected. In the example, the following line would be in the cen of your screen:

t = t * x;

The cursor (denoted by the $^$) is already placed on the faulty " = ". You c insert the missing " : " at once.

The editing commands available are those in the Turbo Modula-2 editor. course, you can also »walk around« in the source, fixing other pieces of text. make space for a text buffer, the compiler must store some of its internal data disk before editing takes place. The amount needed varies between 0 and 15 depending on the length of your program. To be on the safe side, reserve a we space of about 15K on your source disk, plus the size of a .BAK file if there is one yet.

Once correction is completed, you can leave the editor. To save your corr tions, press CTRL K D. As in normal editing, the old version is still p sent, but now has the extension .BAK. The compiler takes over again and trans tion is resumed near the initial change in your program. (Pressing CTRL k Q will save the old version of your source file and the old .BAK file; a changes you have made will be lost and compilation will be aborted.)

If, after saving your changes and continuing on with compilation, there are a more errors in your program, the correction cycle will be repeated.

Running Out of Memory

Following are two instances of memory shortage and their respective causes and solutions.

When the Compiler Runs Out of Memory

The compiler uses the free memory space for two purposes: for its own runtime stack and the heap (that is, the symbol table). Note that the size of the compiled code is inconsequential since it is written to disk as soon as the compiler's internal buffer gets full. In most cases, it's the symbol table that gets too big, which means too many identifiers are visible at a certain point in time. In order to circumvent space problems, you must reduce the number of identifiers. Following are several approaches:

□ First check whether your program imports objects that it doesn't use. Note that unqualified import (for example, IMPORT *Texts*) causes all objects exported by the imported module to be put into the symbol table. The space it occupies equals about the length of the module's .SYM file. It is therefore more economic to import only those identifiers that are actually used; for example,

FROM Texts IMPORT TEXT, OpenText, CloseText;

□ Second, try to structure your program. After compiling a procedure, the compiler no longer needs to know about the objects local to the procedure (except for the parameters). Therefore, it can throw away all the information concerning local objects and reuse the space for other purposes. After compiling a local module, the compiler keeps only the exported identifiers. Declare objects as global only as necessary and also declare them as local as possible. Use local modules to hide information that is unimportant to the rest of the program. The number of exported identifiers should be as small as possible. This not only reduces symbol table space, it also makes for a better program.

□ As a last resort, you may eliminate symbolic constants and enumerated types, replacing their occurrences by their values. For readability and maintenance,

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```
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```

the names should be placed in comments. For example:

VAR

```
color : (*(red,green,blue)*) CARDINAL
```

BEGIN

```
FOR color := 0(*red*) TO 2(*blue*) DO
```

END END

Note that changing *red* to O(*red*) in the whole program can be achieved most efficiently via the editor's global replacement command (CTRL Q A).

When Your Program Runs Out of Memory

When this happens, your program probably has too much data and code to fit into memory. You might use overlays if your program has too much code. When you have compiled to M-code, data is usually more critical than code. Following are some common pitfalls that can be avoided and some techniques to make better use of memory:

- □ Be sure to close all your files as soon as possible. Closing a file frees the space used for the file buffer and the file descriptor. When you reopen a file without first closing it, you allocate a new buffer and a new file descriptor without first giving back the old one. Thus, the memory occupied by it is never reused. If you do that within a loop, you will quickly run out of memory.
- Passing arrays as value parameters is not bad practice. It ensures that the parameter is not changed by the called procedure. However, it forces the compiler to make a copy of the entire array. If the array is large, this also eats up your memory space. So if you are having space troubles, pass large arrays as VAR parameters instead. This also applies to large records.
- □ In contrast to other languages (for example, the CP/M version of Turbo Pascal), the data space of a procedure is not allocated statically, but is created only when you enter the procedure. Therefore, it might be advantageous to declare large structures local to a procedure. Here is an example:

MODULE example; VAR a, b : ARRAY [1..10000] OF CHAR;

PROCEDURE p; BEGIN (* statements involving a *) END p;

PROCEDURE q;
BEGIN
 (* statements involving b *)
END q;

BEGIN

p; q; **END** EXAMPLE.

This module requires 20 Kbytes of data space to run (10 Kbytes for each of the arrays). This can be reduced to 10 Kbytes:

MODULE example;

```
PROCEDURE p;
VAR a : ARRAY [1..10000] OF CHAR;
BEGIN
 (* statements involving a *)
END p;
```

```
PROCEDURE q;
VAR b : ARRAY [1..10000] OF CHAR;
BEGIN
 (* statements involving b *)
END q;
```

BEGIN

p;q; END example.

In the second example, the arrays a and b have been declared local to the procedures p and q. Thus, a and b never exist at the same time. As soon as p is called, 10 Kbytes of memory are used for a. When p is finished, the space is given back and used for b when q is called. Thus, you never need more than 10 Kbytes of memory for the data.

□ Sometimes you don't know exactly how large an array should be, and using a large one to be safe would take up too much memory. In this situation, you might use a pointer to an array and allocate only as much as you need: **MODULE** example;

FROM STORAGE IMPORT ALLOCATE;

VAR a, b: POINTER TO ARRAY [1..10000] OF CHAR;

BEGIN

```
(* Let us assume the program knows at this point that a *)
(* and b need only be 2000 characters long *)
 ALLOCATE(a,2000*SIZE(CHAR)); ALLOCATE(b,2000*SIZE(CHAR));
END example.
```

This technique is not without danger, however. The compiler does not know that the array is actually shorter than the declaration says. When the array is accessed, it will therefore check index expressions against the declared bounds and not against the actual bounds. Thus, in the preceding example you can access a ^ [8000[without receiving a runtime error. Instead, you will access memory that does not belong to a. You may thus destroy other variables, your program, or the operating system, and make your program crash in very interesting ways--use this technique with caution.

Symbol Files

Quite often a module imports objects from other modules. It then contains one or more IMPORT statements following the header line. An IMPORT statement could look like this:

FROM MathLib IMPORT Sin, Cos, Exp;

The compiler must »know« how the imported procedures Sin, Cos, and Exp are defined in *MathLib*; for example, in order to check for type mismatches. This is achieved by compiling the definition part of the imported module into a symbol file (a file with the extension .SYM). This file must be on the disk either by itself or in a library file (a file with the extension .LIB, which contains many .SYMs and their corresponding .MCD files).

The example presented expects the file SYSLIB.LIB to be on your work disk. If the importing module is compiled, the compiler must access the symbol files of all definition modules from which objects are imported. In the example, the compiler would search for a file called MATHLIB.SYM, in order to »learn« about the definitions of Sin, Cos, and Exp. If not found, then the compiler would check the library path and search for any files found there.

All symbol files needed during a compiler run must be online. Specifications concerning the drive where one particular symbol file resides need not be given. This is because the compiler automatically searches all drives that you indicated when you installed the compiler with INSTM2 and searches all libraries in the search path for a needed symbol file.

The fact that all needed symbol files must be online can cause problems when the source files of one large programming project are distributed over several 'isks. The recommended scheme in this case is to combine all the .SYM files and their .MCD files into a common library. This is done with the Turbo Modula-2 liBrarian (described in the previous section).

Compiler Options and Switches

The compiler accepts some options that affect the set of programs that are recognized as valid, the generated object code, and the output of a compiler listing. An option can be set or reset in the source program itself. You can either set options globally by using the switches on the Option menu or set options locally by embedding switches in the code.

This is done by including a dollar sign (\$), an uppercase letter, and either the symbol + or - anywhere between two comment brackets; for example, (* T +*). As you would expect, + turns on the option denoted by the uppercase letter; using - turns it off. An option remains set until the opposite option is given.

Options are set to either on or off by default. The default settings are displayed in the Options submenu of the Turbo Modula-2 shell, where they may also be hanged for the current session and, if desired, saved for future sessions by using ne S option.

Default settings are save directly in the M2.COM file. Thus, the M2.COM file

must be online. Remember the switches on the option menu are global and may be overridden with embedded switches. All available options appear on the menu as follows:

L ist (OFF) N ative (OFF) eX tensions (OFF) T est (OFF) O verflow (OFF) U pper=lower (OFF) Each of these switches has the same effect as their embedded counterparts, but these may be overridden. One exception is the Native switch, which is only effective from this menu. The following describes each switch and presents its embedded code:

\$L The List Option

□ \$L+ generates a listing.

□ \$L- generates none.

If this option is on, the compiler will emit a listing. The listing appears on the screen unless it is redirected, which is done by entering »> listfile« after the »Compile file« message. For example:

>C
Compile file: B:MYFILE > MYFILE:LST

If \$L is turned off, the listing is suppressed; however, the names of procedures and modules will be displayed when encountered.

\$O The Overflow Check Option

□ \$0+ checks for INTEGER and CARDINAL overflow.

 \square \$O- does not check for overflow.

If this option is on, the generated object program checks for an overflow wher certain operations are performed. An overflow occurs when the result of an operation is too large (or too small) to be represented in the computer's memory. For example:

1. VAR a, b: INTEGER; c: CARDINAL

2. BEGIN

3.

- a := 20000;
- 4. b:=a + 15000;
- 5. c:=10;
- $6. \qquad \text{WHILE } c >= 0DO$
- 7. c := c 1
- 8. **END**;

In both the fourth and seventh line an overflow will occur. In the fourth line the sum evaluates to 35000, while 32767 is the largest representable INTEGER. In the sixth line the program loops. The CARDINAL c takes values from 10 down to 0, then c is decremented to -1. Since -1 is not a value that can be represented by a CARDINAL, an overflow occurs in line seven. Overflows are signaled by the runtime error message shown here:

```
OVERFLOW in (Name of module)
Press "C" for Calling Chain >
```

If O is turned off, no error message is given on overflow; instead, the result of the operation is computed *modulo* 2 ^ 16. This method is sometimes desirable for computations; for example, in a random-number generator. Furthermore, suppression of overflow checks can speed up a program considerably. The reader should be warned, however, against some unexpected results, particularly in the case of CARDINAL arithmetic. In the previous example, the variable c would be decremented from 0 to 65535; hence the condition c > =0 would always be fulfilled and the program would loop infinitely!

Overflow checks can be suppressed only for operations involving CARDINAL and INTEGER addition and subtraction and CARDINAL multiplication. Other operations, such as INTEGER multiplication and all operations dealing with REALs and LONGINTs, should always be checked for overflow or have exception handlers provided to trap errors.

\$T The Test Option

 \square \$T+ checks array indices and subrange variables.

 \square \$T- does not check them.

If this option is on, code for several tests is inserted into the generated object program. The tests include checks for subrange variables or array indices lying outside their admissible bounds; functions returning no result; and CASE

statements with an ELSE clause, where none of the other alternatives apply. If it is turned off, none of this test code is generated. Like overflows, turning off the test option can speed up a program and make it more compact. As a rule, however, the resulting safety loss does not make up for this advantage until a program is completely debugged.

\$U The Upper=Lower Case Option

 \Box \$U+ does not distinguish between uppercase and lowercase letters.

 \Box \$U- does distinguish between them.

If this option is on, the Turbo Modula-2 compiler treats an uppercase letter exactly like its lowercase equivalent. If it is off, an uppercase letter and its lowercase equivalent are considered to be different characters. For example:

VAR n,N: CARDINAL;
BEGIN
if n < N THEN</pre>

If this program fragment is compiled with U turned on, the VAR declaration would be illegal because n and N would denote the same identifier.

Compilation with U turned off would cause no problems in this line. However, the third line of the program fragment would then be illegal, since *if* would be considered an identifier rather than the reserved word IF. The Modula-2 standard prescribes that lowercase and uppercase letters are different; that is, that U should be turned off. Programmers conscious of the standard can reset this option permanently in the Options menu by pressing s.

\$X The Extension Option

 \square \$X+ allows Turbo Modula-2 extensions.

 \Box \$does not allow them.

Turbo Modula-2 supports several programming constructs not included in the standard, including the following:

Descal's *READ* and *WRITE* statements can be used for readable input and out-

put.

Exceptions similar to Ada's are supported.

□ Two arrays with elements of type CHAR (strings) can be assigned even if they are not of the same type.

□ Any two arrays of CHAR can be compared.

 \Box Open arrays can be multidimensional.

These extensions are supported only if \$X is turned on. If this option is turned off, nonstandard constructs are flagged by the compiler as errors.

If a programmer intends to use only standard Modula-2, he can turn off \$X permanently in the options menu and save it.

\$N The Native Code Generation Option

 \square N ON generates native code for the Z80.

 \square N OFF generates M-code.

Turbo Modula-2 can also generate native Z80 machine code that will execute faster than the M-code normally generated. In particular, floating-point math operations and I/O will probably not benefit from this option. The generated native code will be about three times as large as the equivalent M-code, and may run more than ten times faster.

Since this option applies only to compilation units, it must be specified from the Options menu; using (* N + *) in the text will have no effect.

The Linker

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Turbo Modula-2's linker combines several separately compiled modules in a single file. A typical large program system consists of a main module and several other support modules. Before such a program is executed, the main module and ull needed support modules are loaded into main memory.

How these modules are loaded depends on the type of output the linker produces. There are two output formats produced by the linker: (1) an .MCD file that

contains object code and (2) a .COM file that contains executable code.

The purpose of linking many object files into one object .MCD file is to speed up loading time by eliminating disk searching and the time it takes to open more than one file.

If a program's support modules exist as separate files, they are automatically brought into main memory. Every module involved in the program must be found on disk before it can be read in. The Turbo Modula-2 system optimizes the search for the necessary files, achieving relatively short loading times. Nevertheless, some gain in speed can be attained if all modules, or even only part of them, are contained in a single file.

The second function of the linker is to produce an executable .COM file by combining the main module, all support modules, and a runtime system.

The linker takes several object files with the extension .MCD and combines them into a single file. Its output consists of either another .MCD file or a .COM file. While .MCD files are run from inside the Turbo Modula-2 environment, .COM files are executed directly form the operating system. For example, if the file DEMO exists with both extensions .COM and .MCD, you would use the eXecute command to run DEMO.COM and the Run command to execute DEMO.MCD. In addition, you could run the DEMO.COM file from your operating system prompt like any other program.

You start the linker by pressing [L] at the main menu. You are then prompted for the program's main module and the name of the linker's output, like so:

Link main module: Output file:

If any of these arguments do not contain an extension, the default extension .MCD is supplied. If the output file name has an extension, it must be either .COM or .MCD. You must specify the extension .COM if you wish to produce an executable file.

After that, you are asked:

Include all needed modules (Y/N)?

Normally, you would press \boxed{Y} (for yes), in which case the linker does the rest of the work for you. It searches for all the modules needed on all the drives that are present in the search path. These modules are combined into one file, which is then written to disk.

If you have several versions of the same object file on different disks and want to pick out one of these to be included in the linked file, you would press [N] (for no) and be prompted like this:

```
Include modules:
```

You can then enter all modules you wish to include on one line. The .MCD extension can be omitted; it will be supplied as a default. If you want to include more modules than would fit on a single line, terminate the line by pressing the space bar and a +, The »Include modules:« prompt is then repeated:

```
include modules: TEXTS FILES B:MATHLIB +
Include modules: B:WINDOWS B:GRAPHICS
```

The linker then displays a list of all linked modules (and produces a linked object file), all modules that are referred to but not linked, and all modules that are missing. An executable file is produced only if all modules are accounted for and unresolved.

Note that unresolved references are perfectly legal if the output file is of type .MCD. The loader will bring all modules that are referred to but not linked automatically into memory during a Run command.

It would be a waste of memory to link one of the modules *Tests*, *Files*, *ComLine*, *Convert*, *Loader*, or *Doubles* into a .MCD file, since they already reside in memory. If you let the linker search library modules automatically, all these modules are left out. When linking a .COM file, the situation changes. When a .COM file is started directly from CP/M, the flexible Turbo Modula-2 loader is not available. Therefore, all modules the main program imports from *must* be included in the linked file.

The included files usually consist of a single object module. It is possible, however, that they are linked and include several modules. In that case, all modules are transferred to the new linked file.

Linking with Overlays

The linker can produce .COM files with overlays. The scheme is more flexible than the one employed in Turbo Pascal, but a bit more difficult. Every overlay consists of a full module; you need not change the module's source code to make it an overlay.

To link a file with overlays, the user must answer the initial question whether to include all needed modules with »No.« The user must then specify all modules that should be linked, but not overlaid. These modules must be entered on a single line or on several lines terminated by + characters. If a module is not preceded by a drive code, its .MCD file is first searched in all libraries of the search path, then on all drives of the system. A name with a drive specification will cause the module to be searched only on the specified drive. After all these modules are processed, the user is asked whether overlays should be used. Typing Y will cause the following prompt to appear:

Include overlay module: Map onto linked module:

First, the name of the module to be overlaid is entered. Next, the module whose space is to be used when it is loaded is entered. Now both modules will be linked to occupy the same memory segment. The prompts will be repeated until the user answers the first question with a single carriage return.

Note: The second module must already have been included n the linked file, otherwise its space will not be available to the overlay module at runtime. Also, more than one overlay module may be mapped onto the same linked module.

As an example, suppose you want to link the module MAIN with three overlay modules (OVER1, OVER2, and OVER3,) and one resident module (SUPPORT) into the file MYPROG.COM. The dialogue with the linker would look like this:

 $> \Gamma$

Link main module : MAIN Output file : MYPROG, COM

Include all needed modules (Y/N)? N

Include modules : SUPPORT OVER1

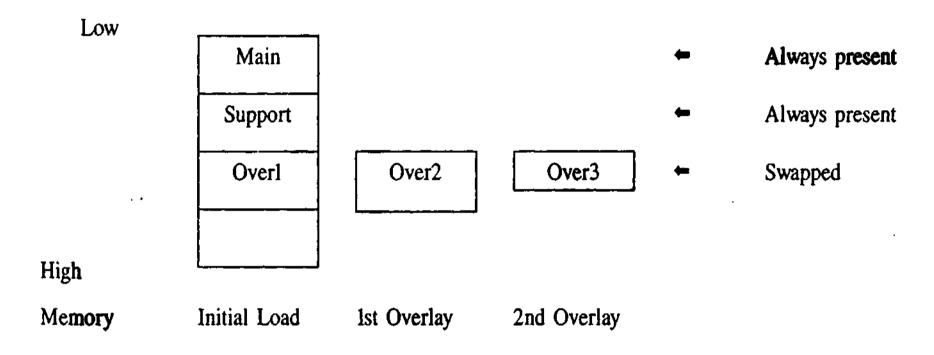
Linking MAIN Linking SUPPORT Linking OVER1

Use overlays (Y/N)? Y

System Operations

Include overlay module	: OVER2
Map onto linked module	: OVER1
Linking OVER2	
Include overlay module	: OVER3
Map onto linked module	: OVER1
Linking OVER3	
Include overlay module	: (RETURN)
THOTAGO OVCITAJ MOGATO	• (10010101)

Figure 10-1. Diagram of Linking Overlay Files



Note that the linker accepts input redirection. Complicated schemes for linking overlay files can be edited once in a file and are then fed to the linker as input. A file to accomplish the task in Figure 10-1 could look like this:

SUPPORT	OVER1	(modules to be included)
OVER2	OVER1	(first overlay)
OVER3	OVER1	(second overlay)

If the file had the name LINKPROG and you started the linker with

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Link main module : MAIN < LINKPROG Output file : MYPROG.COM

you would you would only have to answer two (Y/N) questions; entering all modules to be included or used as overlays would be unnecessary. Of course, input such as this:

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Link main module : MAIN MYPROG.COM < LINKPROG

or even

L MAIN MYPROG.COM < LINKPROG

is also legal.

A few restrictions must be made for overlay modules. First, an overlay module may not contain an initialization part (if so, the linker will issue an error message). Second, two overlay modules residing in the same segment should not import from each other. If the import concerns only constants, types, and variables, this is harmless. However, calling a procedure in another overlay module in the same segment will lead to trouble. In this case the linker issues only a warning message.

A program with overlays will be linked into two files with the extensions .COM and .OVR. The .OVR files contain all overlays needed for the program. They must be online when the program is started.

Every time a procedure in an overlay module is called, the module is brought into memory (provided it is not already there), overwriting whatever was in the segment previously. The same thing happens if a procedure returns to its caller and the caller has moved out of memory in the meantime. The calls to procedures in overlay modules do not need to follow a tree-like structure; they can proceed circularly. By specifying the mapping scheme, you can minimize overlay disk feeds and not bother with address computations, which is done by the linker.

The linker writes all overlay modules to disk as they are processed. Therefore, the length of all overlays is not restricted by memory size (the .OVR file can have a length of up to 256 Kbytes). However, the linker buffers modules that are not

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overlays in main memory. Therefore, the size of the .COM file is restricted by the memory available to the linker.

Linking the Linker

If you experience an OUTOFMEMORY error during linking, you can increase the available memory by making the linker smaller. The linker consists of the file LINK.MCD, which is loaded on top of the Turbo Modula-2 system. The Turbo system contains several modules that are unnecessary for the linker's operation and that may be taking up valuable memory space (the editor, for example). These modules can be removed by linking the linker itself. To do so, simply give the f(ving commands:

>L

Link main module : LINK Output file : LINK.COM

and answer the question

Link all needed modules (Y/N)?

with $\boxed{\mathbf{Y}}$. The result is a file LINK.COM. If the linker is now started from CP/M with the command A > LINK, the memory available for its operation is increased. If this is still not sufficient, you can use overlays for the linker, producing the files LINK.COM and LINK.OVR. You can do this by editing a file called LINKLINK or something similar that consists of the lines

TEXTS TERMINAL COMLINE LOADER

LES LOADER

Next, start the linker with this file as input, and answer »No« to whether to in-

clude all modules. The modules *Files* and *Convert*, which are needed by the linker, are both mapped as overlays onto the segment of the module *Loader*. They no longer use main memory for themselves. Therefore, the space needed by these modules is free to link even longer files.

Notice that the standard, but less efficient, »overlay scheme« that uses the procedure Call in Loader is also available.

Version Control

To prevent a program from running erroneous versions of separately compiled modules, a version number is given to each definition module. There are several ways to generate version numbers. Turbo Modula-2 determines a version number by calculating a checksum of the output produced when compiling a definition module. The number is kept in the symbol (.SYM) files as well as code (.MCD) files that are imported from each library module.

This method of generating numbers is handy since recompiling an unchanged module does not produce a new version number and requires unnecessary recompilation of dependent modules. With this process, you can even add comments to the definition module and then recompile it, which will have no effect on the version number generated.

Version control is the act of checking version numbers for consistency. There are three distinct points where version control is performed: compile time, link time, and runtime.

The compiler checks .SYM files for version numbers. Version conflicts occur when a library module's definition and implementation modules both import from another library module at different times (that is, different definitions, or version numbers, of the imported module are used by the definition and implementation modules). This situation is resolved by recompiling the module that was first compiled of the two importing modules.

If a library definition and implementation module both import from the same library module, then the compiler checks to make sure the definition (version number) has not changed between compiling the definition module and compiling the implementation module.

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The linker and loader check .MCD files for version numbers. Version conflicts occur when trying to link or load a module that imports from a library module that has had its definition and implementation modules changed (and recompiled). The importing module must be recompiled to resolve the conflict.

Conflicts can also occur when a module imports from two library modules that in turn import from another library module at different times (that is, the lowest level module being imported from has changed its definition). To resolve this conflict, you must recompile the first compiled of the two library implementation modules.

The linker compares the version numbers of all the import modules. Thus, if more than one module imports a particular library module, all the version numbers for that module must match. In that case, the version numbers are found in the importing .MCD files.

(nce the loader does dynamic linking, it can also find the same kind of version conflicts the linker finds (in case linking was not done). The loader can also detect version conflicts when loading overlays, which occurs when an overlay module imports from its caller and the caller's definition subsequently changes. This conflict is resolved by recompiling the overlay module.

Utilities

The following utility programs will add to your collection of programming tools. The first utility converts preexisting object files to a form usable by the Turbo Modula-2 system. The second tool allows you to evaluate the performance of your programs.

Linking Microsoft Relocatable Files

In some applications, it is desirable to use existing libraries with Modula-2. On Z80-CP/M systems, these libraries exist mostly in Microsoft relocatable format. Object files in this format are generated by such translators as the Microsoft (ro assembler M80, the Microsoft FORTRAN compiler F80, Pascal MT/+, and others.

Turbo Modula-2 offers a utility to link programs in the Microsoft .REL format

with Modula-2 programs. Only library procedures can be called from Modula-2, but constants and variables cannot be accessed. Nor can, say, a FORTRAN subroutine call a Modula-2 procedure.

Linkage is accomplished by a special program named REL. It takes as input a compiled definition module (with the extension .SYM) and one or more relocatable files (with the default extension .REL). Its output is a normal Modula-2 .MCD file.

In the Modula-2 definition module, all procedures to be called from Modula-2 must be declared with their parameter lists. The names of the procedures must appear as entry points in the relocatable files. Parameters are normally passed on the stack. The definition module could look like this:

DEFINITION MODULE Z80Stuff;

FROM SYSTEM IMPORT ADDRESS, BYTE;

PROCEDURE Movel(source,dest : ADDRESS; 1 : CARDINAL);

<other procedure declarations>

END Z80Stuff.

The input file (called, for example, Z80STUFF.MAC) to the M80 macro assembler consists of the following:

.Z80		
PUBLIC MO	VEL	<more identifiers=""></more>
MOVEL: POP	HL;	return address
POP	BC;	length
POP	DE;	source
· EX	(SP),HL;	exchange return address and destinatio
EX	DE,HL;	exchange source and destination
LD	A,B	
OR	A,C	
RET	Z	
LDIR		
RET	•	

<more code>

You can then translate these files by invoking the Turbo Modula-2 compiler ar M80. Next, REL is executed by entering REL after the run-file prompt; for exar ple:

Run MCD-file: REL Z80STUFF Z80 STUFF

The first parameter given is the name of the definition module. No extension may be given; the extension .SYM is always used. The second parameter given is the name of the relocatable file. If no extension is given, .REL is assumed.

REL produces an M-code file with the name of the definition module and the extension .MCD. This file may be used normally by a program, for example:

MODULE demo;

FROM Z80Stuff IMPORT MoveL;

BEGIN

```
s := ...; d := ...; l := ...;
MoveL(s,d,l);
END demo.
```

The Microsoft FORTRAN convention for passing parameters, however, is different from the scheme explained previously. The difference between these two schemes when linking (for example, FORTRAN routines or libraries) is that parameters are not passed on the stack but in registers. REL offers the command line switch F/\ll (/FORTRAN) to accommodate this. The FORTRAN switch may be given anywhere on the command line--its effect is global. The FORTRAN parameter-passing scheme is used for all REL files on the command line.

REL also has a search switch (*S/*) that permits the user to search libraries and link only those modules that are actually needed. Unlike the FORTRAN switch, the search switch has only a local effect. It is given after a file name and causes only that file to be searched.

Here is a FORTRAN example:

FUNCTION IDIV(I,J) IDIV = I/J RETURN

END

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And the Modula-2 definition module might look like this:

DEFINITION MODULE divide;

PROCEDURE idiv(i, j : INTEGER) : INTEGER;

END divide;

After compiling both programs, link them by entering the following:

Run MCD-file: REL DIVIDE IDIV /F FORLIB /S

(We call our FORTRAN source file IDIV.FOR.) Once again, you can use function procedure *IDIV* any way that it's allowed in Modula-2.

Warnings: Parameters of structured types are always passed as VAR parameters to FORTRAN, even if a value parameter is specified in the definition module (such parameters are not copied).

FORTRAN routines are not reentrant, nor is the scheme used by REL to pass parameters. Since FORTRAN routines cannot currently call Modula-2 procedures, there are no problems with recursive procedures. Programs using interrupts, however, may have trouble.

Profile

Profile is a utility included with Turbo Modula-2 that allows you to estimate the time spent in various procedures of your program.

If the profiler is invoked with the command

>R Run MCD-file:PROFILE

the main menu prompt > will reappear on the screen as if nothing happened. The profiler actually loads a second version of the shell. You can then run the program to be profiled by giving another Run command. When this program has executed, the profiler outputs a detailed list of all procedures and modules and the percentage of time spent in them.

The profiler can only monitor M-code procedures; native code procedures will not appear in its output. In fact, the profiler simply counts M-code operations.

Since all M-code instructions do not execute in the same amount of time, the measurement is slightly inaccurate; but it should be sufficient to find out which modules and procedures are time-critical.

With this information you can now proceed to compile modules into native code or to write extremely time-critical procedures in assembly.

Since output of the profiler is quite long, output redirection is normally used. For example:

Run MCD-file: PROFILE > MYPROG.PRO.

(le following example monitors MYPROG.MCD performance using PRO-FILE and then routes the report to file MYPROG.PRO.

>R
Run MCD-file: PROFILE > MYPROG.PRO

>R
Run MCD-file: MYPROG.PRO

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Chapter 11 The Standard Library

Some constructs needed for programming are not covered by the language Modula-2. Instead, these operations are performed by a set of predefined modules that cover input and output, mathematical functions, string handling, and storage and process management. A good part of the modules deal with input and output, and us form a hierarchy (see Figure 11-1).

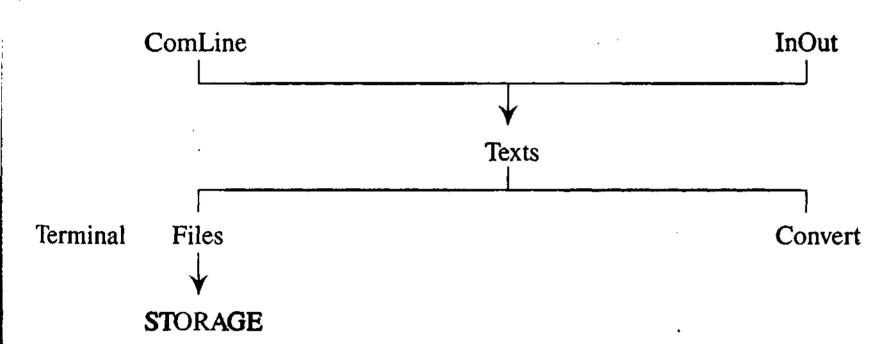


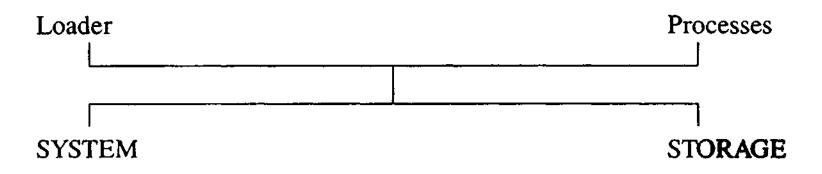
Figure 11-1. Library Module Hierarchy

The arrows in Figure 11-1 denote dependencies on other modules. In general, modules at the top of this drawing can be regarded as high-level modules, and those at the bottom as low-level modules. The module *Terminal* is an independent low-level module; that is, it does not depend on other modules and no module de(d) is on it. The module *STORAGE* does not deal with input and output, but manages heap memory for control blocks and buffers.

The modules *MathLib*, *LongMath*, *Strings*, and *Doubles* comprise what is called a utility library. They provide facilities for manipulating objects.

The low-level modules Loader, SYSTEM, STORAGE, and Processes are systemdependent. Loader and Processes are higher level in that the programs that use them can become portable with minor changes. The modules SYSTEM and STORAGE constitute a special case: They enclose system-dependent primitives needed for low-level programming. The compiler translates all operations imported from them directly into code. *SYSTEM* and *STORAGE* have neither a definition nor an implementation module (nor compiled counterparts), since technically they are not library modules. Because the compiler knows about them in advance, the use of the facilities from these two modules forces the programmer to explicitly specify (in an import list) the use of system-dependent, low-level constructs. Figure 11-2 displays the interdependencies of these modules.

Figure 11-2. Interdependencies of System-Dependent, Low-Level Modules



We can see that the Modula-2 library can be divided into three sections: input/output modules, utility modules, and system and low-level modules. In the next section we will briefly discuss the function of each library module within these three module types; a detailed description of each module will follow.

Overview of Input and Output Modules

Most programs involve input and output of data; for example, entering characters at the keyboard or writing program output to a disk file. Although these processes are different, Turbo Modula-2 treats them in a similar manner.

ComLine Module. Gives a program access to command-line parameters. The standard texts *input* and *output* can be redirected from the standard devices with this module.

Files Module. Procedures providing low-level access to disk files, including random access as well as sequential access. This module is used by the higher-level modules *InOut* and *Texts* to interface with the operating system.

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InOut Module. Wirth's standard procedures for high-level input and output.

Terminal Module. Procedures to read the keyboard and write to the console with

highlighting and cursor control. Includes a procedure to clear the screen and one to check for characters in the keyboard buffer or console.

Texts Module. Procedures to read and write text (character streams) to and from external files and devices. Includes provisions for installable input/output device drivers.

Overview of Utility Modules

Utility modules provide string-handling procedures, mathematical functions, and version from numbers to strings and back again.

Convert Module. Contains procedures to convert strings into numbers and numbers into strings; handles CARDINAL, INTEGER, and REAL numbers.

Doubles Module. Contains procedures to convert strings into double- precision numbers and double-precision numbers into strings; handles LONGINT and LONGREAL numbers.

LongMath Module. Contains several mathematical functions for double- precision numbers, including the common transcendental functions and the natural power functions.

MathLib Module. Contains several mathematical functions for single- precision numbers, including the common transcendental functions and the natural power functions; this module also includes a random-number generator.

Strings Module. Contains procedures for string handling, including deletion, insertion, and copying of substrings.

Overview of System and Low-Level Modules

These modules provide an interface to the operating system, memory, and ports. They allow the programmer to develop system routines for memory management, multiprogramming, and other low-level constructs.

Processes Module. Enables the formulation of loosely coupled processes that are

implemented as coroutines. You can use this module to simulate concurrent programming.

STORAGE Module. Handles memory managment for allocation and deallocation of dynamic variables; also keeps track of available memory.

SYSTEM Module. Contains system-dependent procedures that work with addresses, ports, operating systems and assembly language calls, and facilities for low-level process control.

Loader Module. Handles loading and execution of compiled object modules, enabling the splitting of large programs into smaller parts; the less commonly used parts are loaded from a disk as overlays. This allows the program to manage its own overlays rather than having it done by the runtime system, which is how the overlays produced by the linker are handled.

Details of the Module Library

Rather than defining specific input/output and system-specific statements in the language, these operations are provided in a hierarchy of modules. The modular structure has the effect (and advantage) of hiding computer- specific details, while also providing a means of including new machine- dependent routines when required. What follows is a full description of the services offered by the predefined modules.

Input and Output

Input and output remain one of the biggest problems in high-level language design. This is not surprising, since these operations have to deal with a large number of peripheral devices whose characteristics cannot be contained in a few simple abstractions. In every input/output system, simplicity and brevity of details are in conflict with efficient and flexible use of peripheral devices.

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In Modula-2, this dilemma has been circumvented by not including any input/output primitives in the language at all. Instead, all communication with external devices is provided by a set of modules supplied with the system. And since these primitives are not part of the language (or the compiler), they can be freely supplemented according to the user's needs. However, such a library of input/output functions has an intrinsic disadvantage: It leads to a large set of different primitives that must be remembered by the user. This is because Modula-2 does not allow procedure names to be overloaded (which is when more than one procedure has the same name, but is differentiated by the types of its parameters). Instead, there must be a separate routine for processing each type, even if each routine is essentially the same. For example, you must have one routine to write a character to the screen, another to write an IN-TEGER, another to write a REAL, and so on.

In addition, Modula-2 does not allow procedures to have a variable number of parameters. Thus, when you wish to write three strings to the screen, you must cal *'riteString* three separate times rather than make one call that passes three parameters.

On the other hand, the advantage of having one call for one parameter for each type means you need not guess at the type of the parameter or search out its definition--it is made explicit directly in the code.

In our experience, it is often more difficult to remember the correct usage of the various input/output operations than to deal with the syntax of Modula-2. This is clearly an undesirable situation, particularly for the novice. In Turbo Modula-2, we opted for the best of both worlds: We have included all input/output modules postulated by the standard and allowed the use of general-purpose read and write statements as well, namely *READ*, *READLN*, *WRITE*, and *WRITELN*.

The form of these read and write statements is similar to that of procedures, but they accept varying numbers of parameters, where each may be a different type. This type of procedure is seen with other standard procedures such as *INC* and *DEC*, which accept any scalar type and an optional count parameter.

(1D, READLN, WRITE, and WRITELN are not declared in any standard module; instead, they must be thought of as extensions to the language Modula-2. The compiler translates these statements into corresponding procedure calls to the module *Texts*. This occurs transparently since you can supply your own drivers

to the *Texts* module. You lose nothing in terms of efficiency or flexibility, but gain a lot in simplicity of input and output.

The input and output operations form a hierarchy: At its top are the general *READ* and *WRITE* statements, and at its bottom the underlying operating system. Between the extremes there is a sequence of modules incorporating primitives

with varying degrees of abstraction. Before we delve into the explanation of these modules, let's work out some of the characteristics of most input and output operations.

Input and output usually consists of the reading and writing of a sequence of data items. The process is often strictly sequential; for many peripheral devices, this is the only way to do input or output. A line printer, for example, prints one character after the other, and input from the keyboard consists of a sequence of characters as well. Even if some peripheral device allows random access to data (for example, to a disk drive or a video screen where it is possible to write characters at any position), the sequential operation is often the most convenient. A structure that consists of a sequence of data items is called a *stream*. (This is a purely abstract notion and is not part of the Modula-2 language.)

Streams

As you type at the keyboard, picture a stream of data flowing into the computer from the keyboard. The data output to the disk file is another stream disappearing from the program and being stored on the disk.

A stream, as discussed here, is a sequence of data that is either input from or output to an external medium. The external medium may be either a disk file or a logical device (the keyboard, video screen, or printer); both forms are treated in the same way.

In general, the predefined input/output procedures allow you to link either an input or an output stream to a medium, pass data down the stream, and then sever the connection upon completion.

The following lists the main characteristics of a stream:

□ The number of elements of a stream, called the *length* of a stream, can vary.

□ Only one element of a stream is visible at any one time. Reading starts at the beginning of a stream. After a read operation, the next element in the stream becomes visible.

 \Box A stream can be modified only by **appending elements at its end.** Appending an element is called *writing*.

□ A stream has a mode that can be either *read* or *write*. The mode is specified before any reading or writing is carried out and cannot be changed thereafter.

Notice that none of these characteristics specify the type of the elements of a stream. They can be of any type; however, it is useful to make a broad classification. We generally distinguish between legible and illegible input and output. A legible stream consists of elements of type CHAR, which is also called a *text*. Texts provide the means of communication between the user and the computer, where illegible streams store data for further processing by the computer.

There are several input/output modules that differ in both flexibility and type of st(n handled. For example, the module *Terminal* deals only with the screen and keyboard text streams, while the module *Files* can handle common sequential I/O or random access files that are not streams at all.

A special stream type is the *text stream*, which contains only objects of type CHAR; for example, a stream of characters input from the keyboard or output to the screen or a printer. Text streams are a special case because they are formatted with EOT and EOL characters. (An EOT character marks the end of the text stream, while an EOL character terminates a line.)

Logical Devices

We have just discussed where data originates from and how a program may abstract it; where the data ends up is also relevant. In general, operating systems permit you to write to either a disk file or to *logical devices*. A logical device acts as a code word, specifying to the operating system which path leads to which device, whether it is a printer, a terminal, or another device. Which logical devices you have available will depend on your operating system and your hardware. For example, the CP/M operating system recognizes the following code names:

CON: The video screen for output, the keyboard for input

LST: The printer (output only)

RDR: An additional input interface

PUN: An additional output interface

Note: Your configuration determines which devices can be accessed by RDR: a by PUN:.

The Texts Module

Texts provides the means to input and output a legible stream to and fr peripheral devices. The module Texts uses the following characters to format (streams:

 \Box EOL (=36C, 30 decimal) denotes the end of a line.

 \Box EOT (=32C, 26 decimal) denotes the end of the text.

Note that EOT is not defined as a constant in Texts.

Peripheral devices usually employ either a single carriage return (15C, decimal) or a carriage-return/line-feed (12C, 10 decimal) pair to denote line er The conversion from these control codes to the EOL character and reverse is de automatically by the module *Texts*.

At the center of this module is the type *TEXT*. It describes any legible, sequination tial input and output. This type is declared as a subrange:

TYPE TEXT: [1..16];

Variables of type *TEXT* serve as indices to various internal tables of this mode. The tables themselves are not exported; they remain hidden to guarantee the tegrity of the system.

Standard Text Streams

Texts exports three standard predefined texts that are declared as

input, output, console: TEXT;

The frequently used text streams are offered as predefined standard texts alre

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linked to commonly used mediums. These standard texts do not require the r mal linking and severing operations mentioned earlier. For example:

□ Input is the primary input stream usually assigned to the keyboard, but be redirected to another medium, such as a card reader or other input dev

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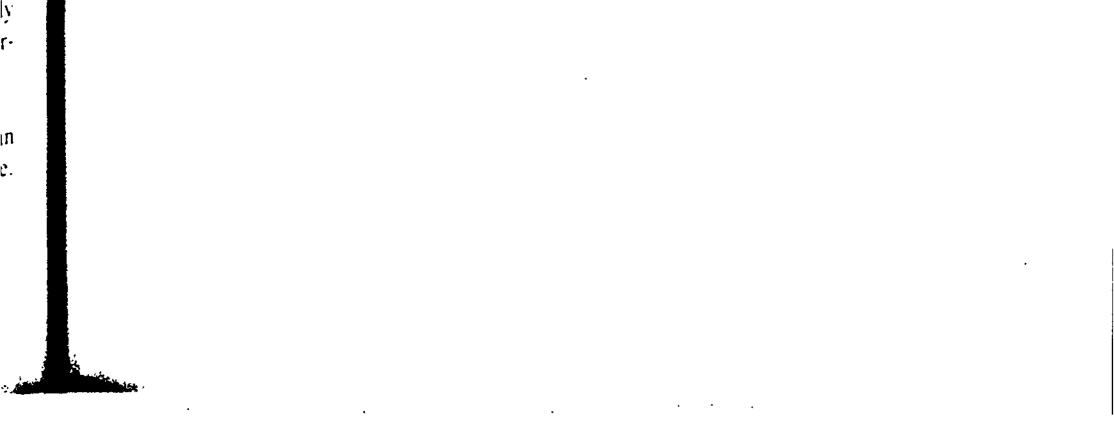
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- Output is the primary output stream to the video console, but can be redirected to another medium, such as a printer or a file.
- ☐ *Console* is the output stream to the video console; it cannot be redirected. It is used to print error messages to the screen when the normal output stream is redirected elsewhere.



Texts Module Specification

DEFINITION MODULE Texts; FROM Files IMPORT FILE; TYPE TEXT = [1..16];

VAR input, output, console: TEXT;

PROCEDURE PROCEDURE PROCEDURE PROCEDURE	ReadString ReadInt	(t: (t:	TEXT; TEXT; TEXT; TEXT;		s: i:	CHAR); ARRAY OF CH AR); INTEGER); CARDINAL);
	Ũ		TEXT;			LONGINT);
			TEXT; TEXT);	VAR 1	r:	REAL);
PROCEDURE	reaum	(6:	IEAI/;			
PROCEDURE	WriteChar	(t:	TEXT;	ch:		CHAR);
PROCEDURE	WriteString	(t:	TEXT;	s:		ARRAY OF CHAR);
PROCEDURE	WriteInt	(t:	TEXT;	i:		<pre>INTEGER; n: CARDINAL);</pre>
PROCEDURE	WriteCard	(t:	TEXT;	c, na	:	CARDINAL);
PROCEDURE	WriteLong	(t:	TEXT;	1:		LONGINT; n: CARDINAL);
PROCEDURE	WriteReal	(t:	TEXT;	r:		REAL; n: CARDINAL;
						digits: INTEGER);
PROCEDURE	WriteLn	(t:	TEXT);			
PROCEDURE	ReadLine	(t:	TEXT; V	Rs:	ARR	AY OF CHAR);
PROCEDURE	ReadAgain	(t:	TEXT);			
PROCEDURE		•	•	BOOL		
PROCEDURE		•	TEXT):		-	
PROCEDURE			TEXT):			
PROCEDURE		•	TEXT):			r -
PROCEDURE	SetCol	(t:	TEXT;	colu	mn:	CARDINAL);

PROCEDURE TextFile (t: TEXT): FILE; PROCEDURE OpenText (VAR t: TEXT; name: ARRAY OF CHAR): BOOLEAN; PROCEDURE CreateText (VAR t: TEXT; name: ARRAY OF CHAR); PROCEDURE CloseText (VAR t: TEXT);

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CONST EOL=36C;

TYPE TextDriver = **PROCEDURE(**TEXT, **VAR** CHAR);

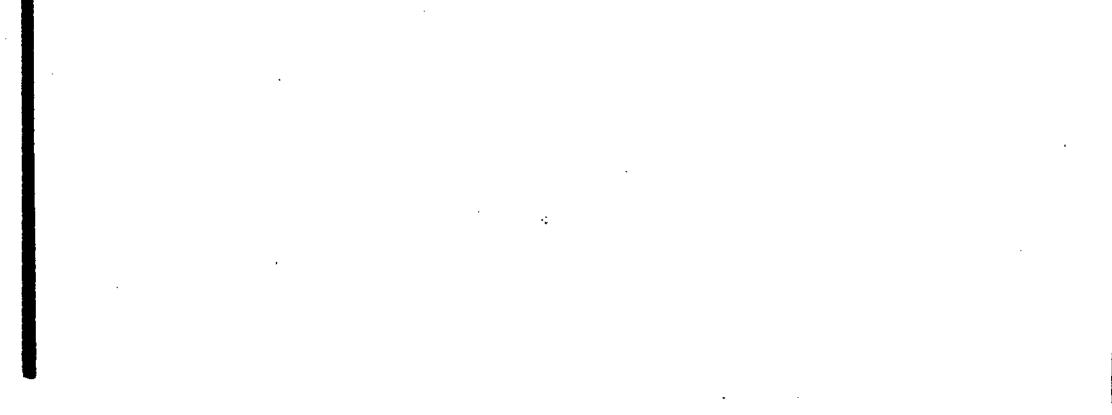
PROCEDURE ConnectDriver(VAR t: TEXT; p: TextDriver);

PROCEDURE Init; (* used only by system *)

VAR haltOnControlC : BOOLEAN; (* TRUE by default *)

EXCEPTION TextNotOpen, TooManyTexts;

END Texts.



The following example shows the use of the Texts module. It reads ten from the keyboard and writes them to a disk file.

```
MODULE DataSave;
FROM Texts IMPORT TEXT, input, Done, CreateText, CloseText,
                  ReadCard, WriteCard;
VAR
 DataFile: TEXT;
 Value, Count: CARDINAL;
BEGIN
 (* Create disk file and link text stream *)
 CreateText(DataFile, 'DATA.DTA');
 (* Read 10 values, save on disk *)
 FOR Count:= 1 TO 10 DO
  ReadCard(Input, Value);
  IF Done(Input) THEN
   WriteCard(DataFile,Value,16)
  END
 END; (* Close disk file *)
 CloseText(DataFile)
END DataSave.
```

Note that since *input* is a standard type TEXT declared in module Texts, it does not require opening or closing.

Stopping the Program During Input and Output

The following variable lets the programmer determine when a program can be interrupted while using the Texts module:

```
VAR haltOnControlC: BOOLEAN;
```

The variable haltOnControlC is exported by Texts and can be specified by the user. If haltOnControlC is TRUE (the default), then the program will halt on either of the following conditions:

□ If you enter a CTRL C as the first character of an input line;

□ If you enter a CTRL S to stop the output to the screen, followed by a CTRL **C** . (Note that WriteLn is the only output statement that checks for keyboard input; thus output to the screen can only be stopped if it is used.) If *haltOnControlC* is set to FALSE by the programmer, then the user may only interrupt by program control.

Opening, Creating, and Closing a Text

Before data can be written or read, a connection must be established between a variable of type *TEXT* and some external medium, such as a disk file or a line printer. This is accomplished with the three procedures that follow.

OpenText (VAR t: TEXT; Name: ARRAY OF CHAR): BOOLEAN;

Associates an internal text value assigned to t with an existing external file identif by the string Name. The variable t can be used only for input. The parameter Name must be the name of a disk file or the code name for one of the operating system's logical input devices, such as CON: or RDR:. In the case of a disk file, a new internal file is created and connected to the existing external file using the procedure Open in module Files. When an input device is specified, the variable t is linked to the external device. In either case, OpenText returns TRUE if the text or device is opened successfully; FALSE if the file or device is not found.

CreateText(VAR t: TEXT; Name: ARRAY OF CHAR);

Establishes a new external text specified by *Name* and connects it to the text variable t. The text t can be used only for writing. Usually, the parameter *Name* identifies a new disk file, which is then created by the procedure *Create* in module *Files*. If the specified name denotes one of the logical output device names, such as CON: or LST:, then the text t is connected to that particular device.

After input or output has been completed on a text, the association with an external medium can be severed by use of the procedure *CloseText*. It is always recommended to close a text when processing is complete; otherwise, output files m_1 to be updated and input files will not have control blocks disposed of properly.

CloseText(VAR t: TEXT);

Severs the connection between the given internal text t and its associated external text. If the external medium is a disk file, this file is closed using *Close* in module *Files*. When t is used for output, the EOT character is appended to the text before it is closed.

A special convention is used for the standard texts *input*, *output*, and *console*. These texts are always open and connected by default to the terminal (imagine them opened with the name CON:). Thus, when reading from the keyboard or writing to the video screen, *input*, *output*, or *console* do not need to be opened or created. When *OpenText* is applied to *input*, the standard input text is redirected to the external medium identified by the parameter Name. Likewise, *CreateText(output,name)* redirects standard output to the medium given by *name*. Closing *input* or *output* will establish the default connection again. Following are some examples.

OpenText(t,"CON:");

Establishes t as an input text with data from the keyboard.

OpenText(input,"RDR:");

Opens the standard text *input* with a different device. This time the standard text *input* is linked to the RDR: device instead of the keyboard; that is, *input* is *redirected*.

OpenText(InText, "B:INDATA.DAT");

Opens existing file INDATA.DAT on drive B for input. Subsequent input from text *InText* is taken from this external file.

CreateText(Printer, LST: ");

Connects the internal output text Printer with the external printer device.

CreateText(OutText,"OUTDATA.DAT");

Creates a new output file on the currently logged drive. Output statements specifying *OutText* write to this file.

CreateText(output,"PROTOCOL");

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Redirects the standard output text. Standard output is no longer displayed on the screen; it is written to a file PROTOCOL that is created by this call.

CloseText(OutText);

Closes the output file B:OUTDATA.DAT, thereby establishing this file in the directory of drive B.

CloseText(input)

Returns the standard input from the RDR: device to the keyboard.

CloseText(output)

Closes file PROTOCOL and returns output to the video screen.

Renaming, Deleting, and Other File Operations

In addition to the previously described functions, you may need to rename, delete, or perform other operations on text files. This can be done via the module Files described on page #. All of the services offered in *Files* can be performed on Texts by using the function TextFile.

TextFile(VAR t: TEXT): FILE;

Returns the value of *FILE* variable associated with the *TEXT t*. If this text has not yet been opened, the value NIL is returned. Here are some examples.

Rename(TextFile(t),'NEWNAME.DAT')

Renames the file associated with the text t to 'NEWNAME.DAT,' and also closes it.

```
Size := FileSize (TextFile(t))
```

Puts the size of t in bytes in the variable Size of type LONGINT.

Flush(TextFile(t))

Flushes the t file buffer.

Reading and Writing Once a text has been opened, data can be read from it. Reading generally involves two operations: (1) the transmission of one or several characters from the external medium into the computer's memory, and (2) an interpretation of these characters. If, for example, a variable of type INTEGER is read, the decimal representation on the external device must be translated into the binary form used internally by the computer. The following set of procedures are applicable when inputting formatted data.

ReadChar(t: TEXT; VAR ch: CHAR);

Reads a single character from text t into ch.

ReadString(t: TEXT; VAR s: ARRAY OF CHAR);

Reads a string; that is, a sequence of characters not containing blanks or control characters. Any leading blanks are skipped. The string s receives as many legal characters as will fit into it. Input is terminated by a blank, an EOL character, or any other control code (a character with a decimal value less than 32). Note that strings cannot be separated by commas.

The next procedures can be used for numeric input.

ReadInt(t: TEXT; VAR i: INTEGER);

Reads a string and converts it to an integer. Again, leading blanks are ignored. Valid input is any sequence of digits 0 to 9, possibly preceded by an arithmetic sign (+ or -). The integer must be in the range MIN(INTEGER) to MAX(IN-TEGER).

ReadCard(t: TEXT; VAR c: CARDINAL);

Reads a string and converts it to CARDINAL. Leading blanks are ignored and no sign is allowed. The CARDINAL must be in the range from 0 to MAX(CAR-DINAL).

ReadReal (t: TEXT; VAR r: REAL);

Reads a string and converts it to a real number. Leading blanks are ignored. The string may contain a decimal point, a mantissa, and an exponent, but these are optional.

ReadLong(t: TEXT; VAR 1: LONGINT);

Reads a string and converts it to a number of type LONGINT. Leading blanks are ignored.

Note: To read and write double-precision real numbers, use the module *Doubles* described later in this chapter.

Note that when t is the standard text *input*, all characters read from the keyboard are echoed on the screen. Line editing is possible until a [RET] is entered. If χ wish to either input a character from the keyboard without echo or to enter a carriage return, use the procedure *ReadChar* provided in the module *Terminal*.

Done(t:TEXT):BOOLEAN;

Monitors correct execution of numeric input requests. When applied after a numerical read operation, *Done* returns a Boolean value that indicates whether the input is valid.

Thus, when a number is read, *Done* is FALSE if the input is syntactically illegal (for example, ABC) or too large to be converted (for example, 1000000) when a cardinal is requested.

Done is unaffected by all other operations. Note the following examples:

```
Declarations:
VAR ch: CHAR; i: INTEGER; c: CARDINAL; r: REAL;
s: ARRAY [0..20]OF CHAR;
t: TEXT;
(____eration: ReadInt(input,i);
Done is TRUE: "0", "123", "-10".
Done is FALSE: "ABC", "1.0", <EOL>, "60000" (too large).
```

Valid Range: -32768 to +32767

Operation: Done is TRUE: Done is FALSE: Valid Range:

```
ReadCard(input,c);
"0", "123", "60000",
"ABC", "1.0", "100000" (too large), "-1."
0 to 65535
```

Operation: Done is TRUE: Done is FALSE: Valid Range:	ReadReal(t,r); "0", "-3.", "3.14", "10.00E+10", "10E10" . "E0", <eol>, "10E40" (too big) -6.80564E38 to +6.80564E38</eol>
Operation:	ReadLong(t,1);
Done is TRUE:	"0", "-10000000", "78"
Done is FALSE:	"ABC", "1.0", "10000000000" (too big)
Valid Range:	-2,147,483,624 to +2,147,483,623

ReadLine(t: TEXT; VAR Line: ARRAY OF CHAR);

Reads a whole line of text into the string variable Line. This is similar to ReadString, but no leading blanks are skipped and input is terminated only by an EOL or EOT character.

ReadLn(t: TEXT);

Advances the read position past the EOL character of the last line read. All characters on the current line, including the next EOL, are skipped. The next read position starts a new line. This procedure is useful to catch trailing blanks on a line or for skipping over unwanted input.

```
ReadAgain(t: TEXT);
```

Causes the last character read from text t to be returned upon the next read operation. For example:

```
Read(t,ch); ReadAgain(t);
IF (ch > = "0") & (ch < = "9") THEN ReadCard(t,x)
ELSE
 ReadString(t,s)
END;
```

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EOLN(t: TEXT): BOOLEAN;

Returns TRUE if the last character read was an EOL (36C) character.

EOT(t: TEXT): BOOLEAN;

Returns TRUE if the last character read was an EOT (32C) character.

Once a text has been created, data can be written to it. Again, writing involves two operations: (1) the translation of the internal representation of data in the computer's memory to one or more characters, and (2) the transmission of these characters to the external medium. Following are procedures to write data.

WriteChar(t: TEXT; ch: CHAR);

writes a single character to the text t.

WriteString(t: TEXT; s: ARRAY OF CHAR);

All characters in the given string s are written, starting from the first element (with index 0) up to the first null character (0C) or the end of s.

WriteInt(t: TEXT; i: INTEGER; FieldWidth: CARDINAL);

Write the integer i to text t. The given number appears right-justified in a field of FieldWidth characters. If FieldWidth is too small, more space is allocated.

WriteCard(t: TEXT; c,FieldWidth: CARDINAL);

Write the CARDINAL c to text t. The given number appears right-justified in a field of *FieldWidth* characters. If *FieldWidth* is too small, more space is allocated.

WriteReal(t: TEXT; r: REAL; FieldWidth: CARDINAL; Digits:INTEGER);

 \checkmark rites real number r, using at least FieldWidth characters; r is right-justified in the FieldWidth character field.

The parameter Digits controls the number of digits used in the mantissa of r. If it is positive, r is written in fixed-point format with *Digits* characters after the decimal point. If it is zero, the decimal point is omitted. A negative value of Digits indicates scientific notation; that is, the decimal point follows the most significant digit and an exponent is present. In this case, the number of digits in the mantissa is equal to ABS(Digits).

WriteLong(t: TEXT; 1: LONGINT; FieldWidth: CARDINAL);

Writes long integer l, right-justified in a *FieldWidth* character field. If more than *FieldWidth* columns are needed to print l, more space is allocated.

WriteLn(t: TEXT);

Terminates output line. WriteLn(t) is equivalent to WriteChar(t, EOL). The EOL character is translated to a carriage-return/line-feed pair.

SetCol(t: TEXT; Col: CARDINAL);

Advances the write position of text t to column *Col* in the current output line. If *Col* is not greater than the current column number of t, nothing happens. Columns are numbered from 0; that is, the left-most column has number 0.

Col(t: TEXT): CARDINAL;

Returns the current column position of text t. After a WriteLn, Col returns 0; it increases by 1 with every character written.

The following are examples of the preceding procedures:

Operation

Output

```
WriteInt(output,1025,5);
                                                           1025 "
WriteInt(t,1025,7);
                                                           1025"
WriteReal(output, 12.28, 10,);
                                                           12.3"
                                                       Ħ
WriteReal(output, 12.28, 5, 0);
                                                              12 "
                                                          Ħ
WriteReal(output, 12.18, 12, -5);
                                                  1.21800E+01
WriteLong(output, -1000L*1000L, 10);
                                                    " -1000000"
SetCol(output,Col(output) DIV 10 + 1) * 10);
                                                 Tabs to the next
                                                  multiple of 10
```

The following example sums up input line by line. (This is recommended for very portable code; for an easier method, see the *READ* and *WRITE* statements that follow.)

MODULE SumUp;

FROM Texts IMPORT input, output, EOLN, EOT, ReadReal, Done, WriteChar, WriteReal, WriteLn, WriteString;

VAR

item,sum: REAL;

BEGIN

REPEAT

```
WriteString(output, "enter real numbers> ");
sum:=0.0;
```

PEAT

```
ReadReal(input,item);
IF Done(input) THEN sum:=sum+item END ;
UNTIL EOLN(input) OR EOT(input);
IF NOT EOT(input) THEN
WriteString(output, "Sum = ");
WriteReal(output, sum,12,-5);
WriteLn(output);
END
UNTIL EOT(input)
```

READ and WRITE Statements

The number of procedures in the preceding section may seem overwhelming; however, the *READ* and *WRITE* statements are much easier to use. The compiler translates them into appropriate calls to procedures in the module *Texts*, which causes an implicit import from that module. *READ*, *READLN*, *WRITE*, and *WRITELN* are predeclared identifiers, not reserved words. Note that *READ* and *WRITE* statements are an extension to Modula-2 and their use may not be portable to (): r Modula-2 implementations. Their full definition follows:

 \Box Let t denote a variable of type TEXT and let v,vl,\ldots,vn denote variables of a readable type; that is, of one of the types INTEGER, CARDINAL, CHAR,

any subrange of them, REAL, LONGINT, or any ARRAY with CHAR elements.

□ Let p,pl,...,pn denote parameters of one of the forms el, el : e2, or el : e2 : e3, where el is an expression of a readable type, e2 is a cardinal expression, and e3 is an integer expression.

READ(t,v1,...,vn)

Causes $v1, \ldots, vn$ to be read from text t. The read items must be separated by blanks or line ends. The text variable t may be omitted.

READ(v1,...,vn) Causes v1,...,vn to be read from the standard text input.

READLN(t,v1,...,vn)

Works exactly like *READ*, except that the remainder of the last line read is skipped.

WRITE(t,p1,...,pn)

Causes p1,...,pn to be written to text t. If the text variable is omitted, output goes to the standard text output, for example.

WRITE(pl,...,pn)

Characters and strings are written without preceding or subsequent blanks (except for blanks in the string itself).

Integers and cardinals are written right-justified in a field of six characters, which can be overridden with a field specifier.

Reals are displayed in scientific notation, right-justified in a 12-character field. However, this may be overridden with a field specifier.

The field width of numbers can be changed by appending a colon and the desired width to the expression. The representation of real numbers can be changed to fixed-point by appending a second colon and the desired width of the fractional part (also see points 6 and 7 that follow).

WRITELN(t,p1,...,pn)

Works exactly like WRITE, except that the line is terminated when all parameters are written. The argument list may be empty; if so, only the EOL character is written.

The translation process from the READ and WRITE statements to calls of procedures in module Texts is as follows:

1. READ(v1,...,vn) is translated to READ(Input,v1,...,vn). WRITE(p1,...,pn) is translated to WRITE(Output,p1,...,pn). The same equivalence holds for READLN and WRITELN. 2.READLN(t,v1,...,vn) is translated to READ(t,v1,...,vn); ReadLn(t). (''RITELN(t,p1,...,pn) is translated to WRITE(t,p1,...,pn); WriteLn(t).

- 4. READ(t,v) is translated to

```
ReadChar(t,v) if v is of type CHAR.
ReadString(t,v) if v is of type ARRAY OF CHAR.
ReadInt(t,v) if v is of type INTEGER.
ReadCard(t,v) if v is of type CARDINAL.
ReadReal(t,v) if v is of type REAL.
ReadLong(t,v) if v is of type LONGINT.
ReadDouble(t,v) if v is of type LONGREAL.
```

5. WRITE(t,p) is translated to

(_riteChar(t,p)	if p is of type CHAR.
WriteString(t,p)	if p is of type ARRAY OF CHAR.
WriteInt(t,p,6)	if p is of type INTEGER.
$\operatorname{Uni} + \operatorname{O} \operatorname{O} \operatorname{O} \operatorname{O} \operatorname{O} \operatorname{O} \operatorname{O} \operatorname{O}$	if n is of tyme CAPDINAT

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WriteCard(t,p,6) if p is of type CARDINAL. WriteReal(t,p,12,-5) if p is of type REAL. WriteLong(t,p,12) if p is of type LONGINT. WriteDoubles(t,p,22,-14) if p is of type LONGREAL.

Note that the standard width for the representation of a number is 6 in the case

of integers and cardinals and 12 in the case of reals; reals are normally written in scientific notation with a 5-digit mantissa.

Also note that you cannot replace the procedure call *ReadLine* with a *READLN* statement. READLN(line) would only read the first string of a line, stopping at the first blank encountered, then skipping to the end of the line without reading anything. On the other hand, ReadLine(Input, LineI) reads in the full line from the start to the next EOL character.

- 6. If x is of type INTEGER, CARDINAL, or LONGINT and n is a cardinal expression, then WRITE(t,x:n) is translated to WriteInt(t,x,n), WriteCard(t,x,n), or WriteLong(t,x,n), respectively; that is, the default width specification is overridden.
- 7. If x is of type REAL or LONGREAL, then WRITE(t,x:n) is translated to WriteReal(t,x,n,-5). Again, the default width specification is overridden.

WRITE(t,x:n:i) is translated Furthermore, if *i* is an integer, to WriteReal(t,x,n,i).

In this case, the form of notation (scientific or fixed-point) is indicated by the programmer. As in the previous explanation of procedure WriteReal, positive values of *m* indicate fixed-point notation with *i* digits behind the decimal point, whereas negative values stand for scientific notation.

The following example presents the same example from the earlier »Reading and Writing« section, except this time we make use of Turbo Modula-2's READ and WRITE extensions. The module becomes shorter and easier to read, even though it is translated into (nearly) the same code as the previous example. The READ and WRITE extensions do not in themselves shorten code generated by the compiler, rather they help to write shorter and clearer source programs.

MODULE SumUp;

FROM Texts IMPORT input, EOLN, EOT, Done;

VAR

item,sum: REAL; BEGIN REPEAT WRITE("enter real numbers> ");

```
sum:=0.0;
REPEAT
READ(item);
IF Done(input) THEN sum:=sum+item END ;
UNTIL EOLN(input) OR EOT(input);
IF NOT EOT(input) THEN WRITELN("Sum =",sum:12:-5) END
UNTIL EOT(input)
END SumUp.
```

User-Defined I/O Drivers

[ts provide communication with disk files and the logical devices of the operating system. If you wish to communicate with some device not falling into these categories, you can install your own I/O drivers and procedure for input and output. Such a procedure must match the following procedure type:

TYPE

TextDriver = **PROCEDURE(**TEXT, **VAR** CHAR);

TextDriver is a template for the many possible I/O drivers. All of these procedures must accept a *TEXT* as their first parameter. Their second argument must be a VAR parameter of type CHAR.

If a text is used for output, the I/O driver sends its second argument; while a driver used for input deposits a character that was read in this parameter. Driver procedures must provide for the correct conversion of the EOL character into end-of-line character sequences used by the external device. The first parameter (of the subrange type *TEXT*) may serve as an index into a table that contains further information about the text on which the I/O takes place. In most situations it can be ignored.

vio install a user-defined I/O driver, use the following procedure:

```
ConnectDriver(VAR t: TEXT; driver: TextDriver);
```

After a call to this procedure, I/O on text t will be handled via the procedure that was substituted for the *driver* argument. This procedure has the effect of opening text t; no further *OpenText* or *CreateText* need be given.

The following is an example of installing a driver for an IEEE interface. We have presented the sketch of a local module, exporting the two texts *InIEEE* and

OutIEEE, communicating with an IEEE interface. It is assumed that line ends are denoted by single carriage-return characters.

```
IMPLEMENTATION MODULE IEEE;
FROM Texts IMPORT TEXT, EOL, ConnectDriver;
EXPORT INIEEE, OutIEEE;
CONST CR=15C;
VAR
 InIEEE, OutIEEE: TEXT;
PROCEDURE Put(t: TEXT; VAR ch: CHAR); (* Output driver *)
BEGIN
 IF ch = EOL THEN ch:=CR END ;
 (* code to write ch to the IEEE interface *)
END Put;
PROCEDURE Get(t: Text; VAR ch: CHAR); (* Input driver *)
BEGIN
(* code to read ch from IEEE interface *)
 IF ch = CR THEN ch := EOL END ;
END Get;
BEGIN (* Inititialization: Install Get and Put *)
ConnectDriver(inIEEE, Get);
 ConnectDriver(OutIEEE ,Put)
```

END IEEE;

The texts *InIEEE* and *OutIEEE* may now be used to input or output characters, strings, or numbers. Statements like the following are now possible:

```
READ(InIEEE,x,y,s);
WRITELN(OutIEEE, "Size of Sample: ",SampleSize);
```

The InOut Module

InOut serves about the same purpose as the module Texts: It provides communication to external mediums without any assumptions about the nature of peripheral devices. The module InOut is postulated to be present in every Modula-2 system. It is included in the Turbo Modula-2 system for the sake of compatibility, even if abstract input and output is generally accomplished more conveniently by using the READ and WRITE extensions to Turbo Modula-2 in conjunction with the module Texts.

The operations provided by *InOut* can be thought of as a subset of those providby *Texts. InOut* is more restrictive, however. Only operations on the standard text streams *input* and *output* are allowed. These standard streams are hidden by *InOut*, but can be accessed directly from *Texts*. As a consequence, procedures provided by *InOut* do not require a parameter to indicate which text stream is used. Read operations always use *input*, while write operations work on *output*. Correct execution of input procedures is monitored in the global variable *Done*, and the global variable *termCH* always contains the last character read.

In addition to the procedures provided by *Texts*, *InOut* exports two more output procedures.

```
WriteOct (c,n: CARDINAL);
```

Writes cardinal c in octal representation (range 0 to 177777 octal).

```
WriteHex (c,n: CARDINAL);
```

Writes cardinal c in hexadecimal representation (range 0 to FFFF hex).

Jur implementation of *InOut* reads and writes real numbers as well as CAR-DINALs and INTEGERs. The user should keep in mind that other implementations might choose to separate these tasks. Procedures to read and write *REALs*

would most likely be imported from the modules RealInOut or RealIO.

Note that when using the procedures *OpenInput* or *OpenOutput*, no file name is provided by the program. Instead, the name is requested from the user at the terminal, which limits the usefulness of these procedures.

InOut Module Specification

DEFINITION MODULE InOut;

CONST EOL=36C; VAR Done: BOOLEAN; termCH: CHAR;

PROCEDURE OpenInput (defext: ARRAY OF CHAR);

(* Requests a file name at the terminal and connects input with that file. The file name may indicate one of the logical devices of CP/M. If the file name does not contain an extension itself, the default extension defext is appended.

*****)

```
PROCEDURE OpenOutput (defert: ARRAY OF CHAR); (* Same as above but for output *)
```

```
PROCEDURE CloseInput;
```

```
(* Closes input file, returns input to terminal. *)
```

PROCEDURE CloseOutput;

(* Closes output file, returns output to terminal. *)

```
PROCEDURE Read (VAR ch: CHAR);
(* Done := Not past end of input *)
```

```
PROCEDURE ReadString (VAR se: ARRAY OF CHAR);
(* Reads string as in Texts. Done := the returned string is not empty
*)
```

```
PROCEDURE ReadInt (VAR x: INTEGER);
(* Reads integer as in Texts. Done := integer was read *)
```

PROCEDURE ReadCard (VAR x: CARDINAL);

```
(* Done := cardinal was read *)
```

```
PROCEDURE Write(ch: CHAR);
PROCEDURE WriteLn;
PROCEDURE WriteString(s: ARRAY OF CHAR);
PROCEDURE WriteInt(x: INTEGER; n: CARDINAL);
```

PROCEDURE WriteCard(x,n: CARDINAL);
PROCEDURE WriteHex(x,n: CARDINAL);
PROCEDURE WriteOct(x,n: CARDINAL);

PROCEDURE ReadReal (VAR x: REAL);
PROCEDURE WriteReal(x: REAL; n,digits: CARDINAL);
END InOut.

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The Files Module

The next lower level of the module hierachy connecting *InOut* and *Texts* with the computer's disk-operating system embodies the concept of a file. There are two ways to look at a file. The first is as an external object: A file describes a collection of data stored on a magnetic disk. Often the data is of the same type. The second is as an internal object: A file represents an internal data structure that describes the external data and how it is accessed. The two notions should not be confused. The type FILE as exported by the module Files describes access to data items, not the data itself. In some operating systems this is referred to as a file control block.

Files offers the possibility to access data collected in a disk file. The elements of a file may be of any type and can be legible or illegible. No interpretation is performed; elements in a file are represented in computer internal binary form. As an example, writing the integer 279 to a *TEXT* consists of the output of the three numerals 2, 7 and 9, or in binary form:

| 00110010 | 00110111 | 00111001 |

When writing the same number as an integer to a file, its internal representation is written without prior conversion into ASCII digits, like so:

| 00000001 | 00011001 |

Physically, a file is a sequence of bytes on disk that can be read or written. The read or write position can be set to any byte of the file, thus allowing data to be accessed randomly.

It is often convenient to think of files at a higher level of abstraction. At this level, files are ordered collections of variables that are usually all of the same type. The type of the file elements is arbitrary--it could be CHAR, a record, or any other type.

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Errors During File Handling Files signals error conditions by raising one of five exceptions. If such an exception is raised, the executing program is stopped and a message describing the cause of the error is displayed on the screen. Programs may recover from such error conditions if the programmer provides an exception handler for the exception raised (refer to Chapter 9). *Files* defines the following exceptions:

StatusError Indicates request of an illegal file-processing operation, such as reading from an unopened file or opening a file twice.

Files Module Specification

DEFINITION MODULE Files;

FROM SYSTEM IMPORT BYTE, WORD, ADDRESS; TYPE FILE;

(VAR f: FILE; name: ARRAY OF CHAR): PROCEDURE Open BOOLEAN; (VAR f: FILE; name: ARRAY OF CHAR); PROCEDURE Create (VAR f: FILE); PROCEDURE Close (VAR f: FILE); **PROCEDURE** Delete (VAR f: FILE; name: ARRAY OF CHAR); PROCEDURE Rename (f: FILE; VAR name: ARRAY OF CHAR); **PROCEDURE** GetName (f: FILE): LONGINT; **PROCEDURE** FileSize (f: FILE): BOOLEAN; PROCEDURE EOF (f: FILE; VAR ch: BYTE); PROCEDURE ReadByte (f: FILE; VAR w: WORD); PROCEDURE ReadWord (f: FILE; VAR rec: ARRAY OF WORD); PROCEDURE ReadRec (f: FILE; buf: ADDRESS; nbytes: CARDINAL): PROCEDURE ReadBytes CARDINAL; PROCEDURE WriteByte (f: FILE; ch: BYTE); (f: FILE; w: WORD); PROCEDURE WriteWord (f: FILE; VAR rec: ARRAY OF WORD); PROCEDURE WriteRec (f: FILE; buf: ADDRESS; nbytes: CARDINAL); PROCEDURE WriteBytes PROCEDURE Flush (f: FILE); (* Flushes the file's internal buffer to disk. Is used to detect DiskFulls at once *) (f: FILE): LONGINT: PROCEDURE NextPos

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PROCEDURE SetPos	(f: FILE; pos: LONGINT);

PROCEDURE NoTrailer (f: FILE);

PROCEDURE ResetSys ();

EXCEPTION EndError, StatusError, UseError, DeviceError, DiskFull;

END Files.

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EndError Indicates attempt to read past the end of a file.

Indicates file creation, renaming, or deletion on a write-UseError protected disk, like the CP/M-message BDOS ERROR ON (drivename): R/O, which is suppressed in this case. Note that changed disks are always write-protected before a system reset. Also note that CP/M will not recognize a physically writeprotected disk as R/O when reset; thus, UseError is not reliable for physically write-protected disks.

DeviceError Indicates data is not readable, presumably because of a bad disk sector. This exception is also raised if a Close operation is unsuccessful.

DiskFull Indicates that data cannot be written due to a full disk, or files or extents cannot be created due to a disk- directory overflow.

Operations on Entire Files

Before any processing can be carried out, the internal file must be connected with an external (disk) file. After the connection is made, the file is then said to be open. New files are opened with Create and existing files are opened with Open:

(VAR f: FILE; name: ARRAY OF CHAR): BOOLEAN; Open Create (VAR f: FILE; name: ARRAY OF CHAR);

These procedures connect an internal file f with an external file. Open searches the directory for an existing file with the given name, returning FALSE if no such file is found. Create always creates a new empty file; if a file with the same name already exists, it is deleted.

The following procedure performs a reset of the disk system. It is useful to prevent UseErrors caused by changed disks.

ResetSys;

After a call to ResetSys, it is possible to write to drives where disks have been swapped, but all open output files will be lost.

After processing has been completed on a file, the connection may be severed by the Close procedure.

Close(VAR f: File);

Disconnects f with its associated external file. If output has been sent to f, closing is mandatory; otherwise, all data of f will be lost. Since closing a file recovers the memory used for control blocks and data buffering, it is advisable to close a file in any case, even if it has only been used for input.

The following procedures are used to delete or rename a file:

```
(VAR f: FILE);
Delete
        (VAR f: FILE; name: ARRAY OF CHAR);
`ename
```

Both procedures assume that f is open. Delete deletes the directory entry that corresponds to f, while Rename renames the entry to its given name. Both procedures have the side effect of closing the internal file f.

The external name of file f is returned by the following:

GetName(f: FILE; VAR name: ARRAY OF CHAR);

The name is returned in a standard format: The first character is the drive code, which can assume the values A through P. The second and third characters are the user area of the file. The fourth character is always a colon. The file name is next, consisting of up to 8 characters, with its end marked by a period. If the file name contains an extension, it is appended. To hold a returned file name, the name parameter should be declared with at least 16 characters.

For example, assuming the procedure calls

```
Open(f, "B4:INDATA.DAT" );
Jreate(out, "OUTDATA")
```

then the results will be GetName(f,fname), which will yield »B04:IN-DATA.DAT,« and GetName(out,outname), which will yield »A00:OUTDATA.«

The following procedure returns the size of an external file:

FileSize (f: FILE): LONGINT;

This returns the exact number of bytes in the file. Since files can be larger than

65535, the maximal CARDINAL value, the result is of type LONGINT. (. since its maximum value is in the trillions, it should be adequate for some tir

Unfortunately, CP/M has no means to determine the exact size of a file in by To correct this restriction, Turbo Modula-2 uses a special convention: The byte of the last CP/M record (128 bytes) in a file indicates the number of def bytes in the record. This last byte has an offset value of 128; that is, if it is no bytes in the record are defined. A value of 255 indicates 127 defined bytes. value below 128 means that the last record is completely filled. Using this byte and the BDOS function that returns the number of 128-byte records in a the file's exact size can be computed.

This scheme imposes almost no restriction on the file formats that can be r In particular, reading ASCII files generated by WordStar or other program possible without encountering problems. If you run into problems transfer files between Turbo Modula-2 programs and other software, you can use this cedure:

```
NoTrailer (f: FILE);
```

Note that the file f must be already open, thus allowing *NoTrailer* to cause last byte of the last CP/M record of f to be interpreted as a data byte instea a length byte. Consequently, a subsequent call of *FileSize(f)* will always retu multiple of 128. If the length of f is changed by write operations, no length will be appended to f when it is closed.

File Processing

We can think of a file as a sequence of bytes stored on disk. The number of l in a file is called the *length* of the file. A file's elements are all of the same and each can consist of several bytes. However, only one element can be acce at a time.

The position number of the accessible element is called the *current positic* the file. The current position can point to any element, or it may denote the of the file; that is, it can range from 0 up to the FileSize(f). Initially, if no proving has been carried out, the current position will be 0. Reading advances the rent position past the read data. Likewise, writing advances the current pos past the modified data.

Once a file is open (an Open or Create operation applied to it), reading

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writing becomes possible. The following operations are available for file processing and can be carried out only on open files. If one of these operations is applied to a file that is not open, the exception *StatusError* is raised. The file operations that follow read data from the given file f and differ in the kind of data that is read:

```
keadByte (f: FILE; VAR ch: BYTE);
KeadWord (f: FILE; VAR w: WORD);
FeadRec (f: FILE; VAR rec: ARRAY OF WORD);
```

ReadByte reads a single byte and assigns it to the parameter *ch. BYTE* is a special type, imported from the pseudomodule *SYSTEM*. It matches every variable occupying 1 byte of memory. This includes variables of the type CHAR, BOOLEAN, subrange types with bounds in the range 0 to 255, and enumeration types with, at most, 256 elements. If the file elements are one of these types, *ReadByte* should be used for reading.

ReadWord reads 2 bytes (a word) and assigns them to the parameter w. The type WORD is also imported from the pseudomodule SYSTEM. It matches any variable coupying 2 bytes of memory. Examples are variables of type INTEGER, CAR-DINAL, BITSET, sets, and all pointers. If the file elements are one of these types, *ReadWord* should be used for reading.

ReadRec reads everything not covered by *ReadByte* and *ReadWord*. The type ARRAY OF *WORD* matches variables of any type. This works since the storage of every element is rounded up to a word offset. As many words as are needed to fill out the given parameter are read. Employing this procedure for reading is 40propriate for file elements occupying more than one word; in particular, for tecords, arrays, long integers, and reals.

In all three procedures, the current position is advanced by as many bytes as are read. A subsequent read operation will then access the next element in the file. If the current read position is higher than the end position, the exception indError is raised.

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The following file operations write data to the given file f and differ in the kind 4 data that is written:

```
WriteByte (f: FILE; ch: BYTE);
WriteWord (f: FILE; w: WORD);
WriteRec (f: FILE; VAR rec: ARRAY OF WORD);
```

These procedures give the value specified in the second parameter to the element at the current position in the given file f. If the current position is not higher than the end position, the corresponding file element is modified. If the current position points to the end of the file, data is appended and the length of the file is incremented.

While *WriteByte* is appropriate for file elements occupying 1 byte, *WriteWord* is used for word-sized elements and *WriteRec* applies to elements of a larger size (for example, records, arrays, or reals).

If writing is impossible, the exception *DiskFull* is raised. There are also two lower level procedures for reading and writing data.

ReadBytes (f: FILE; buf: ADDRESS; nbytes: CARDINAL): CARDINAL;

Reads as many bytes as are specified in the *nbytes* parameter into consecutive addresses, starting at the address denoted by *buf*. If less than *nbytes* bytes remain in the file *f*, only the number of remaining bytes are read. Hence, a call to this procedure will never cause the exception *EndError* to be raised. The number of bytes read is returned as a function result.

WriteBytes (f: FILE; buf: ADDRESS; nbytes: CARDINAL);

Writes as many bytes as are specified by the given *nbytes*. Data is written from consecutive addresses, starting at the address *buf*.

EOF(f: FILE): BOOLEAN;

Returns TRUE if the end of file f is reached; returns FALSE if there are still bytes in f to be read.

Note that this procedure provides a limited form of *lookahead*. You know that the end of a file has been reached before undefined data has been read. This works even if the file is empty, a fact that distinguishes a *FILE* from a *TEXT*. With *TEXT* you have to read the EOT character to know that the *TEXT* has been completely read. The appropriate form to process a *FILE* is a WHILE loop:

```
IF Open( f, fname ) THEN
WHILE NOT EOF(f) DO
 ReadRec(f,data);
 Process(data);
END;
Close(f);
END
```

```
SetPos(f: FILE; pos: LONGINT);
```

Allows data to be accessed randomly. Sets the current position of the file f to ρos . This parameter denotes the byte position where subsequent file processing will take place. The next read operation will then access the element at position pos. The next write operation will modify the element at this position. The parameter pos can point to any element in the file or it can point to the end of the file; its legal range is 0 up to and including FileSize(f). If pos is larger than FileSize(f), the exception EndError is raised.

If all file elements are of the same type T, and you know the ordinal number n of the selected element in the sequence (counting again from 0), you can compute its byte position as

BytePosition := n * SIZE(T)

Thus, a call like SetPos(f, LONG(n)*LONG(SIZE(T))) would set the current file position correctly. Note that SetPos requires a parameter of type LONGINT. Since type coercion is not performed in Modula-2, the construct SetPos(f,0) is illegal; use SetPos(f,LONG(0)) or SetPos(f,OL) instead.

The current file position can be examined by calling

NextPos (f: FILE): LONGINT;

which will return the current position of the given file f.

To demonstrate how files work we will present two examples. The first example shows a series of operations on a file (represented by boxes) and how these procedures affect the file and the file pointer (the up arrow). The declarations VAR f: FILE; c: CHAR; are used in the procedure calls in Example 1.

Example 1

1. Open(f, "INDATA");

| 01001100 | 01100101 | 01101100 | 01101100 |

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Steps 2 through 4 show how to modify a file element: First read it in, then set the current position back by one and write the modified data.

2. ReadByte(f,c);

| 01001100 | 01100101 | 01101100 | 01101100 |

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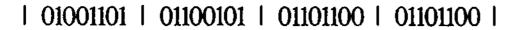
c now has the value 01001100 binary (*L«).

3. SetPos(f,NextPos(f)-1L);

| 01001100 | 01100101 | 01101100 | 01101100 |

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4. INC(c); WriteByte(f,c);



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Steps 5 and 6 show how to append data at the end of a random access file: Set the position to the length of the file and write the data to be appended.

5. SetPos(f,Size(f));

i 01001101 i 01100101 i 01101100 i01101100 i

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6. writeByte(f, "y");

| 01001101 | 01100101 | 01101100 | 01101100 | 01111001 |

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Example 2 is a practical implementation of a file copy utility that shows the typical usage of the *Files* module. Its operation is similar to the Filecopy command in the Turbo Modula-2 shell. Data is first written into a temporary file with the extension ---. If the transfer succeeds, the temporary file is renamed to whatever the user indicates. This scheme avoids an accidental loss of data.

Among others, two procedures of the module *FileExtensions* are imported, *StripExt* and *AppendExt*. (This module is not in the standard library. It is used as a programming example in the section on the module *Strings*.) In short, *StripExt* strips the extension from a file name and *AppendExt* appends an extension. The procedure *PromptFor*, imported from the standard module *Comline*, read, .ext from the command line or, if none is found, prompts the user for input.

Example 2

MODULE FileCopy;

FROM SYSTEM IMPORT ADR;

FROM FileExtensions IMPORT StripExt,AppendExt;

(* See the discussion of the Strings Module for a listing of the FileExtensions routines.

*)

```
FROM ComLine IMPORT PromptFor;
FROM Files IMPORT FILE, Open, Create, Close, Rename, Delete, ReadBytes,
                 WriteBytes, DiskFull;
CONST BufferSize = 20000;
VAR
                           : FILE ;
 inFile, outFile
 inName, outName, tempName : ARRAY [0..20] OF CHAR;
                           : ARRAY [1...BufferSize] OF CHAR;
 buffer
                           : CARDINAL;
 fetched
BEGIN
 PromptFor("Copy file: ", inName);
 IF inName[0] # OC THEN (* no empty string entered *)
  PromptFor("Copy to : ", outName);
  IF outName[0] # OC THEN
   IF Open(inFile, inName) THEN
    tempName:=outName;
    StripExt(tempName);
    AppendExt(tempName, "$$$");
    Create(outFile, tempName);
    REPEAT
     fetched := ReadBytes(inFile,ADR(buffer),BufferSize);
     WriteBytes(outFile, ADR(buffer), fetched);
    UNTIL fetched < BufferSize;
```

Rename(outFile, outName);

Close(inFile);

ELSE WRITELN(inName, " not found.") END

END

END

EXCEPTION

```
DiskFull: WRITELN("DISK FULL"); Delete(outFile)
END FileCopy.
```

Files with Elements of Mixed Types

Up to now, we have only encountered files with elements all of the same type. However, sometimes it is convenient to include elements of varying types in one file; for example, a file can have a header as its first element, containing various information about a file's data. The actual data would follow the header in a different format. You can process such a file the same way you would a file with uniform elements. The procedures *ReadByte*, *ReadWord*, *ReadRec*, *ReadBytes*, *WriteByte*, *WriteWord*, *WriteRec*, and *WriteBytes* are functional. Of course, the procedure chosen must match the type of accessed element. For example, *Read-Byte* would be used to read a character, while *ReadRec* would serve to input a record.

The Terminal Module

The module *Terminal* provides communication over the operator's terminal (the keyboard and the video screen), without the abstraction of a text stream. The following procedures show how to implement basic input/output routines.

ReadChar(VAR ch: CHAR);

Reads a single character from the keyboard. The character is not echoed on the screen, which distinguishes the module *Terminal* from *Texts* or *InOut*. Line ends are denoted by carriage returns (15C); no conversion to the EOL character is performed.

BusyRead(VAR ch: CHAR);

Tests to see if a character has been typed. A typed character is returned in the given ch. If no key is pressed, ch is set to 0C.

ReadAgain;

Causes the last character read to be returned again upon the next call of *ReadChar* or any read statement from *Texts* or *Terminal*.

ReadLine(VAR s: ARRAY OF CHAR);

Reads a line (terminated by a carriage return) into a string.

WriteChar(ch: CHAR);

Writes a single character; no conversion from EOL to carriage-return/line-feed pairs is performed.

WriteLn;

Terminates a line.

WriteString(s: ARRAY OF CHAR);

Writes a string to the terminal.

Terminal Module Specification

DEFINITION MODULE Terminal;

PROCEDURE ReadChar (VAR ch: CHAR); PROCEDURE BusyRead (VAR ch: CHAR); **PROCEDURE** ReadAgain; **PROCEDURE** ReadLine (VAR CHAR); s:

OF

ARRAY

PROCEDURE WriteChar (ch: CHAR); PROCEDURE WriteLn; PROCEDURE WriteString (s: ARRAY OF CHAR);

TYPE

```
SpecialOps (clearEol, insertDelete, highlightnormal);
           = SET OF SpecialOps;
OpSet
```

VAR available : OpSet; **VAR** numRows, numCols : CARDINAL;

```
PROCEDURE ClearScreen;
PROCEDURE GotoXY(x,y: CARDINAL);
```

PROCEDURE ClearToEOL; **PROCEDURE** InsertLine; **PROCEDURE** DeleteLine;

```
PROCEDURE Highlight;
PROCEDURE Normal;
```

PROCEDURE InitScreen; **PROCEDURE** ExitScreen;

END Terminal.

Terminals may require a different set of control codes to do certain screen functions, such as cursor positioning or clearing the screen. Thus the following procedures of this module work only if the Turbo Modula-2 system has been properly installed for the terminal running the system. Note: It is possible to install standalone Turbo Modula-2 programs as well as the system (see Appendix B »Installation Procedures«).

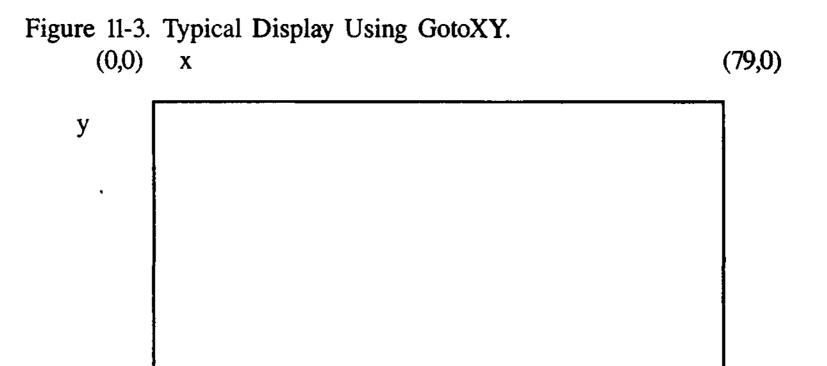
Some of the screen functions available in the module *Terminal* are described here.

ClearScreen ();

Clears the screen and homes the cursor (places it in the upper left corner of the screen).

GotoXY(x,y: CARDINAL);

Places the cursor on column x, row y of the screen. Columns and rows are numbered from 0. The upper left corner is at (0,0). A typical display has 80 columns and 24 lines, as shown in Figure 11-3.





Inside the module Terminal are two variables, numRows and numCols, set by

the terminal initialization to give the screen height and width. They are defined as follows:

VAR

```
numRows,numCols: CARDINAL;
```

```
where for common terminals, numRows = 24 and numCol = 80.
```

You can highlight a piece of text with the procedures Highlight and Normal.

Highlight highlights output to the screen by underlining it, using inverse video, . changing its brightness. This effect is dependent on the characteristics of your terminal and how the system is installed. *Normal* returns you to normal display mode.

The remaining procedures, *ClearToEOL*, *DeleteLine*, and *InsertLine*, are used mainly for text editing.

ClearToEOL deletes all characters from the cursor position to the end of the cursor line. *DeleteLine* deletes the cursor line completely and moves all following lines up one to close the gap. *InsertLine* inserts a blank line at the current cursor position.

After a call to any of these three functions, the cursor position is undefined. The cursor has to be placed explicitly with a call to *GotoXY*.

Since these functions are not available on all terminals, there is an emumeration type (*SpecialsOps*) and a set variable (*OpSet*) exported by *Terminal* that allow you to determine which functions were installed. They are shown in the following:

```
IPESpecialOps = (clearEol, insertDelete, highlightNormal);OpSet= SET OF SpecialOps;
```



available : OpSet;

The variable *available* can be used as shown in the following examples. To clear to the end of a line, first determine if the procedure *ClearToEOL* is installed on the terminal.

The ComLine Module

 Λ . This module provides access to the command line and handles the redirection of

Input and output. The command line consists of any arguments that follow the command that began the program. ComLine will work in both CP/M and Turbo Modula-2 modes. The command line is simply declared in ComLine as a text.

VAR

commandLine: TEXT;

Once imported, it can be read like any other text; for instance, READ(commandLine,fileName) works perfectly. Of course, this text is quite short, consisting of only a single line terminated by one EOT (32C) character. The text does not need to be opened explicitly; ComLine does it on initialization.

You may have noticed that all Turbo Modula-2 system programs accept arguments on the command line. If no argument is given there, the user is prompted to enter it. This is accomplished by a call to the following procedure:

PromptFor (prompt: ARRAY OF CHAR; VAR s: ARRAY OF CHAR);

This returns an input string in the result parameter s. PromptFor first tries to perform a ReadString from the command line. If no further data is found there, it displays the prompt string and performs a ReadString on s from the terminal. This method is user friendly, since it allows for interactive use and batch processing with command line arguments.

Redirection of Input and Output

The command line can contain redirection arguments: The symbol <, followed y a file name, redirects the standard text *input*; while the symbol >, followed by a file name, redirects *output*. Since many interactive programs will not work with I/O redirection, redirection of input or output is not automatic; instead, there are the procedures *RedirectInput* and *RedirectOutput*.

If an input redirection argument is given on the command line, *RedirectInput* connects the standard text input with the file or device specified by that argument. Similarly, *RedirectOutput* connects the standard text output with some device or file, provided an output redirection argument is included in the command line.

If the command line is read, any redirection arguments are ignored to avoid interference with normal command line arguments.

Note: Redirected files are not automatically closed when a program terminates. Therefore, if output goes to a disk file, you must close the text (and the associated file) explicitly with the *CloseText* procedure from *Texts*.

CloseText(output) called before program termination will cause the redirected output file to be correctly closed.

ComLine Module Specification

DEFINITION MODULE ComLine; FROM Texts IMPORT TEXT ;

VAR

commandLine	: TEXT ;
inName,outN ame	: ARRAY [019] OF CHAR;
progName	: ARRAY [07] OF CHAR;

```
PROCEDURE RedirectInput;
PROCEDURE RedirectOutput;
```

PROCEDURE PromptFor (prompt: ARRAY OF CHAR; VAR s: ARRAY OF CHAR);

END ComLine

The Standard Library

The names following the symbols $\langle \text{or} \rangle$ on the command line are saved in the two variables *inName* and *outName*. These are declared **ARRAY** [0..19] **OF** CHAR;. If no redirection arguments are given, both *inName* and *outName* are set to CON:«.

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The last item exported by *ComLine* is the variable *ProgName*. It is declared as **ARRAY** [0..7] **OF** CHAR;.

This contains the name of the executing program (without drive code or extension). If a program is called from CP/M, this string is empty.

As an example, for *Comline* the following program CO copies the standard input to the standard output text. Using I/O redirection, it can be used for a large number of purposes, displayed in the following:

CO <B:TEXTFILE

		Displays the contents of TEXTFILE			
CO	<b:textfile>L</b:textfile>	ST: Prints out TEXTFILE			
CO	>B:TEXTFILE	Enters characters typed at the keyboard into			
		TEXTFILE until a ^Z is read			
CO	(no arguments)	Guess			
MOE	ULE CO;				
FROM	ComLine IMPORT Red	<pre>irectInput,RedirectOutput;</pre>			
FROM	FROM Texts IMPORT EOT, input, output, CloseText;				
VAR		· -			
ch:	CHAR;				
BEGI	J				
Redi	irectInput; Redirec	tOutput;			
LOOP)				
RE	AD (ch);				
IF	IF EOT(input) THEN EXIT END ;				
WR.	[TE (ch);				

END ; CloseText(input); CloseText(output) END CO.

The module ComLine has an unexported exception called NoInputFile. This ex-

ception is not usually trapped by user programs. If necessary it can be trapped with the ELSE clause in an exception handler, like so:

```
MODULE TrapUnexportedException;
FROM ComLine IMPORT RedirectInput, inName;
BEGIN
WRITELN("inName is ",inName);
RedirectInput;
EXCEPTION
ELSE
WRITELN('Must be non-existent file');
END TrapUnexportedException.
```

The exception is only raised if the name found in *inName* is not found. Thus, if »JUNK« is not a valid file, the following invocation of the program causes the error

Run MCD-file: MOO:UNEXPEXC < junk

inName is JUNK Must be nonexistent file

Utility Modules

This section describes library modules that provide common mathematical and string-handling functions, and conversions to and from strings and numbers.

The MathLib and LongMath Modules

MathLib provides common mathematical functions, while LongMath provides the same functions for double-precision variables, replacing every declared REAL with a LONGREAL. Following are the functions provided by MathLib.

.qrt(x: REAL): REAL:

Computes the square root of the (positive) argument x. If x is negative, the exception ArgumentError is raised.

Exp(x: REAL): REAL;

Computes the natural exponent of the argument x. To prevent overflow from occurring, x must be smaller than 87.4; otherwise, the exception ArgumentError is raised.

Ln(x: REAL): REAL;

Returns the natural logarithm of the (positive) argument x. The exception ArgumentError is raised on negative x.

Sin(x: REAL): REAL; Cos(x: REAL): REAL;

Returns sine and cosine of the argument x. The argument must be given in radians (radians = degrees * pi/180).

ArcTan(x: REAL): REAL;

Returns the arc tangent of argument x. The result is given in radians and lies within the interval of -pi/2 to pi/2.

DEFINITION MODULE MathLib;

PROCEDURE	Sqrt	(x	: REAL)	: REAL;
PROCEDURE	Exp	x:	REAL):	REAL;
PROCEDURE	Ln	x:	REAL):	REAL;
PROCEDURE	Sin	x:	REAL):	REAL;
PROCEDURE	Cos	x:	REAL):	REAL;
PROCEDURE	ArcTan	x:	REAL):	REAL;
PROCEDURE	Entier	x:	REAL):	INTEGER;

```
PROCEDURE Randomize(n: CARDINAL);
PROCEDURE Random (): REAL;
```

EXCEPTION ArgumentError; (* Is raised if an argument is outside its legal range *)

END MathLib.

LongMath Module Specification

DEFINITION MODULE LongMath;

PROCEDURE	Sqrt	x:	LONGREAL):	LONGREAL;
PROCEDURE	Exp	x:	LONGREAL):	LONGREAL;
PROCEDURE	Ln	x:	LONGREAL):	LONGREAL;
PROCEDURE	Sin	x:	LONGREAL):	LONGREAL;
PROCEDURE	Cos	x:	LONGREAL):	LONGREAL;
PROCEDURE	ArcTan	x:	LONGREAL):	LONGREAL;
PROCEDURE	Entier	x:	LONGREAL):	LONGINT;

EXCEPTION ArgumentError;

(* Is raised if an argument is outside its legal range *)

END LongMath.

Entier(x: REAL): INTEGER;

Returns the integer part of a real number rounded toward negative infinity. For example:

if x >= 0, then entier(x) = INT(x)if x <= 0, then entier(x) = INT(x-I)

Thus,

```
Entier( 2.7 ) = 2
Entier(-2.7 ) = -3
Entier(-1.1 ) = 2
Entier( 1.1 ) = 1
```

Other mathematical functions can be easily constructed by combining the preceding functions. For example:

Tan(x)	= Sin(x) / Cos(x)
x raised to the y	= Exp(Ln(x)*y)

The last tranformation is recommended only when y is not a whole number. For integer y, the following algorithm is more efficient:

```
MODULE PowerTest;
```

```
PROCEDURE power(x: REAL; n: INTEGER): REAL;
VAR
i: CARDINAL;
z: REAL;
BEGIN
i := ABS(n); z := 1.0;
WHILE i>0 DO
```

```
(* z * x**i = x0**ABS(n) *)
IF ODD(i) THEN z := z * x END ;
x := x * x; i := i DIV 2
END ;
IF n>=0 THEN RETURN z
ELSE RETURN 1.0/z
END
```

END power;

BEGIN

WRITELN(power(23.9,2)); END PowerTest.

In addition to the previous functions, *MathLib* (but not *LongMath*) contains a random-number generator. There are two user calls to the random-number generator: *Randomize* and *Random*.

Random(): REAL;

Returns the next element of a pseudo-random-number sequence. Numbers are distributed evenly in the interval from 0.0 to 1.0.

Randomize(n: CARDINAL);

Reseeds the generator. A different random-number sequence corresponds to every possible argument n. Any random sequence may be repeated by providing *Randomize* with the same value of n.

Randomize takes one argument, a long (32 bit) integer, and sets the seed for the random-number generator equal to that number. Random takes no arguments, and returns a floating-point number x in the range 0 <= x < 1. The number may be single precision or double precision.

Since there is a default value for the seed, most users need only call *Random*. *Randomize* is provided so that users can replicate simulations, since *Random* is a deterministic function of the seed. (In computer science jargon, it is a pseudorandom-number generator and not a true random-number generator.)

You should not call *Randomize* too frequently, because if *Randomize* is called for each call to *Random* then the numbers will not be much more random than the arguments to *Randomize*.

The least-significant bits in the real number returned by Random may not be particularly random.

The random-number generator maintains a 32-bit seed, which it treats as an unsigned integer. Each call to *Random* changes the seed by the formula seed := 134775813 * seed + 1 mod 4294967296

and then returns the real number seed / 4294967296.

For example, if we call *Randomize* with the argument 1, then the seed is set to 1 and the next call to Random changes the seed to 134775814 and returns

134775814 / 4294967296 + 0.03137994...

No matter what the seed is, the random-number generator will pass through 4,294,967,296 numbers before it repeats.

The default value of the seed is 860098850.

The Strings Modules

A string in Modula-2 is an array with elements of type CHAR. The current contents of a string do not have to fill out the array completely; the end of the string is marked by a null character (0C). For convenience, there is the predefined type

TYPE

String = ARRAY [0..80] OF CHAR;

The module Strings offers a number of functions to manipulate strings, concatenate them, extract or delete substrings, and so on. Since their parameters are open arrays, they will work with any array of characters, not only with the predefined type String. Keep in mind, however, that formal, open array parameters map an actual array parameter into an index range starting at zero. Therefore, all index parameters passed to the following procedures are expected to have a range starting at zero. Thus, we recommend setting the lower bound to cero when you define your own string type. The exported string procedures follow.

Length (VAR str: ARRAY OF CHAR): CARDINAL;

Returns the length of the contents of the given array. The returned length does not need to coincide with the size of the str. If the array a is filled completely, HIGH(a)+1 is returned; otherwise, Length will yield the index of the first null character encountered.

For example, let Alfa be declared as ARRAY [0..100] OF CHAR. Thus,

Alfa := " "; WRITE(Length(Alfa)) will give 0
Alfa := "ABC"; WRITE(Length(Alfa)) will give 3

Pos (substr,str: ARRAY OF CHAR): CARDINAL;

Pos scans for the first occurrence of the given string substr in string str. The procedure returns the index of the substring's first element. If substr is not contained in str, HIGH(str)+1 is returned. Hence, this procedure can give back any value between 0 (if substr is a prefix of str) and HIGH(str)+1 (if substr is not found).

Insert (substr: ARRAY OF CHAR; VAR str: ARRAY OF CHAR; inx: CAR-DINAL);

Inserts the given string *substr* into the given *str* at the index position *inx*. As always, indices are assumed to start at zero. If the array *str* is not large enough to hold the augmented string, the exception StringError is raised. Note that no error is raised if the *substr* is inserted at an index greater than the length of the string but still within the size of the string.

Strings Module Specification

```
DEFINITION MODULE Strings;

TYPE

String = ARRAY [0..80] OF CHAR;

PROCEDURE Length (VAR str: ARRAY OF CHAR): CARDINAL;

PROCEDURE Pos (substr, str: ARRAY OF CHAR): CARDINAL;

PROCEDURE Insert (substr: ARRAY OF CHAR; VAR str: ARRAY OF CHAR;

inx: CARDINAL);

PROCEDURE Delete (VAR str: ARRAY OF CHAR; inx,len: CARDINAL);

PROCEDURE Delete (VAR str: ARRAY OF CHAR; inx,len: CARDINAL);
```

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PROCEDURE Append (substr: ARRAY OF CHAR; VAR str: ARRAY OF CHAR);
PROCEDURE Copy (VAR str: ARRAY OF CHAR; inx,len: CARDINAL;
VAR result: ARRAY OF CHAR);
PROCEDURE CAPS (VAR str: ARRAY OF CHAR);

EXCEPTION StringError;

END Strings.

Delete (VAR str: ARRAY OF CHAR; inx, len: CARDINAL);

Deletes *len* characters in the given string *str*, starting at the element with index *inx*.

Append (substr: ARRAY OF CHAR; VAR str: ARRAY OF CHAR);

Appends the given string *substr* to the given *str*. If the array *str* is not large enough to hold the augmented string, the exception *StringError* is raised.

Copy(VAR str: ARRAY OF CHAR; inx,len: CARDINAL; VAR result: ARRAY JF CHAR);

Assigns a substring of str, starting at position inx, consisting of len characters to string result.

CAPS (VAR str: ARRAY OF CHAR);

Changes all the characters in str to uppercase.

The following utility module demonstrates use of the *Strings* module. When dealing with files, it is often necessary to supply default extensions or to use several files with the same name but different extensions. These tasks can be simplified by using a library module like the following one:

```
DEFINITION MODULE FileExtensions; TYPE
```

```
Extension = ARRAY [0..2] OF CHAR;
```

```
PROCEDURE AppendExt (VAR str: ARRAY OF CHAR; ext: Extension);
PROCEDURE StripExt VAR str: ARRAY OF CHAR);
PROCEDURE GetExt (str: ARRAY OF CHAR; VAR ext: Extension);
```

END FileExtensions.

The procedure AppendExt supplies a default extension if the given str does not contain an extension itself. StripExt removes any extension in str, while GetExt returns the extension of str or the empty string if str does not have an extension. Using the services exported by Strings, these procedures can be implemented as follows:

```
IMPLEMENTATION MODULE FileExtensions;
FROM Strings IMPORT Length, Pos, Append, Copy, Delete;
PROCEDURE AppendExt(VAR str: ARRAY OF CHAR; ext: Extension);
VAR len: CARDINAL;
BEGIN
IF Pos(".", str) = HIGH(str)+1 THEN (* no "." in str *)
len := Length(str);
str[len] := "."; (* Strings go from 0 to Length(str)-1 *)
Append(ext, str)
END
END AppendExt;
```

```
PROCEDURE StripExt(VAR str: ARRAY OF CHAR);
VAR
period: CARDINAL;
BEGIN
period := Pos(".", str);
IF period # HIGH(str)+1 THEN
Delete(str, period, Length(str)-period)
END
END StripExt;
```

```
PROCEDURE GetExt(str: ARRAY OF CHAR; VAR ext: Extension);
VAR
```

```
period,elen: CARDINAL;
```

BEGIN

```
period := Pos(".",str);
elen := HIGH(str)-period;
IF elen > 3 THEN elen := 3 END ;
Copy(str, period+1, elen, ext)
END GetExt;
```

END FileExtensions.

The Convert Module

Convert exports procedures to convert strings into standard Modula-2 numeric types and back again. (*Doubles* provides the same services for double-precision real numbers.)

The first four procedures of the *Convert* module convert strings to INTEGERs, CARDINALS, LONGINTS, and REALS, respectively. The result is placed into the second parameter. The Boolean function result indicates whether a conversion is possible. It is TRUE if the string represents a legal number; otherwise, it is FALSE.

The second four procedures convert numbers to strings. The number is placed into the string starting at the right-most index. The left end of the string is padded with blanks. If the number does not fit into the given string, the exception TooLarge is raised. The *digits* parameter of procedure *RealToStr* has the same meaning as its equivalent in the procedure *WriteReal* (see the module *Texts*): It controls the size of the mantissa and the form of the string result (scientific or fixed point). For example, given the declaration

VAR

s: ARRAY [0..11] OF CHAR;

a call of RealToStr(2.5, s, 2); gives *2.50 and RealToStr(2.5, s, -4) gives *2.5000E+00«.

Convert Module Specification

TRCMD3 **DEFINITION MODULE Convert;**

PROCEDURE StrToInt(VAR s: ARRAY OF CHAR; VAR i: INTEGER): BOOLEAN;PROCEDURE StrToCard(VAR s: ARRAY OF CHAR; VAR c: CARDINAL): BOOLEAN;PROCEDURE StrToLong(VAR s: ARRAY OF CHAR; VAR 1: LONGINT): BOOLEAN;PROCEDURE StrToReal(VAR s: ARRAY OF CHAR; VAR r: REAL): BOOLEAN;

```
PROCEDURE IntToStr (i: INTEGER; VAR s: ARRAY OF CHAR);
PROCEDURE CardToStr (c: CARDINAL; VAR s: ARRAY OF CHAR);
PROCEDURE LongToStr (1: LONGINT; VAR s: ARRAY OF CHAR);
PROCEDURE RealToStr (r: REAL; VAR s: ARRAY OF CHAR; digits: INTEGER);
EXCEPTION TooLarge;
```

END Convert.

The Doubles Module

Doubles exports procedures that provide support for double-precision real numbers (LONGREALs), similar to those provided for single-precision real numbers (REALs) in Texts and Convert.

As shown in the definition module, the variable *legal* monitors input from *Read-Double* in a similar fashion to *Done* and *ReadReal* in *Texts*. The other routines are identical to their single-precision *REAL* counterparts.

Doubles Module Specification

```
DEFINITION MODULE Doubles;
FROM Texts IMPORT TEXT;
VAR legal: BOOLEAN;
PROCEDURE ReadDouble (t: TEXT; VAR d: LONGREAL);
PROCEDURE WriteDouble (t: TEXT; d: LONGREAL; n: CARDINAL;
m: INTEGER);
PROCEDURE StrToDouble (VAR s: ARRAY OF CHAR;
VAR d: LONGREAL): BOOLEAN;
PROCEDURE DoubleToStr (d: LONGREAL): BOOLEAN;
digits: INTEGER);
```

END Doubles.

System-Dependent Modules

The four modules described here provide utilities of a low-level nature. *Processes* and *Loader* are heavily dependent on the underlying system. They are coded in a high-level manner because *SYSTEM* and *STORAGE* provide a standard interface to machine-dependent operations such as memory allocation and process control.

The Processes Module

This module provides the synchronization between loosely coupled or largely independent processes. A process consists of a piece of program and a work space its data. It is realized by the standard Modula-2 concept of a coroutine using the primitives *PROCESS*, *NEWPROCESS*, and *TRANSFER* in the pseudomodule *SYSTEM*.

A process takes the form of a parameterless procedure, which must be declared at the global level. Processes are not invoked by a procedure call, however. Instead, flow of control between processes is achieved via variables of type *SIGNAL*. Only two operations are applicable to signals: *SEND* or *Awaited*. When a process waits for a signal, its execution is paused; that is, control transfers to some other process. The waiting process is resumed when the awaited signal is sent by the currently executing process. More than one process can wait for the same signal. In that case, waiting processes are inserted into a queue, with the first process in the queue resuming once it has been sent the required signal. Sending an unanticipated signal has no effect.

The services exported by Processes are described next.

StartProcess(P: PROC; n: CARDINAL);

rts a concurrent process with program P and a workspace of size n (in bytes). A minimum workspace consists of about 50 to 100 words. After a call to this procedure, control is transferred to the newly created process. For more information on this procedure, see the procedure *NEWPROCESS* in the *SYSTEM* module and Wirth's book. Processes Module Specification

```
DEFINITION MODULE Processes;
```

TYPE SIGNAL;

PROCEDURE	StartProcess	P: PROC; n: CARDINAL);
PROCEDURE	SEND	(VAR s: SIGNAL);
PROCEDURE		(VAR s: SIGNAL);
PROCEDURE	Awaited	(s: SIGNAL): BOOLEAN;
PROCEDURE	Init	(VAR s: SIGNAL);

EXCEPTION DeadLock;

END Processes.

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SEND(VAR s: SIGNAL);

If there is no process waiting for s, SEND has no effect. If one is waiting, it is resumed. If several processes are waiting for the same signal, they are inserted into a queue. The first process in the queue is resumed when the call to SEND(s) occurs.

WAIT(VAR s: SIGNAL);

Causes the currently executing process to be suspended until it receives the signal ^Drocesses ready for execution are ordered in a queue. After a call to *WAIT*, the next process in the queue is resumed. If no process is ready for execution (that is, all processes are waiting), the exception *DeadLock* is raised.

```
Awaited(s: SIGNAL): BOOLEAN;
```

Returns TRUE if at least one process is waiting for s; otherwise, it returns FALSE.

Init(VAR s: SIGNAL);

Initialization of a SIGNAL; this is mandatory before a SIGNAL is used.

DeadLock;

This exception is raised if all current processes are waiting for a signal; it indicates an error in your signal-sending logic. A procedure constituting the program of a process cannot be called, nor can it return like a normal procedure. Its instructions are usually enclosed in a LOOP statement whitout a corresponding EXIT. enable transfer of control to some other process, such a procedure must contain ... teast one SEND or WAIT statement.

A state can arise where all processes are waiting for some signal. In this case, no process can execute and subsequently the system will come to a halt. This situation is known as a *deadlock*, or *deadly embrace*. When it is detected by *Processes*, the exception DeadLock is raised.

For example, when polling a number of external devices; assume the computer is connected to a number of external devices that can be serviced independently from one another. The computer will ask each device: Do you require service? When a service request is found, it sends out the message: Device No. *n* needs service. If there is a process ready to serve this device, it then takes control the processor. When it is finished, this process starts the polling again by puttinitself into a wait state for the next request. If the service is time-intensive, it coujust as well enable polling repeatedly in the middle of its operation. This is achie ed by waiting for the signal RESUME, which transfers control to a further loc through the polling routine. Only when no further service is needed is the sign RESUME sent, causing one of the processes waiting for it to be resumed. sketch of a module that services devices by polling follows:

```
MODULE Poll;
```

```
FROM Processes IMPORT SIGNAL, SEND, WAIT, Awaited, Init,
```

StartProcess;

VAR

```
Service1,..., ServiceN, Resume : SIGNAL;
```

PROCEDURE Device1;

BEGIN

LOOP

WAIT(Service1);

(*"Service device #1"*)

```
IF (*"Service is complicated"*) THEN
```

```
(* Check if there are other devices waiting for service *)
WAIT(Resume)
```

END ;

```
(*"Resume service of device #1"*)
```

END

END Device1;

PROCEDURE Device2;

```
(* Body of Device2 similar to Device1 *)
END Device2;
```

PROCEDURE DeviceN;
(* Body of DeviceN similar to Device1 *)
END DeviceN;

```
BEGIN (* Main program, containing the polling loop *)
Init(Service1); ... Init(ServiceN);
Init(DeviceCheck); StartProcess(Device1,100);
StartProcess(Device2,500);
```

```
StartProcess(DeviceN,200);
```

LOOP

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```
IF (*"ServiceRequest of Device #1"*) & Awaited(Service1) THEN
   SEND(Service1)
```

ELSIF (*"ServiceRequest of Device #2"*) & Awaited(Service2) THEN SEND(Service2)

```
ELSIF (*"ServiceRequest of Device #N"*) & Awaited(ServiceN) THEN
SEND(ServiceN)
```

ELSE

```
(* If there are any pending services, resume one of them *)
SEND(Resume)
```

END

END

```
END Poll.
```

Note that the polling process encapsulated in the main program does not contain any *WAIT* statements. It is always available for execution, excluding the possibility of a deadlock. Every other process in this module pauses only by executing a *WAIT* statement; therefore, the only process ready for execution after issuing a wait is the polling process--a guarantee that polling occurs regularly.

A more rudimentary polling scheme can be implemented without the notion of processes and signals. In this scheme, the polling loop calls the service procedures directly when a service request is detected. However, in order to express a feature like the resume operation conveniently, processes are essential.

The Pseudomodule SYSTEM

This module contains types and procedures for low-level programming. An implementation part for this does not exist; rather, the compiler translates all exported operations directly into code, which is why *SYSTEM* is called a *pseudomodule*. Everything in it must be imported to become available, thereby making the use of low-level constructs explicit. The following sections describe the definition part of *SYSTEM*.

Low-Level Access to Data

The type WORD represents a machine word (2 bytes, 16 bits). Every type occupying a word or less is assignment-compatible with WORD. In particular, a formal parameter of type WORD accepts any actual parameter occupying one machine word. No operations (except assignment) can be performed on variables of type WORD. However, a variable of type WORD can be the argument of a type-transfer function.

The type BYTE represents a byte. It can be considered a subrange of type WORD. A BYTE can be assigned any value with a decimal equivalent in the range of 0 to 255.

Array of Word

If a formal parameter is declared as an ARRAY OF WORD, its corresponding actual parameter can be of any type. The upper bound of the open array is adjusted to match the size of the actual parameter; thus, no restrictions are imposed on a procedure's arguments. The most common examples of these procedures are *ReadRec* and *WriteRec* found in the library module *Files*.

Pseudomodule SYSTEM Specification

DEFINITION MODULE SYSTEM

TYPE

WORD; BYTE; ADDRESS; PROCESS;

VAR

IORESULT,HLRESULT: CARDINAL
PROCEDURE ADR(VAR v: AnyType): ADDRESS;
PROCEDURE TSIZE(AnyType): CARDINAL;

PROCEDURE TRANSFER(VAR source, dest: PROCESS); PROCEDURE IOTRANSFER(VAR source, dest: PROCESS; n: CARDINAL); PROCEDURE NEWPROCESS(p: PROC; a: ADDRESS; n: CARDINAL; VAR q: PROCESS);

PROCEDURE BIOS(n: CARDINAL; w: WORD): CARDINAL;
PROCEDURE BDOS(n: CARDINAL; w: WORD): CARDINAL;
PROCEDURE CODE(AnyStringLiteral);

PROCEDURE MOVE(source,dest: ADDRESS; len: CARDINAL);
PROCEDURE FILL(adr: ADDRESS; len: CARDINAL; val: BYTE);
PROCEDURE INP(port: WORD): CARDINAL;
PROCEDURE OUT(port: WORD; data: CARDINAL);

EXCEPTION OVERFLOW, REALOVERFLOW, OUTOFMEMORY, BADOVERLAY;

END SYSTEM.

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ADDRESS

ADDRESS is a type that represents memory locations. It can be thought of as a **POINTER TO** WORD; thus, dereferencing an ADDRESS will yield a WORD. Addresses can be computed; it is possible to add and subtract CARDINALs from addresses with the result being of type ADDRESS. ADDRESS is compatible with a CARDINAL and with every pointer type. In particular, if a formal parameter is of type ADDRESS, the corresponding actual parameter may be of any pointer type.

ADR

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The procedure ADR returns the address of its argument. It is declared as

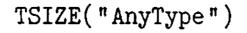
ADR(VAR x: "AnyStructuredType"): ADDRESS;

Note that since Turbo Modula-2 implements register variables in local procedures (see Chapter 8, »Low-Level Facilities«), the *ADR* function will not accept simple variables of unstructured types. This is because a scalar variable in a procedure may reside in a register that has no address.

TSIZE

The procedure TSIZE accepts the name of a type as its argument. It returns the minimum size of any variable of the argument type. Thus, when variable x is declared as VAR x: T, then SIZE(x) = TSIZE(T).

TSIZE has an alternate syntax similar to the NEW procedure: If T is a record type whose last field is a variant, a tag value of this variant can be indicated behind the type. In this case, TSIZE returns the amount of memory used by a variable created with a call to NEW with the same tag- value indication. If the last variant contains another variant as its last field, a tag value for this variant may be given, too. Thus, TSIZE is informally declared as



or

TSIZE("AnyType",TagValue,TagValue,...)

Coroutines and Interrupts

Modula-2 includes the concept of a coroutine, which consists of instructions and a workspace separate from the main program. A coroutine can represent a process or detail how statements will manipulate data. (The main program itself is a process, since it consists of statements acting on data.) Coroutines lead to the introduction of loosely coupled processes. At any one time, a single-processor computer can execute only one process. The pseudomodule *SYSTEM* exports the type *PROCESS* to be used to reference a coroutine.

Although the body of a coroutine looks like that of a parameterless procedure, it's excecution is more like that of a main program. A coroutine cannot be called .h a call statement or exited by a **RETURN** statement--coroutines should never reach the final end. Since coroutines are never exited by a **RETURN** or **END** statement, their procedure body is usually enclosed by a **LOOP** statement without a corresponding **EXIT**.

Control to and from a coroutine is done via the *TRANSFER* statement. When a coroutine transfers control away from itself, its state is preserved until it is reactivated by a transfer from another coroutine. When a coroutine's state is preserved, all variables retain their values and modules remain initialized. When reactivated, the coroutine continues with the statement directly after the last *TRANSFER*.

Note that the program bodies of coroutines and processes (as described in the section, »The Processes Module«) are remarkably similar. In fact, processes are modeled by coroutines. The module *Processes* implements *StartProcess*, *SEND*, and *WAIT* with the primitives that follow.

NEWPROCESS(p: PROC; a: ADDRESS; n: CARDINAL; VAR q: PROCESS);

ates a coroutine and initializes the given process q with procedure body p and a workspace of n words starting at address a. This workspace must be large enough to contain p's local variables, local stack, and local heap. A subsequent TRANSFER(r,q) will transfer control to the first statement of procedure p. PROC is a standard procedure type representing a parameterless procedure. It is exported from the SYSTEM module as

TYPE

PROC = PROCEDURE();

TRANSFER(VAR source, dest: PROCESS);

Transfers control to the coroutine *dest*. The currently active coroutine is assigned to *source* and suspended. A subsequent *TRANSFER* to *source* will resume the suspended coroutine with the next statement after the transfer.

Coroutines are used to express interrupt handling, such that a coroutine waiting for an interrupt will transfer control to some other coroutine (the main program) to do something in the meantime. When the interrupt occurs, control is transferred back to the interrupt-handling coroutine by an unscheduled *TRANSFER* statement.

It is as if a transfer instruction is explicitly inserted into the executing coroutine at the point of interrupt. Since we do not know the state of execution of the interrupted routine, no explicit *TRANSFER* can be used. Thus, a special transfer instruction is provided to allow unscheduled transfers.

IOTRANSFER(VAR source, dest: PROCESS; n: CARDINAL);

Performs a normal transfer from source to dest. When the interrupt specified by the given n occurs, control is transferred back to the next statement after *IOTRANSFER*. Any available interrupt vector can become n.

Interrupts must sometimes be disabled to avoid disturbing critical program parts. This is done by placing critical procedures in a module that is given a priority. Such a module is called a *monitor*. The priority (a numeric value) is indicated in square brackets after the module name; for example:

MODULE CriticalStuff[1];

IMPLEMENTATION MODULE Processes[1];

When a procedure in a monitor is executed, only interrupts of a higher priority than the monitor are enabled. However, in Turbo Modula-2 there are no interrupts with priorities since the Z80 hardware does not usually recognize them. All interrupts are disabled when a piece of a monitor is executed; that is, any number in brackets after the module name shuts out all (maskable) interrupts.

Warning: CP/M is not designed for interrupts; in particular, it is not reentrant. Therefore, when a CP/M operation is suspended by an interrupt, the operation (and possibly others as well) cannot be invoked by the interrupting routine. (Since interrupts are only of limited use when dealing with CP/M, those of you interested in a more detailed discussion can refer to Wirth's book.)

Z80-Specific Procedures

The following procedures allow the programmer to take direct advantage of certain Z80 machine instructions. *MOVE* and *FILL* are very fast and their use is recommended anywhere speed is important. *INP* and *OUT* are for accessing the Z80 I/O ports. The native code generator produces highly efficient inline code for *INP* and *OUT*.

MOVE(source,destin: ADDRESS);

Moves blocks of data in memory. Its operation is also appropriate for blocks of overlapping memory: If *source* < destin, then the upper addresses are moved first; and if *source* > = destin, then the lower addresses are moved first.

FILL(adr:ADDRESS; nbytes: CARDINAL; val: BYTE);

Fills the block of memory starting at *adr*, which is *nbytes* large, with the byte value *val*.

INP(port: WORD): CARDINAL;

Receives (inputs) a value from an I/O port.

OUT(port: WORD; data: CARDINAL;);

Outputs a value to an I/O port.

interface to CP/MThe next two procedures allow you to directly access the operations of CP/M.

BDOS(n,w: WORD);

Results in a call to memory location 5, the CP/M entry location. The function number is specified in the given n; w denotes an additional parameter. If some *BDOS* operation returns a result in the accumulator A, it can be found in the variable *IORESULT*. If an operation returns a 16- bit result in register HL, it can be retrieved from the variable *HLRESULT*.

IORESULT and HLRESULT are declared as CARDINALS:

VAR HLRESULT, IORESULT: CARDINAL;

The action performed by BDOS is shown in the following:

 \Box Load register C with n.

 \Box Load register DE with w.

 \Box CALL 5.

 \Box Assign the contents of accumulator A to *IORESULT*.

 \Box Assign the contents of register HL to *HLRESULT*.

BIOS(n,w: WORD): CARDINAL;

Results in a call to the BIOS jump vector. The given n indicates which entry is called: 0=WARMBOOT, 1=CONSTAT, 2=CONIN, and so on. Its exact operation is as follows:

- \Box Load A with the given n.
- \Box Load BC with the given w.
- \Box CALL WARMBOOT+n*3.
- \Box Assign the contents of accumulator A to *IORESULT*.
- \Box Assign the contents of register HL to *HLRESULT*.

For example, to read a character directly from the console, do the following:

BDOS(1,0); ch:=CHR(IORESULT);

To do the same using a call to the BIOS vector:

BIOS(2,0); ch:=CHR(IORESULT);

Assembler Interface

Assembly routines can be included in a Turbo Modula-2 program by using

CODE("Any string literal");

A call to *CODE* can be inserted behind a procedure heading, replacing the body of the procedure. Its body may not contain a declaration part, BEGIN statement, or any other statements. The final END must be present. Compilation of a *CODE*

statement causes the .COM file whose name is given as an argument to be inserted into the object program. For example:

```
PROCEDURE MOVE(source,dest: ADDRESS; n: CARDINAL);
CODE("MOVE")
END MOVE;
```

establishes *MOVE* as an assembly routine. During compilation, the file MOVE.COM is read from disk and inserted into the object program. A call to *MOVE* will execute the assembly routine MOVE.COM. The file extension .COM supplied automatically.

Assembly routines can have an arbitrary number of parameters and can return results; that is, they can be used as function procedures. It is essential to declare function procedures with the correct result type. Assembly routines that return a result when none is declared can crash the system.

Since where an object program will be loaded is unknown at compile time, included assembly routines must be fully relocatable. Only relative jumps may be used, and calls to subroutines or absolute access to data within the routine are not allowed. Furthermore, to determine the exact size of a routine, it must contain its length in the first 2 bytes. These bytes are stripped off by the compiler; they are not executed.

An assembler routine can expect the following environment:

□ Before an assembly procedure is called, its parameters are pushed onto the stack exactly as they are declared in the procedure heading. Value parameters of unstructured types are loaded immediately. VAR parameters and parameters of an ARRAY or RECORD type are loaded by address. The return address is at the top of the stack.

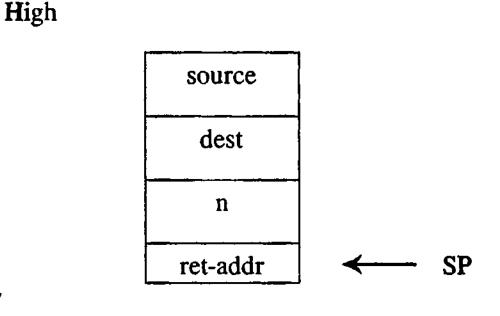
Upon entry, register HL points to the beginning of the routine's object code.

- Thus, data embedded in the program text can be retrieved using HL plus an index.
- □ If an assembly routine returns a result, it is pushed onto the stack. In this case, be sure that all parameters have been removed from the stack and the return address is saved.

□ The stack itself is 64 bytes deep. If more space is needed, it must be relocated and restored upon return. All registers can be destroyed.

To continue with the MOVE example, we will show how the stack is set up after a call to MOVE, but before any of MOVE's instructions have executed. MOVE's parameter source was pushed first, followed by dest, and then the count n. The return address is on the top of the stack and the current PC value is in HL.

For example, the parameters for the procedure *MOVE* are situated on the stack as follows:



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The assembly code for *MOVE* pops all parameters off the stack, replacing the return address. It then checks the count word and if it is greater than zero, it performs the move and returns.

A possible implementation of MOVE is shown in the following:

	ORG	1 00H	;unimportant, must be relocatable
	DEFW	MOVEEND-MOVE	; indicate size of object code
MOVE	POP POP	HL BC	;save return address ;load BC with count n
	POP	DE	;load DE with destination
	EX	(SP),HL	;load HL with source and
			;put return address back on stack
	LD	A,B	; if BC=0 then return
	ΩD	A C	

OR A,C RET Z (

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	LDIR	;Move	•
	RET		
MOVEEND	END		

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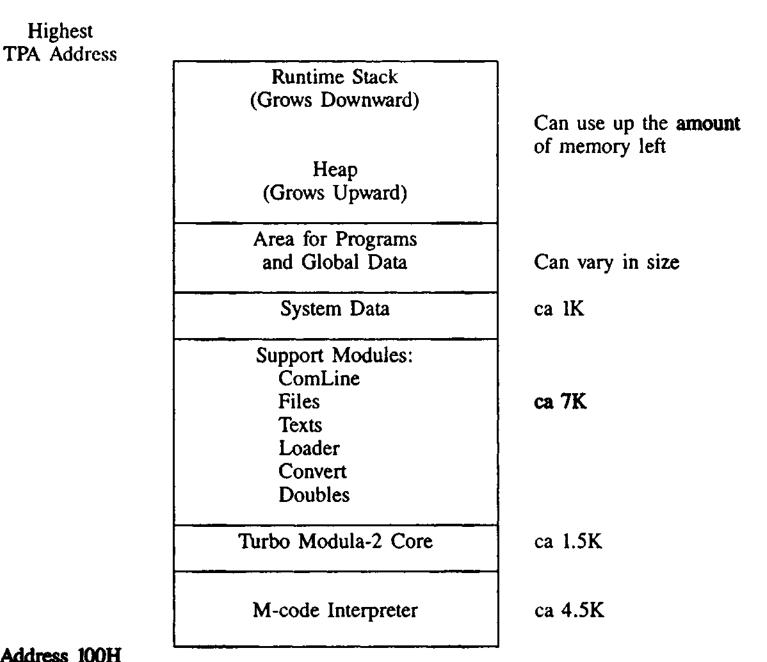
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Modules in Memory Management

This section introduces the modules STORAGE and Loader. Storage allocates a deallocates dynamic data, while Loader loads and executes overlay modul Since both modules affect the way data and programs are held in memory, I first take a look at the memory organization of Turbo Modula-2.

The memory available for Turbo Modula-2 is the *transient program area* (T) of CP/M. The TPA starts at address 100 hex and extends to the start of the BD part of CP/M. How Turbo Modula-2 uses this area is shown in Figure 11-5.

Figure 11-5. Turbo Module-2's Use of TPA



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A MARAAAA AAA AAAA

At the bottom of the TPA is the M-code Interpreter. All other parts of the Ti Modula-2 system and all application programs written within it and not comp with the native code option exist in an intermediate code called M-code. Th a variant of the instruction set of Wirth's Modula computer, Lilith. The coc A

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optimized for space conservation. Every M- code instruction is interpreted by this part of the system.

The object code of the Turbo Modula-2 core resides directly above the interpreter. It constitutes a runtime supervisor that has the main tasks of setting up the rest of the system and diagnosing and handling exceptions (errors).

There are a few support modules used by virtually every program: *Texts*, *Files*, *Loader*, *Convert*, and *ComLine*. A program's loading time can be improved if these modules are already present in memory. Thus all of these modules are linked together in the file M2.COM, and are loaded into memory when the system is started.

The resident support modules occupy about 7K of main memory. If an application does not need these modules and memory space is at a premium, the program can be transformed into a .COM file using the linker (see Chapter 10 for more about the linker's operation). The linker will include into the .COM file only those modules that are needed. This can result in a memory savings of up to 6K.

There is space for other programs and their data above the area occupied by M2.COM. Such programs include the system file SHELL.MCD, which interprets the user's commands and the compiler COMPILE.MCD as well as application programs. The object modules together with their global data reside at the bottom of this area.

The remaining space is partitioned dynamically between the runtime stack for local data and the heap. The heap holds all variables that were created dynamically by the *NEW* and *ALLOCATE* procedures. The stack is used for all local variables, procedure parameters, and sometimes to evaluate complicated arithmetic or logical expressions. A program is out of memory when the runtime stack and the heap meet; in that case, the exception OUTOFMEMORY is raised.

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The STORAGE Module

This module handles allocation and deallocation of dynamically created variables. All such variables reside in the heap area. Like SYSTEM, STORAGE is a pseudomodule. It has neither an object file (STORAGE.MCD) nor a symbol file (STORAGE.SYM). Instead, all the following services offered by this module are built into Turbo Modula-2. The following procedures are provided by the module STORAGE.

ALLOCATE(VAR a: ADDRESS; size: CARDINAL);

Allocates a space of *size* bytes on the heap and makes the pointer *a* point to the beginning of the allocated area.

Note: Due to the allocation scheme employed by STORAGE, a minimum of (bytes is always allocated, even if the *size* parameter specifies a smaller value.

DEALLOCATE(VAR a: ADDRESS; size: CARDINAL);

Releases the area referred to by the given pointer a. The released area is assumed to have the given *size*. The *size* must be equal to the size indicated when the area was created. The deallocated area is available for future allocation of other data The pointer a is set to nil.

Standard Procedures Dependent on Storage

NEW(a:POINTER TO »AnyType«);

NEW is translated into a call to ALLOCATE of the form ALLOCATE(a TSIZE(»AnyType«)). ALLOCATE must be imported if the standard procedure NEV is used.

DISPOSE(a: POINTER TO »AnyType«); -

DISPOSE is translated into a call to DEALLOCATE of the form DEALLOCATI a, TSIZE(»AnyType«)). DEALLOCATE must be imported if a program makes us of the standard procedure DISPOSE.

Heap Pointer The top of the heap is marked by the heap pointer, which is inaccessible to a plication programs. The heap can contain usable space because of the deallocation of variables. If a variable residing in the middle of the heap is disposed, the released area is appended to a *free list*. There is one exception to this rule: If the variable residing at the high end of the heap is disposed, its area is not appended to the free list; instead, the heap pointer is decremented and the heap is compressed. When a variable is allocated, the free list is searched to find an area large enough to hold the required data. If the search is unsuccessful, the area is allocated at the top of the heap; that is, the heap pointer is incremented. Thus, the heap status consists of two elements: (1) the heap pointer, marking its top end, and (2) the free list, containing information about holes available for future allocation.

STORAGE Module Specification

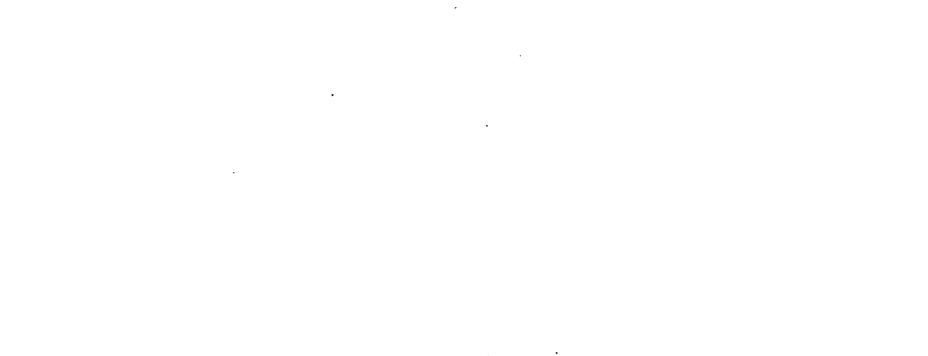
DEFINITION MODULE STORAGE; **FROM** SYSTEM **IMPORT** ADDRESS;

PROCEDURE ALLOCATE (VAR a: ADDRESS; size: CARDINAL);
PROCEDURE DEALLOCATE (VAR a: ADDRESS; size: CARDINAL);

PROCEDURE MARK(VAR a: ADDRESS);**PROCEDURE** RELEASE(VAR a: ADDRESS);

PROCEDURE FREEMEM (): CARDINAL;

END STORAGE.



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A user may want to handle the heap in a stack-like fashion; for example, create a number of variables and then throw them away all at once. The following procedures allow for this.

MARK(VAR a: ADDRESS);

Creates a new heap segment. The new segment is directly above the old heap pointer. Its free list is initially empty. Until a call to RELEASE(a), all allocations will allocate space in the new segment. The given address a is made to point to the bottom of the segment; that is, it equals the old heap pointer.

RELEASE(VAR a: ADDRESS);

Releases the heap segment created by a call to MARK(a). The heap pointer and free list of the old segment are restored. The heap pointer is reset to the given address a. This address must have been set by a previous call to MARK(a). The address a has the value nil after a call to RELEASE(a).

In a newly created heap segment, variables can be allocated and disposed of in the normal way. While allocation is always safe, disposing presents some problems. The user must make sure that only variables residing in the currently active heap segment are disposed. Disposing of a variable that resides in a segment buried below the one last created by a call to *MARK* will result in a *BadHeap* exception. Similarly, disposing of a variable in an already-released segment causes the same exception to be raised.

The following instruction sequence is legal:

```
MARK(a);
NEW(p);
NEW(q);
DISPOSE(p);
RELEASE(a)
```

And the following sequences result in the exception BadHeap:

```
NEW(p);
MARK(a);
DISPOSE(p);
               (Disposing a variable in some buried
                segment is not allowed)
MARK(a);
NEW(p);
RELEASE(a);
               (p is already released)
DISPOSE(p);
```

Note: Creating or opening a file allocates space on the heap. When the file or text is closed, this area is disposed again. As a result, the preceding precautions must also be taken when a file or text is closed. For example, the following is illegal:

```
Open(f, "INDATA");
MARK(a);
Close(f)
```

The user can interrogate the space that remains for heap allocation with the next procedure.

FREEMEM(): CARDINAL;

Returns the number of bytes between the current value of the heap pointer and the current top of the runtime stack. The size of available holes contained in the free list is not taken into account. For this reason, FREEMEM gives somewhat pessimistic information about the space available for heap allocation. The exact number of available bytes is returned only if procedures ALLOCATE and DEALLOCATE are used in a stack-like manner.

Dynamic Variable Errors

While dynamic variables are a very powerful concept, they must be used with some care. The following are common sources of errors and how the module STORAGE reacts to them:

- A variable is disposed when there are still other references to it. In this case, the value(s) of the disposed variable is undefined. Worse, another variable may have been allocated in the same area. Assignment to the disposed variable would result in overwriting other data. Assignment could also ruin the free-list management, which would result in raising the exception BadHeap.
- □ The heap becomes too big. If the heap pointer overruns the runtime stack during an allocation request, no space is allocated and the exception OUTOFMEMORY is raised. Since OUTOFMEMORY is exported by SYSTEM, it can be handled by an exception handler in the application program. Note that it is possible to generate another OUTOFMEMORY exception in the exception handler by calling a procedure with many or large parameters (for example, WriteString or other I/O statements). Thus, exception handlers for OUTOFMEMORY must have enough memory to operate correctly.
- □ A variable not residing in the active heap segment is disposed. This error can only occur if MARK, RELEASE, and DISPOSE are not executed in the correct order. This problem will usually cause the exception BadHeap to be raised some time in the future.

The Loader Module

The *Loader* module handles the allocation and execution of object modules and provides a standard method to activate *overlays*. These services may be necessary if an application requires more memory than is currently available.

Note: The Turbo Modula-2 system linker provides a more flexible and convenient method for defining overlays, which does not require any code modifications (see the section, "The Linker," in Chapter 10). You should consider using it before using the procedures described here.

If you get an OUTOFMEMORY error during program execution, your program needed more memory than was available. Overlays provide one possible solution to memory problems, they work as follows: A large program usually consists of some number of largely independent pieces, not all of which have to be physically in memory at the same time. The Loader Module provides a method to dynamically load only those modules that are required. Once their execution is terminated, they disappear, freeing the memory space they occupied. Other program modules can be loaded in their place, and executed. Thus the memory required to run a large program system can be significantly less than the sum of all modules used by the program. *Loader* provides the *Call* procedure to dynamically load a module.

Call (modName: ARRAY OF CHAR);

Loads the object module specified by modName into main memory and starts its execution. When execution is complete, the memory space occupied by the object code and data is released again. Modules executed by *Call* involves memory management and disk operations in addition to normal procedure execution time.

As an example, *Call* ("OVER") loads and begins execution of the object file OVER.MCD. The called module can import and access all objects of the calling program. Direct communication in the reverse direction is not possible, because the called module and its data area disappear after execution.

Note: Direct communication between a called module and its caller is not possible. This can be solved by the use of objects (message buffers) imported by the called procedure from the caller. Such objects can be freely modified by the called procedure.

Variables created by an overlay with the NEW procedure are preserved after termination of the overlay.

Call searches for the specified module on all logged disk drives (as specified in the .MCD search path during installation). The variable *FirstDrive* can be used to indicate which drive should be searched first for any overlay modules. This can be used to improve the loading time for external overlays.

VAR

firstDrive: [0..15]

Indicates the first drive to be accessed when searching for the next overlay. The encoding is 0 for drive A, 1 for drive B, and so on. An application may set *firstDrive* to provide the drive where the next execution of *Call* should start its search. This is useful if many overlays are used and the program does not know which drive the overlay files will be on until runtime.

If the loading of a module is unsuccessful, the exception LoadError is raised.

(The reason for an unsuccessful load is displayed in an additional message.) LoadError can occur because of the following:

 \Box The object file is not found.

□ There is not enough space to hold the loaded object modules.

□ A version conflict is detected. Turbo Modula-2 maintains a system-wide version-control scheme. If objects of a definition module are imported, the importing module remembers the version of this definition module. If the definition module is later changed and recompiled, all client modules have to be recompiled as well. If this is not done, a version conflict results when the client module is loaded. Note that if a definition module is recompiled but not changed, its version is preserved.

The following example shows communication between overlay modules. The main module is declared as an implementation module so that it may export a communication buffer to the overlay modules. Overlays are controlled via this record.

```
DEFINITION MODULE Main;
```

```
TYPE
```

Commands = (SayHello, CallOver, none);

VAR

```
OverlayCommBuffer: RECORD
```

Command: Commands; StrBuf: ARRAY [0..80] OF CHAR; END ;

END Main.

The main program imports the Call procedure from the Loader module as shown in the following:

IMPLEMENTATION MODULE Main; FROM Loader IMPORT Call; FROM Terminal IMPORT BusyRead;

PROCEDURE Pause; **VAR** ch: CHAR;

BEGIN

```
REPEAT BusyRead(ch) UNTIL ch#0C;
END Pause;
PROCEDURE DisplayOverString;
BEGIN
 WRITE('The string communication buffer ');
 IF OverlayCommBuffer.StrBuf # '' THEN
  WRITELN('contains "', OverlayCommBuffer.StrBuf, '"')
 ELSE
  WRITELN('is empty.')
END;
END DisplayOverString;
BEGIN
 WRITELN('Main program about to call overlay one.');
 OverlayCommBuffer.Command := SayHello;
 OverlayCommBuffer.StrBuf := '';
 Call('OVER1');
 WRITELN('Return from call to overlay 1');
 DisplayOverString;
 WRITELN('Now call overlay one again with a null request.');
 WRITELN('Will it be reloaded, press a key to see . . .');
 Pause;
 OverlayCommBuffer.Command := none;
 OverlayCommBuffer.StrBuf := '';
 Call("OVER1"); WRITELN('Returned from second call to overlay 1',
     'did the drive light go on ?');
 DisplayOverString;
 Pause;
 WRITELN('Call overlay two, which will call overlay one.');
 OverlayCommBuffer.Command := CallOver;
 OverlayCommBuffer.StrBuf := '';
 Call("OVER2");
```

WRITELN('Return from call to overlay 2',

```
'the drive light did go on, right!');
DisplayOverString;
WRITELN('That's all folks!');
Pause;
END Main.
```

The overlay modules are defined as follows; notice that they also import the Call procedure from the Loader Module.

```
MODULE Over1;
FROM Loader IMPORT Call;
FROM Main IMPORT OverlayCommBuffer, Commands;
```

BEGIN

CASE OverlayCommBuffer.Command OF SayHello: WRITELN('Hello there. This is overlay one running'); WRITELN('Message left in the string area. Goodbye!'); OverlayCommBuffer.StrBuf := 'Message from overlay 1 passed to caller'; CallOver: WRITELN('Overlay one about to call overlay two. '); WRITELN('Say hello number two . . .'); OverlayCommBuffer.Command := SayHello; OverlayCommBuffer.StrBuf := ''; Call('OVER2'); IF OverlayCommBuffer.StrBuf # '' THEN WRITELN('Overlay two passed me this string: ', OverlayCommBuffer.StrBuf); END;

ELSE

```
WRITELN('Overlay two : no command passed');
```

END;

END Over1.

MODULE Over2;

FROM Loader IMPORT Call;

FROM Main IMPORT OverlayCommBuffer,Commands;

BEGIN

CASE OverlayCommBuffer.Command OF SayHello: WRITELN('Hello there.'); WRITELN('This is overlay two running'); WRITELN('Message left in the string area.'); WRITELN('Goodbye!'); OverlayCommBuffer.StrBuf :=

```
'Message from overlay 2 passed to caller';
i
CallOver: WRITELN('Overlay two about to call overlay one. ');
WRITELN('Say hello number one . . .');
OverlayCommBuffer.Command := SayHello;
OverlayCommBuffer.StrBuf := '';
Call('OVER1');
IF OverlayCommBuffer.StrBuf # '' THEN
WRITELN('Overlay one passed overlay two
this string: ',
OverlayCommBuffer.StrBuf );
END;
I
ELSE
WRITELN('Overlay two : no command passed');
END ;
END ;
END Over2.
```

Loader Module Specification

DEFINITION MODULE Loader;

VAR

```
FirstDrive: [0..15];
```

PROCEDURE Call(modName: ARRAY OF CHAR);

EXCEPTION LoadError;

END Loader.



Chapter 12 Turbo Modula-2 Reference Directory

This chapter provides a complete alphabetical directory to Turbo Modula-2's standard identifiers, extensions, library procedures and modules, and reserved words.

Each entry contains a definition, usage and any restrictions, general comments, an example, a declaration, and a cross reference(s) to similar items where appropriate.

The following notation is used throughout this look-up section to describe operators, statements, types, procedures, and/or modules.

()	Where	appropriate,	module	names	are	enclosed	in
	parenth	eses after an	entry.				

- Items enclosed in square brackets are optional; the items can be used only once or not at all.
 Items enclosed in curly brackets can be repeated any number of times, including none.
- "[", "]", "{", "}" The use of square or curly brackets within quotation marks means the bracket is part of the syntax and not just notational.
- Items enclosed in angle brackets indicate that another syntactic construct is defined elsewhere.
- UPPERCASE Words written entirely in uppercase characters generally have a special meaning. All reserved words and stan-

dard identifiers are written in uppercase. All identifiers exported from the pseudomodules SYSTEM and STORAGE are also uppercase. Other library identifiers that are uppercase are usually special; for example, the file types TEXT and FILE exported from the modules Texts and Files are uppercase.

Each entry in the Reference Directory contains a Class descriptor. This is a quick reference to describe which of the general categories listed below the entry belongs to. In some cases, an entry belongs to more than one general category, and is listed appropriately. The Class descriptor can take on the following values:

E = Turbo Modula-2 Extension

L = Library

R = Reserved Word

S = Standard Identifier



Turbo Modula-2 Keference Directory

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Description	ABS returns the absolute value of the expression X .
Usage	Y := ABS(X)
	Argument X is of type REAL, INTEGER, LONGINT, or LONGREAL.
	Result Y must be the same type as X.
Comments	The absolute value is the positive value of a number; thus, is the function argument X is -12, the result is 12. A positive value is returned unchanged.
Example	CONST
	Mass = 120.0;
	VAR
	XPar,AbsX:INTEGER
	Acceleration,AbsForce:REAL
	BEGIN
	AbsX := ABS(XPar);
	AbsForce := ABS(Ma ss * Acceleration);

Description	ADDRESS is a type that represents memory addresses.
Declaration	TYPE ADDRESS = POINTER TO WORD;
Usage	WAR A.ADDRESS

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Usage

ADDRESS must be imported from the pseudomodule SYSTEM.

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Comments	ADDRESS can be considered as POINTER TO WORD; thus, dereferencing an ADDRESS will yield a WORD.
	Addresses can be computed, and it is possible to add and sub- tract cardinals from addresses. The result of such a computa- tion is again of type ADDRESS.
	ADDRESS is compatible with CARDINAL and with every pointer type. In particular, if a formal parameter is of type AD-DRESS, the corresponding actual parameter may be of any pointer type.
	This is a low-level concept; its use will reduce the portability of the code that employs it.
	Note: Taking the ADR of a simple variable is not allowed.
See Also	ADR SYSTEM WORD
Example	<pre>MODULE WhereAreXandY; FROM SYSTEM IMPORT ADDRESS, ADR; FROM InOut IMPORT WriteHex; TYPE atype = RECORD</pre>
	<pre>VAR adrx, adry : ADDRESS; x, y : atype; BEGIN adrx := ADR(x);</pre>

adry := ADR(y); WRITE('x is at '); WriteHex(adrx); WRITELN; WRITE('y is at '); WriteHex(adry); WRITELN; END WhereAreXandY;

ADR procedure (SYSTEM) L

Description	ADR returns the address of a structured variable.
Declaration	PROCEDURE ADR(VAR v: AnyType): ADDRESS;
Usage	y := ADR(x);
	ADR must be imported from the pseudomodule SYSTEM.
	x may be a variable of any structured type and y must be a pointer or a cardinal variable.
Comments	ADR yields a value of type ADDRESS, which is a 2-byte value indicating the address of the argument variable.
	This is a low-level routine; its use will reduce the portability of the code that employs it.
See Also	ADDRESS SYSTEM
Example	MODULE WhereAreXandY; FROM SYSTEM IMPORT ADDRESS, ADR; FROM InOut IMPORT WriteHex; TYPE atype = RECORD A,B: REAL END ;
, 1	VAR adrx, adry : ADDRESS; x, y : atype; EEGIN adrx := ADR(x);

;

adrx := ADR(x); adry := ADR(y); WRITE('x is at '); WriteHex(adrx); WRITELN; WRITE('y is at '); WriteHex(adry); WRITELN; END WhereAreXandY;

ALLOCATE procedure (STORAGE) L

Description ALLOCATE allocates an area from the heap.

Declaration PROCEDURE ALLOCATE (VAR a: ADDRESS; size: CARDINAL);

Usage ALLOCATE(a, size)

ALLOCATE must be imported from the pseudomodule STORAGE.

a must be compatible with type ADDRESS (any pointer).

size must be of type CARDINAL.

Comments A space of *size* bytes is allocated on the heap, and the pointer *a* is made to point to the beginning of the allocated area. If the memory requested is not available the exception OUTOFMEMORY is raised. You may check available memory with *FREEMEM*.

A safer and more comfortable way to allocate dynamic variables is by using the procedure NEW, although you must still import ALLOCATE.

The counterpart routine to release this memory is called *DEALLOCATE*.

Note that the size of an ADDRESS is only 2 bytes; thus AD-DRESS is compatible with WORD.

See Also

DEALLOCATE DISPOSE FREEMEM OUTOFMEMORY NEW STORAGE

Turbo Modula-2 Regerence Directory

	Example	Allocate 100 bytes off of the heap:
		VAR work: ADDRESS; BEGIN ALLOCATE(work, 100);
	AND R	· · · · · · · · · · · · · · · · · · ·
(Description	AND is a binary logical operator resulting in a Boolean expression.
	Usage	IF Raining AND NoUmbrella THEN Run ELSE Walk END ;
		AND is a reserved word.
		Raining and NoUmbrella are Boolean expressions.
	Comments	AND is used to concatenate two logical expressions, where both subexpressions must be true for the entire expression to be true.
		Note that the second subexpression in an AND expression is only evaluated if the first subexpression is true. This is called short-circuit evaluation.
	See Also	OR NOT
(غxa mple	WHILE statement using an AND to test bounds condition prior to indexing an array (short-circuit evaluation):

```
VAR
```

```
s: ARRAY [1..maxitems] OF Info;
BEGIN
WHILE i#0 AND s[i] > amount DO
 (* process s[i] *)
END ;
END ;
```

APPEND procedure (STRINGS) L Description Append appends a substring to a string. Declaration **PROCEDURE** Append(substr: **ARRAY OF** CHAR; VAR str: ARRAY OF CHAR); Usage Append(substr, str) Append must be imported from the library module Strings. str and substr can be arrays of character with any bounds. Comments A string's wend« is marked by a zero byte; thus Append will tack on substr at the first zero byte in str. If str has not been declared to be long enough to hold the two together, the exception StringError is raised. Delete See Also Insert StringError Strings Write out 'Hello world !': Example **MODULE** Main; FROM Strings IMPORT Append; VAR str, substr: ARRAY [0..80] OF CHAR; BEGIN

str := 'Hello'; substr := 'world !'; Append(substr, str); WRITELN(str); END main. Arctan function (MATHLIB, LONGMATH) L

	Description	Arctan returns the arc tangent of X , with the result expressed in radians.
	Declaration	PROCEDURE Arctan (x: REAL): REAL;
		and
		PROCEDURE Arctan (x: LONGREAL): LONGREAL;
	Usage	Y := Arctan(X)
		Arctan must be imported from the library module MathLib for single-precision reals and from LongMath for double- precision reals.
		Argument X and the target Y of the result must be the same type, either both REAL or both LONGREAL.
	Comments	The result is within the range -Pi/2 to Pi/2 radians. If you want the result expressed in degrees instead of radians, use the following expression:
		Degrees:= Arctan(X) * 180.0/3.141592
		The inverse of the Arctan function is tangent, which you can calculate with the Sin and Cos functions:
*		Tan:= Sin(X)/Cos(X).
	See Also	Mathlib LongMath

Sin Cos

Example

MODULE ArcTanTest; FROM MathLib IMPORT Arctan; CONST RadsToDegs = 180.0/3.141592;

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VAR

Opposite, Adjacent, Angle: REAL;

BEGIN

```
Opposite := 1.0;
Adjacent := 1.0;
Angle := Arctan(Opposite/Adjacent) * RadsToDegs;
WRITELN('Angle=',Angle,' and it better be
45 degrees !');
END ArcTanTest.
```

ArgumentError exception (MATHLIB) L/E

- Description ArgumentError is raised by the module *MathLib* if an invalid parameter is passed to one of the procedures exported by *MathLib*.
- **Declaration EXCEPTION** ArgumentError;

Usage EXCEPTION ArgumentError: WRITELN('Argument error');

ArgumentError must be imported from the module MathLib.

Comments This exception is raised if the parameter to a procedure is out of the valid range for that function.

See Also MathLib LongMath

Example MODULE MathError; FROM MathLib IMPORT Exp, ArgumentError; VAR x: REAL; BEGIN x := Exp(99.0); EXCEPTION ArgumentError: WRITELN('argument to Exp must be less than 87.4'); END MathError.

.RRAY standard type R

Description An array consists of a fixed number of components all of the same type, the *base type*. Each component can be individually accessed by indices whose values are of the *index type*. Arrays can also be treated as a whole when being assigned or passed as parameters.

Usage a = ARRAY IndexType OF ComponentType

The index type can be BOOLEAN, CHAR, subrange, or enumeration types. The *ComponentType* can be of any type.

Multidimensional arrays are expressed with additional index types separated with commas.

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Comments You can use an array to handle several related items of identical type; for example, an array of soups of the day could be Day = (Sun, Mon, Tue, Wed, Thu, Fri, Sat);

```
Soup = (Minestrone, CreamOfAsparagus,
      VegetableBeef, SplitPea, ChickenNoodle,
      Chowder, Bouillabaisse);
```

SoupOfTheDay = ARRAY Day OF Soup;

Each component in an array has an index with a value defined by the index type. Thus, in the preceding example, a component is specified with an index of type *Day*; for example, *SoupOfTheDay[Mon]*, *SoupOfTheDay[Sat]*, and so on.

A component can take values defined by the component type. In the example, an element of *SoupOfTheDay* can take any value from *Minestrone* to *Bouillabaisse*.

A multidimensional array is simply an array with an array as a component type. For example:

a2=ARRAY IndexType1 OF ARRAY IndexType2 OF CARDINAL

This can also be rewritten as

a2 = ARRAY IndexType1, IndexType2 OF CARDINAL

The components are accessed as either

MultiDim[Index1][Index2]

MultiDim[Index1, Index2]

No operators other than simple assignment are directly applicable to arrays, but any operator applicable to the component type can operate on a component. Thus, if *Numbers* is an array of REAL components, then Numbers[X] := Numbers[Y] * Numbers[Z]

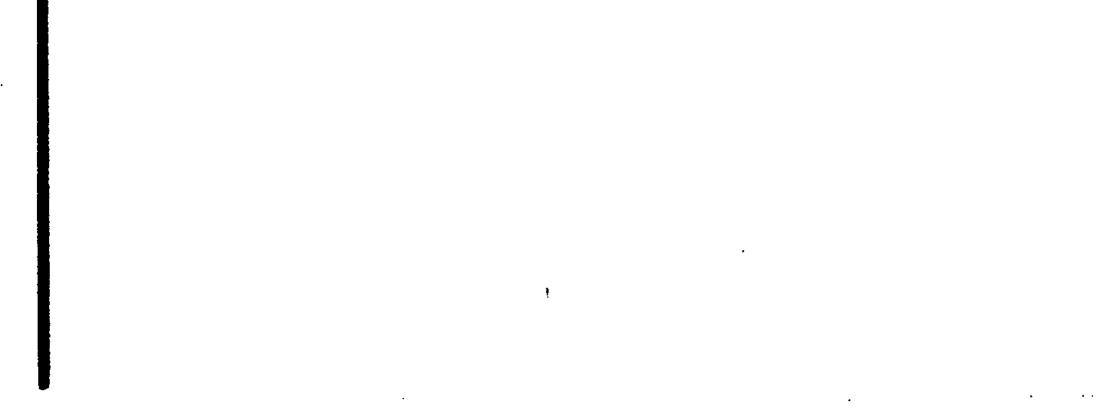
Simple assignment is possible for identically structured arrays. For example, if *First* and *Second* are arrays of the same type, the following assignment makes each component of *First* equal to the corresponding component in *Second*:

```
First:= Second
```

Example

)

```
MODULE Arrays;
TYPE
 Alphabet = ['A'...'Z'];
Days = (Sun, Mon, Tue, Wed, Thu, Fri, Sat);
 Shift = RECORD
          Day : [0..8];
          Swing: [0..8];
          Night: [0..8]
         END;
VAR
HoursSun : ARRAY Days OF REAL;
 Character : ARRAY [1..10] OF Alphabet;
 CharType : ARRAY CHAR OF (Letter, Digit);
WorkRecord: ARRAY Day, [1..100] OF Shift;
BEGIN
HoursSun[Tue] := 12.6;
HoursSun[Mon] := HoursSun[Sat] + HoursSun[Sun];
Character[3]:= "R";
Character[1]:= Character[3];
WorkRecord[Sun,1] := 0;
END Arrays.
```



available variable (TERMINAL) L

Description	<i>available</i> holds the currently installed terminal operation, which may not be available on all terminals.
Declaration	<pre>TYPE SpecialOps = (clearEol, insertDelete, highlight- normal); OpSet : SET OF SpecialOps; VAR available : OpSet;</pre>
Usage	IF clearEol IN available THEN ClearToEOL END ;
	available is a predefined variable declared as type OpSet, which must be imported from the module Terminal.
Comments	This variable is useful for writing terminal-independent pro- grams. The value of <i>available</i> is set by the installation program INSTM2.
See Also	SpecialOps OpSet Terminal

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Example **MODULE** TermStuff; FROM Terminal IMPORT available, SpecialOps, ClearToEOL, InsertLine, numRows, numCols; VAR I, CurRow: CARDINAL; ScreenLine: ARRAY [0..23] OF ARRAY [0..79] OF CHAR; BEGIN IF insertDelete IN available THEN InsertLine ELSE FOR I := 1 TO numCols DO WRITE(' ') END ; WRITELN; FOR I := CurRow TO numRows DO WRITELN(ScreenLine[I]) END; END; END TermStuff.

Awaited procedure (PROCESSES) L

Description	Awaited tests to see if any processes are waiting for a certain signal.
Declaration	PROCEDURE Awaited(s: SIGNAL): BOOLEAN;
Usage	<pre>flag := Awaited(siggy)</pre>
(Awaited must be imported from the library module Pro- cesses.flag must be of type BOOLEAN and siggy must be of type SIGNAL imported from Processes.
Comments	Awaited only makes sense when used with the related routines WAIT and SEND.

Awaited will not start up the waiting processes, it only lets the program know if processes are waiting for a certain signal. Presumably, if Awaited returns TRUE, then the signal will be sent with the SEND command.

`~

See Also	Init Processes SEND StartProc ess WAIT
Example	IF Awaited(Printer) THEN SEND(PrinterAvailable) END
BADOVERLAY	exception (SYSTEM) L/E
Description	BADOVERLAY is raised by the module SYSTEM when an overlay file cannot be read.
Declaration	EXCEPTION BADOVERLAY;
Usage	EXCEPTION BADOVERLAY: WRITELN('Bad overlay'); END
	BADOVERLAY must be imported from the module SYSTEM.
Comments	This exception occurs only when the linker is used to produce overlays.
See Also	SYSTEM OUTOFME MORY OVERFLOW REALOVERFLOW

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Example BadOverlays; FROM Overlayed IMPORT Proc1; FROM SYSTEM IMPORT BADOVERLAY; BEGIN Proc1; EXCEPTION BADOVERLAY: WRITELN('Could not load overlayed module.'); END BadOverlays.

OS procedure (SYSTEM) L

Description BDOS invokes a BDOS (CP/M operating system) function.

Declaration PROCEDURE BDOS(n, w: WORD);

Usage BDOS(n,w)

BDOS must be imported from the pseudomodule SYSTEM.

n and w must be compatible with type WORD (which can be an integer, character, enumeration, and so on).

Comments The BDOS function n will be invoked; w is a parameter to the operating system, inserted in register DE.

If a function returns a result in the accumulator A, it can be extracted out of the variable *IORESULT*.

If a result is returned in the register HL, it can be extracted from *HLRESULT*.

They are declared in SYSTEM as

VAR

HLRESULT, IORESULT: CARDINAL.

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See Also	BIOS SYSTEM IORESULT HLRESULT Also see the BDOS section of your CP/M manual.
Example	Read a character from the console:
	<pre>BDOS(1,0); ch:=CHR(IORESULT);</pre>
BEGIN R	
Description	BEGIN is a key word that divides the declaration part of a module or procedure from the statement part of the same.
Usage	BEGIN
Comments	A BEGIN is used to mark the beginning of the code part o a procedure or module.
See Also	END
Example	<pre>MODULE Begin; BEGIN IF TRUE THEN WRITE('Only '); WRITELN('One BEGIN') END ; END Begin.</pre>

BIOS procedure (SYSTEM) L

 $c \sim$

Description BIOS results in a call to the specified BIOS jump vector.

Declaration PROCEDURE BIOS(n, w: WORD);

Turbo Modula-2 -- eference Directory

Usage	BIOS(n,w)
	BIOS must be imported from the pseudomodule SYSTEM.
	<i>n</i> and <i>w</i> must be compatible with type <i>WORD</i> (which can be an integer, character, enumeration, and so on).
Comments	The given n indicates which vector is called: 0=WARMBOOT, 1=CONSTAT, 2=CONIN, and so on.
	If a function returns a result in the accumulator A , it can be extracted out of the variable <i>IORESULT</i> .
	If a result is returned in the register HL, it can be extracted from HLRESULT.
	HLRESULT and IORESULT are declared in SYSTEM as car- dinals.
See Also	BDOS SYSTEM HLRESULT IORESULT
Example	Read a character directly from the console:
	BIOS(2,0); ch := CHR(IORESULT);
See Also	 1=CONSTAT, 2=CONIN, and so on. If a function returns a result in the accumulator A, it can be extracted out of the variable <i>IORESULT</i>. If a result is returned in the register HL, it can be extracted from <i>HLRESULT</i>. <i>HLRESULT</i> and <i>IORESULT</i> are declared in <i>SYSTEM</i> as can dinals. BDOS SYSTEM HLRESULT IORESULT Read a character directly from the console:

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BITSET standard type S

Description BITSET is a variable type that can assume as a value a set of up to 16 integers with values between 0 and 15.

Usage As a constant set:

```
[BITSET] "{" [element {, element}] "}"
```

element may be a constant, subrange, or variable of type CAR-DINAL with a value between 0 and 15. The standard identifier BITSET is optional in constant sets.

The standard identifier is used mainly in variable declarations, as in the following:

VAR

mask: BITSET;

Comments

BITSET is a standard predefined set type. All the operators you can apply to other set types can be used on BITSET-type variables (see »Operators« in Chapter 3).

You denote BITSET constants in the same way as other set types:

{0..9,12,14} {} BITSET{6,8,11}.

A BITSET value requires 2 bytes for storage in memory.

Example

MODULE BitSets; CONST Mask = {5..7,12}; VAR Bits: BITSET;

BEGIN

```
Bits:= {1,3,6..13};
Bits:= Mask * Bits; (* AND the bits *)
(* Bits is now {6,7,12} *)
```

```
Excl(Bits,7); (* Exclude bit 7 *)
(* Bits is now [6,12] *)
END BitSets.
```

BOOLEAN standard type S

Description	BOOLEAN is a variable type that can assume the logical truth
	values FALSE and TRUE.

Comments You can use BOOLEAN variables and expressions when you want to calculate a statement that will have the answer TRUE or FALSE; for example, the statement *Today is Tuesday and it is raining« gives a BOOLEAN result.

There are two groups of operators you can apply to obtain BOOLEAN expressions: relational operators and logical operators.

Relational operators compare different variables, constants, and so on, and give a BOOLEAN result. For example, the expression:

(Altitude > 2000.0)

compares the REAL variable *Altitude* with the value 2000.0 to get a TRUE or FALSE result. Thus, relational operators can compare any items of similar type.

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On the other hand, logical operators are only applicable to BOOLEAN variables and expressions. For example:

SwitchOn AND (Altitude > 2000.0)

has a logical AND operator and is TRUE only if both parts of the expression are TRUE.

A BOOLEAN value requires 1 byte for storage in arrays and 2 bytes as stand-alone variables or fields in a record.

Example

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MODULE Booleans;

VAR

PowerAvailable, SwitchOn, PowerOn: BOOLEAN; Temperature:REAL;

BEGIN

PowerAvailable:= SwitchOn AND PowerOn; IF PowerAvailable AND (Temperature > 90.0) THEN WRITELN('Turn on air conditioner '); END END Booleans.

BusyRead procedure (Terminal) L

Description BusyRead tests to see if a character has been typed at the keyboard.

Declaration **PROCEDURE** BusyRead (VAR ch: CHAR);

Usage BusyRead(ch)

BusyRead must be imported from the system library Terminal.

ch must be of type CHAR.

Comments BusyRead, together with ReadAgain, provides much the same service as Turbo Pascal's KeyPressed; however, BusyRead and ReadAgain are more flexible.

> If a character is typed at the keyboard, *BusyRead* will return it in *ch*. If nothing is typed, *ch* is returned as OC (a zero byte). For example:

```
PROCEDURE KeyPressed( ): BOOLEAN;
VAR ch: CHAR;
BEGIN
BusyRead(ch);
IF ch#OC THEN
ReadAgain; RETURN TRUE
ELSE
RETURN FALSE;
END
END KeyPressed;
```

The procedure emulates the *KeyPressed* function. To use the character again in another portion of the code we can use *ReadAgain*.

Notice that using the function *KeyPressed* requires two steps: (1) determine if there is a character and (2) if there is, read the character. This can be a problem in Modula-2 because of its interrupt handlers.

Suppose a program tests (with *KeyPressed*) whether a character is at the keyboard, and before it can read the character it is interrupted. If the interrupting routine also reads the keyboard, then when control returns to the interrupted program the character will not be available. This problem is solved if the procedure that reads a character simply returns a flag when no characters are available.

See Also

ReadAgain Terminal Example Display the ordinal value of a key that is pressed:

```
MODULE BusyReads;
FROM Terminal IMPORT BusyRead;
VAR ch: CHAR;
BEGIN
REPEAT
WRITELN('Press a key ('Q' to quit): ');
REPEAT
BusyRead(ch);
UNTIL ch#OC;
WRITELN('The ordinal value is ',ORD(ch));
UNTIL CAP(ch)='Q'
END BusyReads.
```

BYTE type (SYSTEM) L

Description	BYTE is a low-level type used to represent the scalar types that take up 1 byte of memory.
Usage	VAR b : BYTE; BYTE must be imported from the pseudomodule SYSTEM.
Comments	BYTE is declared as a subrange of WORD and is therefore assignment-compatible with all scalar types.BYTE is compatible with BOOLEAN, CHAR, and enumeration types that have 256 elements or less.

BYTE is compatible with WORD.

Only assignment operations are allowed on variables of type BYTE. A stand-alone variable of type BYTE takes 2 bytes of storage (also fields in a record). A BYTE in an array is packed into 1 byte of storage.

Example **PROCEDURE** p1(b: BYTE);

Call procedure (Loader) L Description Call allocates and executes an overlay in the form of a module. Declaration **PROCEDURE** Call(modName: **ARRAY OF** CHAR); Usage Call(modname) Call must be imported from the library module Loader. modname must be the character array containing the name of the overlay file. Comments If modname does not have an extension, .MCD will be appended. The object module specified by modname will be loaded into memory and begin executing. In this sense, it is not unlike a procedure call, but it is much slower due to disk access. Also, when execution is completed, the memory needed for object code and data is released again. Communication between the calling program and the overlaid module is only possible through variables declared in the calling program and imported by the called overlay. firstDrive See Also Loader Also see linker described in Chapter 10.

Example

Load and execute the module OVER.MCD:

Call("OVER")

Description	CAP returns the capital of an alphabetic character.
Usage	Ch := CAP(Ch)
	Argument Ch (and result) is of type CHAR.
Comments	You can use this function if you want to change lowercase let ters to uppercase letters. This is useful for testing keyboard in put.
	Note that if the argument has no uppercase equivalent, th argument is returned unchanged. In other words, spaces an punctuation characters will remain unaltered.
Example	MODULE CAPs; VAR ch: CHAR; BEGIN LOOP BusyRead(ch); IF CAP(ch) = 'Q' THEN EXIT END END END CAPs.

CAPS makes an entire string variable uppercase. Description

Declaration **PROCEDURE** CAPS(VAR str: ARRAY OF CHAR);

Usage

CAPS(str)

CAPS must be imported from the library module Strings.

str must be of type ARRAY OF CHAR.

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CAPS saves you from typing the following code anywhere you Comments don't want to distinguish between uppercase and lowercase: FOR i := 0 TO Length(str)-1 DO str[i] := CAP(str[i]); END; See Also CAP Length Example Capitalize the string »Hello«: str := "Hello"; CAPS(str); (* str now has the value "HELLO" *) CARD standard function S Description CARD converts a numeric argument to type CARDINAL. Usage Y := CARD(X)Argument X can be of INTEGER, CARDINAL, REAL, LONGINT, or LONGREAL. The argument must be in the range 0 to 65535. Result Y is of type CARDINAL. When you use this function with a REAL argument, the value Comments is truncated (the fractional part removed); thus, value 12.35

will become 12.

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CARD is not applicable to enumeration or BOOLEAN- and CHAR- type arguments. Use ORD with these types.

If the argument cannot be converted (that is, to negative), the runtime error BoundsError is raised.

Example	MODULE CARDConversion;
	VAR
	r: REAL;
	c: CARDINAL;
	BEGIN
	r := 3.14;
	c := CARD(r);
	(* c now has the value 3 *)
	END CARDConversion.

CARDINAL standard type S '

Description	CARDINAL is a standard type with variables that can assume the values between 0 and 65535. In addition, CARDINAL may be used as a type-transfer function.
Usage	VAR c: CARDINAL;
	or
	c := CARDINAL(-1)
Comments	You can use CARDINAL variables whenever you know that possible values are limited to positive whole numbers. For ex- ample, if you are counting the number of people in a room you know the count can only be a positive whole number. It your program suddenly produces a negative count, an error message will be written.

The CARD standard function will convert other simple data types into CARDINAL. The use of CARDINAL as a type transfer function should be considered a low-level facility tha

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may not be portable.

A CARDINAL value requires 2 bytes for storage.

Example	MODULE CARDINALs;
-	CONST
	SearchValue = 3.65;
	N = 20;
	VAR
	DataArray: ARRAY [0N] OF REAL;
	I, Count : CARDINAL;
	BEGIN
	FOR $I := 0$ TO N DO
	IF (DataArray[I] = SearchValue) THEN
	Count:= Count + 1
	END
	END
	END CARDINALS.

CardToStr	procedure	(Convert)	L
-----------	-----------	-----------	---

Description	CardToStr converts a CARDINAL to a string.
Declaration	PROCEDURE CardToStr(c: CARDINAL; VAR s: ARRAY OF CHAR);
Usage	CardToStr(card, string)
	CardToStr must be imported from the library module Convert.
	card must be of type CARDINAL.
	string can be any array of characters.
Comments	The number is placed into the string starting at the right- most index. The left end of the string is padded out with blanks. If

the number does not fit into the given string, the exception TooLarge is raised.

See Also

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Convert IntToStr RealToStr StrToCard

```
Example MODULE xets;
FROM Convert IMPORT CardToStr;
VAR
card: CARDINAL;
string: ARRAY [0..4] OF CHAR;
BEGIN
card := 12;
CardToStr(card, string);
WRITE('"', string '"'); (* " 12" is output *)
END xets.
```

CASE statement R

Description	CASE selects a different statement sequence depending on the value resulting from an expression.
Usage	CASE Selector OF Case { Case} [ELSE Statement sequence] END
	Selector is a variable or expression of type CARDINAL, IN- TEGER, BOOLEAN, CHAR, enumeration, or subrange.
	Case = [Case label: Statement sequence]
	Statement sequence = Statement (; Statement)
	Each case label can be either a single constant value or a range of constant values of the same type as the selector, separated by commas.

The ELSE part is executed if it is present and there are no matching values in the CASE label lists.

Comments

The selector, whether it is an expression or a variable, gives a value that causes the selection and execution of the statement sequence containing that value in its label. A value can appear in only one label.

Example

```
CASE X + Y OF

1 0..5 : Z := 0; Y:= R * X

1 6..8 : Z := X + Y - 5

1 9..10: Z := 8; Y:= R * X

END ;
```

CASE Day OF

Sun:	Message:= 'Closed all day';
	OpenHours:= 0
MonWed,Fri:	Message:= 'Normal hours';
	OpenHours:= 8
Thu,Sat:	Message:= 'Half day';
	OpenHours:= 4

END

You can define an empty case if necessary. For example, suppose in the last example you have no statement sequence for the value *Sun*:

```
CASE Day OF

Sun: |

Mon..Wed,Fri: Message:= 'Normal hours';

OpenHours:= 8

Thu,Sat: Message:= 'Half day';

OpenHours:= 4
```

END

Notice that the case of *Sun* explicitly states that no action is performed. When you have code to execute for every value except those in the CASE lists, then you can use an ELSE:

```
CASE Day OF
| Sat : WRITELN('Go for a picnic');
```

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| Sun : WRITELN('Go shopping'); ELSE WRITELN('Go to work') END;

CHAR standard type S

Description CHAR is a standard type with variables that can assume a character as a value. In addition, CHAR may be used as a type-transfer function. Usage VAR ch: CHAR; AND ch := CHAR(27);Comments You can use CHAR-type variables and constants wherever you want to handle text. A CHAR variable can take any ASCII character as a value (which are ordered by their ASCII value); for example, the ordinal of character A is equal to the ASCII value 65, while the character B has an ordinal of 66. Constants of type CHAR are denoted by a character enclosed within single or double quotation marks, or are octal numbers within the range 0 to 377 followed by a C; for example, *9*, 'D', 0C. You cannot apply arithmetic operators directly on CHAR-type variables, but you can convert the value to CARDINAL and vice versa. To convert a character to a CARDINAL type, you use the standard function ORD. To convert a CARDINAL to a CHAR, use the standard function CHR.

Turbo Modula-2 permits the comparison and assignment of strings of characters, and the module *Strings* provides several procedures for string handling.

A CHAR variable occupies 2 bytes in memory unless it is declared as an element of an array, in which case it occupies 1 byte in memory.

See Also	BYTE CHR ORD VAL
Example	<pre>MODULE Characters; ch: CHAR; BEGIN LOOP READ(ch); IF CAP(ch) = 'Q' THEN EXIT END IF ch < ' ' THEN WRITE('.') ELSIF ch > CHR(127) THEN WRITE('!') ELSIF (ch >= 'a') AND (ch <= 'f') THEN WRITE(CAP(ch)) ELSE WRITE(ch) END END END END END Characters.</pre>

CHR standard function S	
Description	CHR returns the character with ordinal X.
Usage .	Ch:= CHR(X)
	Argument X is of type INTEGER or CARDINAL.
	Result Ch is of type CHAR.
	The argument must be in the range 0 to 255.

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Comments	You can use the CHR standard function to convert from an ASCII value in the range 0 to 255 to the corresponding character.
	Note: The characters A to Z have ASCII values 65 to 90; characters a to z have ASCII values 97 to 122; numerals 0 to 9 have ASCII values 48 to 57.
	Converting a character to ASCII is performed by the standard function ORD.
('e Also	CHAR ORD
Example	<pre>PROCEDURE NumToChar(N: CARDINAL): CHAR; BEGIN IF N < 10 THEN RETURN CHR(N + 48) FLSE RETURN CHR(48) END END NumToChar;</pre>
ClearEol enume	rated value (terminal) L
Description	clearEol is the first value of the enumerated type Ter- minal.SpecialOps.
Declaration	<pre>SpecialOps = (clearEol, insertDelete, highlightNor- mal);</pre>
Usa ge	IF clearEol IN available THEN ClearToEOL END ;

SpecialOps must be imported from the library module Terminal.

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If this value is a member of the set Terminal.available, then Comments the program may use the procedure ClearToEOL to clear to the end of the line. To use this identifier, include SpecialOps in your import list. The identifiers of each of SpecialOps' values become visible automatically. ClearToEOL See Also available insertDelete highlightNormal Terminal Example Clear the right half of the screen: MODULE CheckAvailableOperations; FROM Terminal IMPORT available, SpecialOps, ClearEOL, GotoXY; VAR row: CARDINAL BEGIN FOR row := 0 TO 24 DO GotoXY(40,row); IF ClearEol IN available THEN **FISE**arToEOL; ManualClearEOL; END; END; GotoXY(0,0);END CheckAvailableOperations.

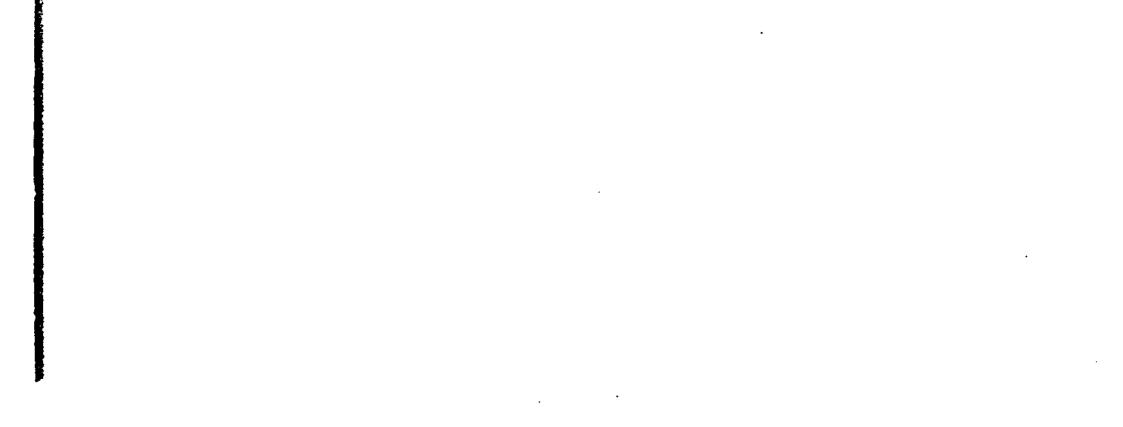
ClearScreen procedure (Terminal) L

Description ClearScreen clears the screen and homes the cursor.

Declaration **PROCEDURE** ClearScreen;

Usage	ClearScreen	
	ClearScreen must be imported from the library module Ter- minal.	
Comments	This function will work only if the Turbo Modula-2 system has been installed on your terminal.	
See Also	ClearToEOL GotoXY Hightlight Terminal	
Example	Clear the screen:	
	MODULE Clear; FROM Terminal IMPORT ClearScreen; BEGIN ClearScreen; END Clear.	
ClearToEOL procedure (Terminal) L		
Description	ClearToEOL clears the screen from the current cursor position until the end of the line.	
Declaration	PROCEDURE ClearToEOL;	
Usage	ClearToEOL	
	ClearToEOL must be imported from the library module Ter- minal.	
Comments	The cursor position is undefined after a call to this routine; reposition it with a call to GotoXY.	

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See Also	ClearScreen GotoXY Highlight Terminal
Example	Clear the right half of the screen:
	<pre>MODULE ClearHalfScreen; FROM Terminal IMPORT ClearEOL, GotoXY; VAR row: CARDINAL BEGIN FOR row := 0 TO 24 DO GotoXY(40,row); ClearToEOL; END ; GotoXY(0,0); END ClearHalfScreen.</pre>

Close procedure (Files) L

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Description	Close disconnects a FILE variable from an external disk file and updates the disk directory.
Declaration	PROCEDURE Close (VAR f: FILE);
Usage	Close(f);
	Close must be imported from the module Files.
	f must be of type FILE imported from Files.
Comments	If output has been sent to f, closing is mandatory; otherwise,

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the file size in the directory and the trailer byte will not be updated and fs data could be lost.

Since closing a file frees up the memory used for data buffering, we advise closing a file in any case, even if it has been used only for input. Turbo Modula-2 Reference Directory

See Also	Files Open NoTrailer
Example	Perform minimal file handling (open and close a FILE):
	<pre>MODULE OpenAndCloseFile; FROM Files IMPORT FILE, Open, Close; VAR oldFile : FILE; BEGIN IF Open(oldFile,'FILE.DAT') THEN Close(oldFile) END END OpenAndCloseFile.</pre>

CloseInput procedure (InOut) L

Description	CloseInput closes an input file and returns input to the ter- minal.
Declaration	PROCEDURE CloseInput;
Usage	CloseInput
	CloseInput must be imported from the library module InOut.
Comments	These routines are provided to maintain compatibility with other Modula-2 implementations (the <i>Texts</i> module is easier to work with).
	CloseInput is equivalent to the call CloseText(input), using the CloseText procedure from Texts.



OpenInput CloseOutput InOut

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Example	<pre>WriteString(s); WriteLn; CloseInput; ReadString(s);</pre>	<pre>eLn; OF CHAR; filename *) given, use MOD *) ; (* Read string from file *) (* Display it *) (* Sever the link to the file *) (* Input comes from console *)</pre>
	— • • •	(* Input comes from console *) (* Display it *)

CloseOutput procedure (InOut) L

- DescriptionCloseOutput closes an output file and returns output to the ter-
minal.DeclarationPROCEDURE CloseOutput;
- Usage CloseOutput

CloseOutput must be imported from the library module InOut.

Comments These routines are provided to maintain compatibility with other Modula-2 implementations (the *Texts* module is easier to

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work with).

CloseOutput results in the call CloseText(output), using the CloseText procedure in Texts.

See Also	OpenOutput OpenInput Inout
Example	MODULE Output;
	FROM InOut IMPORT
	OpenOutput, CloseOutput, ReadString,
	WriteString, WriteLn;
	VAR
	s: ARRAY [0255] OF CHAR;
(BEGIN
N	WriteString('Enter output file and data:');
	WriteLn;
	<pre>OpenOutput("MOD");</pre>
	ReadString(s); (* Read data from console *)
	(* Place it in the file *)
	WriteString(s); WriteLn;
	CloseOutput; (* Sever the link to the file *)
	WriteString('The file has been closed.');
	WriieLn;
	END Output.

CloseText procedure (Texts) L

Description	<i>CloseText</i> disconnects a <i>TEXT</i> file variable from an external disk file.
Declaration	<pre>PROCEDURE CloseText(VAR t: TEXT);</pre>
(ge	CloseText(t)
	CloseText must be imported from the module Texts.

t must be of type TEXT imported from Texts.

Comments	If output has been sent to t , closing is mandatory; otherwise, the file size in the directory and the trailer byte will not be updated and t 's data could be lost.
	Since closing a file frees up the memory used for data buffer- ing, we advise closing a file in any case, even if it has been used only for input.
	If the external medium is a disk file, the file is closed internal- ly using the procedure <i>Close</i> from the module <i>Files</i> .
	Closing <i>input</i> or <i>output</i> re-establishes the default connections (to CON:).
See Also	OpenText TEXT Texts NoTrailer
Example	<pre>Perform minimal text-file handling (open and close a TEXT): MODULE OpenAndCloseText; FROM Texts IMPORT TEXT, OpenText, CloseText; VAR oldFile : TEXT; BEGIN IF OpenText(oldFile,'T.TXT') THEN CloseText(oldFile) END END OpenAndCLoseText.</pre>

CODE procedure (SYSTEM) L

Description CODE allows the user to include an assembler routine.

Declaration **PROCEDURE** CODE(s: **ARRAY OF** CHAR);

Usage	CODE("Any string literal");
	CODE must be imported from the pseudomodule SYSTEM.
	The string must be a literal file name.
Comments	A call to <i>CODE</i> must be inserted after a procedure heading; thus replacing the body of the procedure. No declaration part, BEGIN , or any other statements may be present in its body; however, the final END must be included.
(Compilation of a <i>CODE</i> statement causes the ».COM«-File whose name is given as argument to be inserted into the object program. The length of the file must be in the first 2 bytes of the file.
	A CODE procedure may use all Z80 registers without restor- ing them.
See Also	SYSTEM
Example	Include MOVE.COM written in assembler:
	<pre>PROCEDURE MOVE(source: ADDRESS; n: CARDINAL); CODE("MOVE") (* MOVE.COM is inserted *) END MOVE;</pre>
Col function	(Texts)
(scription	Col returns the current column position of a text file.
Declaration	PROCEDURE Col(t: TEXT): CARDINAL;

Usa ge	<pre>currentCol := Col(t)</pre>
	Col must be imported from the library module Texts.
	currentCol must be of type CARDINAL.
	t must be of type TEXT imported from Texts.
Comments	After a WriteLn or a CreateText, the column position is zero; it increases by one with every written character.
See Also	SetCol Texts
Example	Start a new line if the current column position of TEXT t is greater than 79.
	IF $Col(t) > 79$ THEN WriteLn(t) END
ComLine modul	e L
Description	<i>ComLine</i> enables command line processing (arguments and redirection).
Declaration	DEFINITION MODULE ComLine; FROM Texts IMPORT Text;
	VAR commandLine: Text; inName, outName: ARRAY [019] OF CHAR; progName: ARRAY [07] OF CHAR;

(

PROCEDURE RedirectInput;

(* Input redirection as ordered on command line. *)

PROCEDURE RedirectOutput;

(* Output redirection as ordered on command line.*)

PROCEDURE PromptFor(Prompt: ARRAY OF CHAR; VAR S: ARRAY OF CHAR); (* Prompts for command line. *)

END ComLine.

The TEXT variable commandLine contains any arguments written after the command that started the program. It can be read like a normal TEXT.

inName contains the input medium, which is normally CON:.

outName contains the output medium, which is normally CON:.

progName contains the program name.

Comments

The command line consists of any characters or arguments that follow the command that started the program. The contents of the command line are accessed through the TEXT commandLine.

The command line can contain redirection arguments:

- >FileName Redirects the standard text Output to *FileName*. The new medium *FileName* is stored in outName.
- < FileName Redirects the standard text Input to *FileName*. The new medium *FileName* is stored in inName.

The redirection symbols and file names do not appear in the command line.

Note that if there is no redirection argument, inName and outName contain the name of the standard medium CON:.

See Also

Texts Also refer to each identifier in the definition module.

Example	If you start a program by typing
	MyProg Name
	the TEXT commandLine will contain the word Name. You would access this like so:
	READ(commandLine,InputFilename);
	If you write a program to compare two disk files, you will want to specify the file to be compared on the command line.
	By using <i>ComLine</i> procedures you can pass the file names directly to the program. Your program will include the following lines:
	MODULE Compare; FROM Files IMPORT FILE, Open,Close;
	FROM ComLine IMPORT
	<pre>commandLine, RedirectInput, RedirectOutput;</pre>
	<pre>VAR Filename1, Filename2: ARRAY [014] OF CHAR; f1,f2: FILE;</pre>
	BEGIN
	RedirectInput; RedirectOutput;
	READ(commandLine,Filename2); IF Open(f2,Filename2) THEN
	READ(commandLine,Filename1);
	IF Open(f1,Filename1) THEN
	READLN(options);
	(* compare the files *) (* Write differences to standard o utput *)

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END ;
Close(f1);
Close(f2);
END Compare.

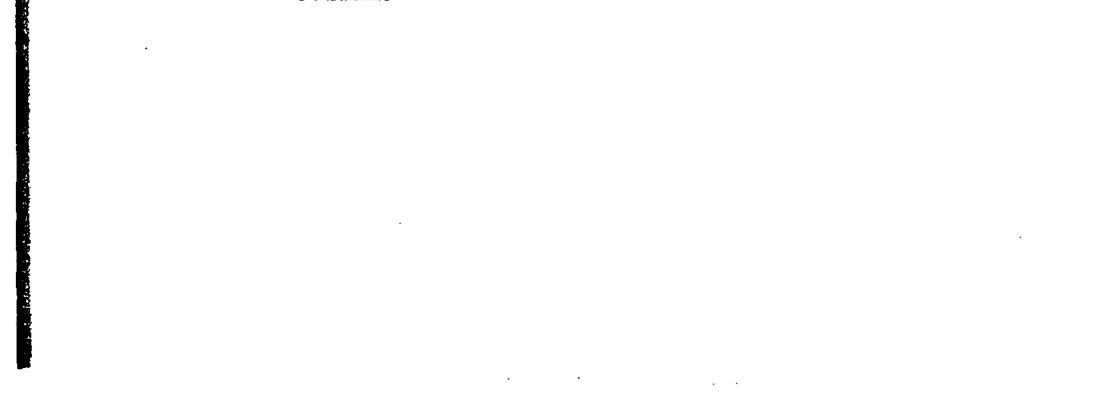
For example, you can start a program and define a command line by typing

Compare A:testfile B:testfile <B:Compare.Ops >A:Compared.dif

This line invokes the compare program with two files as arguments. Any input requested from the console is redirected from the keyboard to the file COMPARE.OPS. The output of the program is redirected from the screen to the file COM-PARED.DIF.

commandLine variable (ComLine) L

Description	<i>commandLine</i> is Predefined text that contains arguments pass- ed on the command line when a program is invoked.
Declaration	VAR commandLine: TEXT;
	TEXT is imported from the module Texts.
Us age	READ(commandLine,filename);
	filename is a string variable
Comments	Treat <i>commandLine</i> like any <i>TEXT</i> variable. It contains anything typed on the command line after the program name, up to 80 characters long.
See Also	PromptFor ComLine



Example	MODULE OffTheCommandLine;
	FROM ComLine IMPORT commandLine;
	VAR
	x,y: REAL;
	BEGIN
	READ(commandLine,x,y);
	WRITELN(x:5:2,'*',y:5:2,' = ',x*y:5:2);
	END OffTheCommandLine.

ConnectDriver procedure (Texts) L		
Description	ConnectDriver allows the user to install her own input and ou put drivers.	
Declaration	TYPE TextDriver = PROCEDUREE(TEXT, VAR CHAR); PROCEDURE ConnectDriver(VAR t: TEXT; p: TextDriver	
Usage	ConnectDriver(t, driver)	
	t must be of type TEXT imported from the library modu Texts.	
	Driver must be compatible with the type TextDriver.	
Comments	Allows users to install their own read and write charac routines, which are then used by all I/O statements in the st dard module <i>Texts</i> , including the extensions <i>READ</i> , <i>WRI</i> . <i>READLN</i> , and <i>WRITELN</i> .	

See Also

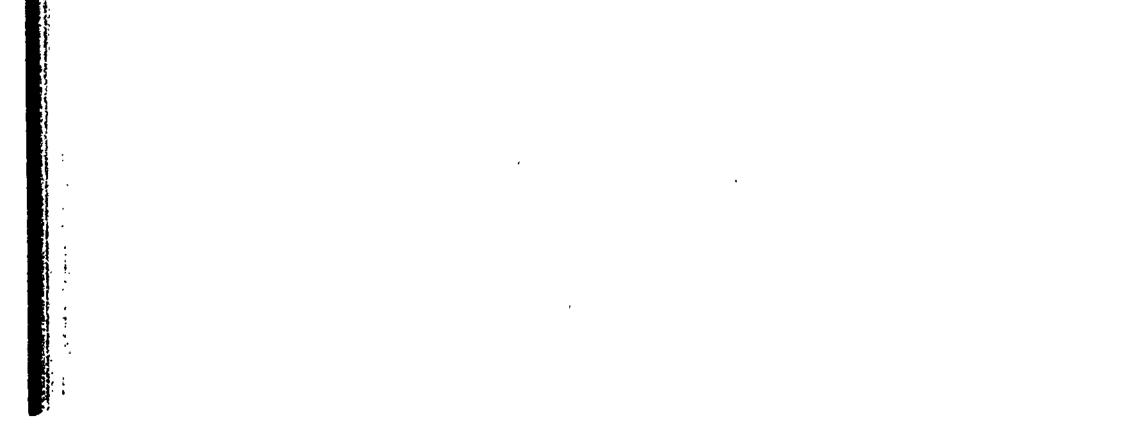
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Turbo Modula-2^{*}Reference Directory

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Example	Connect the user-defined driver to the text t:
	MODULE AlwaysUpCase;
	FROM Texts IMPORT TEXT, output, ConnectDriver;
	<pre>PROCEDURE WriteUpcase(t: TEXT; VAR ch: CHAR); BEGIN</pre>
	Write(output,CAP(ch));
	END WriteUpcase;
	VAR t: TEXT;
	BEGIN
	ConnectDriver(t, WriteUpcase);
	WRITELN(t, 'This will be displayed all uppercase');
	END AlwaysUpCase.
	_
console (Texts)	L
Description	An auxiliary output TEXT attached to the console.
Declaration	VAR console: TEXT;
Usage	WRITELN(console, 'output to the console');
	console must be imported from the library module Texts and can be used anywhere an output TEXT can be used.
Comments	console is always open and, by default, is connected to the ter- minal. It is as if the call CreateText(console, »CON:«) has taken place before the execution of the main module.
	console is useful if the output text stream has been redirected

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but you still want certain messages (prompts, errors, and so on) to go to the terminal. The *console* cannot be redirected.

See Also output input Texts Example Write out an error message by passing redirection:

```
MODULE consoleOutput;
FROM Texts IMPORT console;
VAR recnum: CARDINAL;
BEGIN
 (* processing loop *)
 WRITE(console, 'Error at record number: ', recnum);
END consoleOutput.
```

CONST declar	ration R
Description	The reserved word CONST precedes the declaration of constants.
Usage	CONST Pi = 3.14159265; TwoPi = 2.0*Pi;
Comments	Modula-2 allows the use of constants in the definition of fur ther constants, like the <i>Pi</i> in <i>TwoPi</i> .
Example	<pre>MODULE Constants; CONST nThings = 100; LastThing = nThings-1; TYPE ThingRange = [0LastThing]; VAR Things : ARRAY ThingRange OF CHAR; which : [0lastthing];</pre>
	thingy : CARDINAL;

BEGIN

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FOR thingy := 0 TO lastthing DO
Process(things[which])
END

END Constants.

Convert module	L
Description	<i>Convert</i> is a standard module that you can use when converting between numeric types and strings.
Declaration	DEFINITION MODULE Convert;
	PROCEDURE StrToInt (VAR s: ARRAY OF CHAR; VAR i:INTEGER) :BOOLEAN;
	PROCEDURE StrToCard (VAR s: ARRAY OF CHAR; VAR c:CARDINAL) :BOOLEAN;
	PROCEDURE StrToLong (VAR s: ARRAY OF CHAR; VAR 1:LONGINT) :BOOLEAN;
	PROCEDURE StrToReal (VAR s: ARRAY OF CHAR; VAR r:REAL) :BOOLEAN;
,	PROCEDURE IntToStr (i:INTEGER
	VAR s: ARRAY OF CHAR); PROCEDURE CardToStr (c:CARDINAL
	VAR s: ARRAY OF CHAR); PROCEDURE LongToStr (1:LONGINT
	VAR s: ARRAY OF CHAR); PROCEDURE RealToStr (r:REAL VAR s: ARRAY OF CHAR;
	digits:INTEGER);
	EXCEPTION TooLarge;
	END Convert.
Usage	See individual identifiers
Comments	The first four procedures convert strings to numeric types; the next four reverse the conversions.

See Also

The exception TooLarge is raised in the last four procedures if the number is too large to fit in the target string. (TooLarge is only raised by the second four procedures.)

The module *Doubles* provides the same functions for doubleprecision variables (LONGREAL).

Copy procedur	e (Strings) L
Description	Copy copies a substring starting at a given position with given length of a string.
Declaration	<pre>PROCEDURE Copy(VAR str: ARRAY OF CHAR; inx,len: CARDINAL; VAR result: ARRAY OF CHAR);</pre>
Usage	Copy(string, from, length, resultstring)
	Copy must be imported from the library module Strings.
	string and result must be character array variables.
	from and length must be of type CARDINAL.
Comments	A string is terminated by a zero byte. If a zero byte is countered before <i>length</i> characters have been processed, copy will be prematurely interrupted.
See Also	Concat Delete Insert Strings
Example	Copy 'holes' into holestring:
	Copy('Donut holes', 6, 5, holestring)

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Cos function (MathLib, LongMath) L		
Description	Cos returns the cosine of X, where X is expressed in radians.	
Declarations	<pre>PROCEDURE Cos(x: REAL): REAL; PROCEDURE Cos(x: LONGREAL): LONGREAL;</pre>	
Usage	Y := Cos(X)	
	Argument X and result Y must be of the same typeeither both REAL or both LONGREAL.	
Comments	If you want the argument expressed in degrees instead of ra- dians, use the following expression:	
	Result:= Cos(X * 3.141592/180.0)	
	If you need to calculate the inverse of cosine, you can use the ArcTan function in the following expression:	
	ArcCos:= Arctan(X/Sqrt(1.0 - X*X)) - 3.141592/2.0	
Example	<pre>MODULE Cosine; FROM MathLib IMPORT Cos; CONST DegsToRads = 3.141592/180.0; VAR Degs,Radians,CosAngle:REAL BEGIN Radians:= Degs * DegsToRads; CosAngle:= Cos(Radians); END Cosine.</pre>	

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Create	procedure	(Files)	L
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Description	Create creates a file on disk with a given name.
Declaration	PROCEDURE Create(VAR f: FILE; name: ARRAY OF CHAR);
Usage	Create(f, filename)
	Create must be imported from the library module Files.
	f must be declared as FILE.
	FILE must be imported from the library module Files.
	filename must be declared as ARRAY OF CHAR.
Comments	<i>filename</i> must be a legal CP/M filename, and there must be room on the directory and the disk for a new file.
	f can only be used for output after being opened with Create; use Open for reading a file.
	If a file is already present, it will be overwritten, so use cau- tion.
۰	After writing to this file, close it to update the file size in the directory and the file trailer byte. Failure to do this will probably result in the loss of all written information.
See Also	Close Files Open

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Example Create an empty file on disk:

```
MODULE CreateAnEmptyFile;
FROM Files IMPORT FILE, Create, Close;
VAR
newFile :FILE;
BEGIN
Create(newFile,'FILE.DAT');
Close(newFile);
END CreateAnEmptyFile.
```

CreateText procedure (Texts) L

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Description	CreatéText associates a TEXT with an external medium and opens it for writing.
Declaration	<pre>PROCEDURE CreateText(VAR t: TEXT; name: ARRAY OF CHAR);</pre>
Usage	CreateText(t, fname)
	CreateText must be imported from library module Texts.
	t must be of type TEXT imported from Texts.
	fname must be of type ARRAY OF CHAR.
Comments	<i>fname</i> must be a legal CP/M file name or device, such as »MYFILE.DAT« or »CON:«.
	t can only be used for output after being opened with CreateText; use OpenText for reading a TEXT file.

current, as openies for reading a rest me.

If a file is already present it will be overwritten, so use caution.

After writing to this file, close it to update the file size in the directory and the file trailer byte. Failure to do this will probably result in the loss of all written information.

See Also	CloseText OpenText Texts NoTrailer
Example	<pre>Create an empty text file on disk: MODULE CreateAnEmptyText; FROM Texts IMPORT TEXT, CreateText, CloseText; VAR newFile: TEXT; BEGIN CreateText(newFile,'EMPTY.TXT'); CloseText(newFile); END CreateAnEmptyText.</pre>

DeadLock exception (Processes) L/E

Description	DeadLock is raised in the module <i>Processes</i> when all processes are waiting for a signal.
Declaration	EXCEPTION DeadLock;
Usage	<pre>EXCEPTION DeadLock: WRITELN('Deadly embrace: all processes terminated.'); END</pre>

DeadLock must be imported from the module Processes.

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Comments When a dead lock occurs, your signal handling logic is fal You can detect this problem by using this exception.

See Also Processes SYSTEM

Example

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MODULE Signals; FROM Processes IMPORT Init, SIGNAL, WAIT, DeadLock; **VAR** s: SIGNAL; BEGIN Init(s); WAIT(s); EXCEPTION DeadLock: HALT; END Signals.

DEALLOCATE procedure (STORAGE) L

DEALLOCATE deallocates a block of memory on the heap that Description had been previously associated with a pointer variable.

Declaration PROCEDURE DEALLOCATE (VAR a: ADDRESS; size: CARDINAL);

Usage DEALLOCATE(a, size)

> DEALLOCATE must be imported from the library module STORAGE.

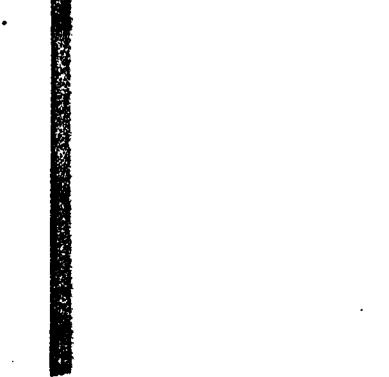
a must be compatible with type ADDRESS (any pointer).

size must be of type CARDINAL.

Comment

You can only deallocate portions of memory that you have previously allocated. The variablesa and size must be the same location and amount as when they were allocated.

The pointer a will be set to *NIL* and the deallocated area will be available for future allocation.



See Also	ALLOCATE NEW DISPOSE STORAGE MARK RELEASE FREEMEM
Example	Allocate and deallocate 100 bytes: MODULE HeapMem; FROM STORAGE IMPORT ALLOCATE, DEALLOCATE; VAR a: POINTER TO ARRAY [099] CHAR; BEGIN ALLOCATE(a,100); a^ := 'This string is on the heap'; DEALLOCATE(a, 100); (* Now the string is gone. *) END HeapMem.

DEC standard procedure S

Description	DEC returns a predecessor of argument X.
Usage	DEC(X)
	or
	DEC(X,N)

Argument X may be of type INTEGER, CARDINAL, CHAR, BOOLEAN, or a user-defined scalar type.

The second form returns the Nth predecessor of X.

Comments If you subtract 1 from a CARDINAL value, the result is the value prior to the original value. With *DEC*, you can do exactly the same thing with any ordinal type.

When decrementing a value, you may reach its *MIN* value; for example, the *MIN(CARDINAL)* is 0. You may choose whether or not this situation will generate an error by using the overflow compiler switch. This can be done globally or locally. Thus with overflow checking turned off, as in

VAR

```
i: CARDINAL;
BEGIN
i := MIN(CARDINAL);
(*$0-*)
DEC(i);
(*$0+*)
WRITELN(i);
END
```

the *i* would wraparound to *MAX(CARDINAL)* and no error will be generated. If overflow checking has been turned on, then the exception OVERFLOW will be raised. This can be trapped as follows:

```
MODULE dec;
FROM SYSTEM IMPORT OVERFLOW;
VAR
i: CARDINAL;
BEGIN
(*$0+*)
i := MIN(CARDINAL);
DEC(i);
```

EXCEPTION OVERFLOW: WRITELN('Trapped overflow error'); END dec.

See Also

INC

Example For example, suppose you have an enumeration variable: **VAR Energy:** (Kinetic, Potential, Heat); You can assign any of the three values to the variable *Energy*. Now suppose you want to decrement the value of Energy to a lower value; for example, to the value preceding the current value: DEC(Energy) You have performed a subtraction operation on the enumeration variable. The procedure can operate on any ordinal type. **MODULE** Decrement; VAR i: INTEGER; state: BOOLEAN; BEGIN i:= 0; DEC(1,2); (* now i = -2*)state:= TRUE; DEC(state); (* now state is FALSE*) END Decrement. **DEFINITION** declaration R

Description DEFINITION specifies to the compiler that a compilation

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unit is the definition part of a library module.

Usage **DEFINITION MODULE** myMod

Comments The definition module is the »visible« part of a library module that can be imported into other modules. In the definition module *myMod* you will find all the declarations necessary to use the facilities of *myMod*.

> Every definition module will have a corresponding implementation module that contains the hidden parts of that module. It will contain all executable code, as well as those definitions relevant only to the internal operation of the module.

> All identifiers mentioned in a definition module are exported. The identifiers are exported in qualified mode; although, in most cases, they will be dequalified using the FROM clause in the module that imports them.

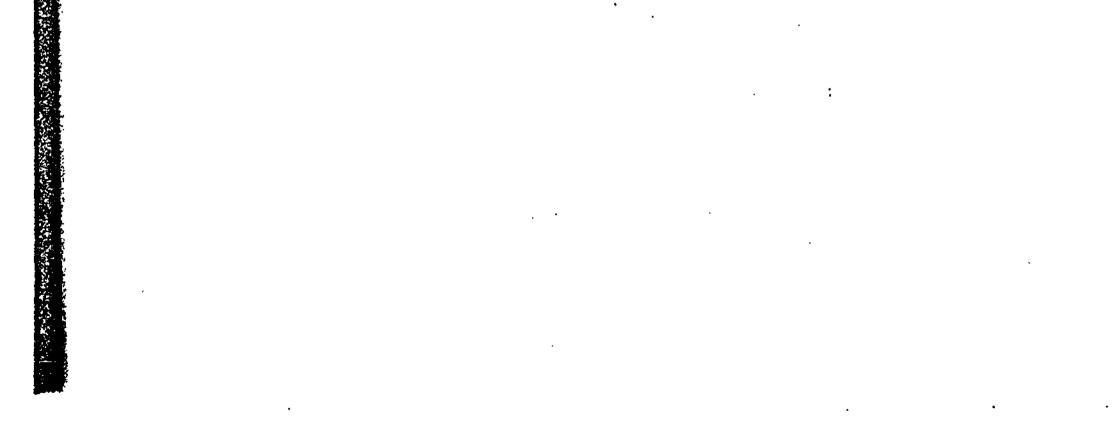
> There is no code in a definition module. The compiler simply produces a symbol table file that can later be used to do typechecking.

Definition modules usually reside in files with the extension .DEF. Compilation results in the creation of a file with the extension .SYM.

The definition module cannot have the compilation unit in the same file; thus definition modules and implementation modules must be in separate files. The resulting .SYM and .MCD files can be combined, however, into a .LIB file using the Turbo Modula-2 librarian.

See Also

IMPLEMENTATION MODULE



Example A simple user-definition module in file 'SIMPLE.DEF':

DEFINITION MODULE SimpleMath;

PROCEDURE ADD(y,z : INTEGER): INTEGER;

END SimpleMath.

The corresponding implementation module in file 'SIM-PLE.MOD':

IMPLEMENTATION MODULE SimpleMath;

PROCEDURE ADD(y,z :INTEGER) :INTEGER; BEGIN RETURN (y+z); END Add;

END SimpleMath.

DELETE procedure (Files) L

Description Delete erases a file from disk.

Declaration PROCEDURE Delete(VAR f: FILE);

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Usage Delete(f)

Delete must be imported from the library module Files.

f must be an open file of type FILE imported from Files.

Comments

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The file must have already been successfully opened.

The file is closed when it is deleted, thus its buffers are freed.

See Also	Close Files Open Rename
Example	Delete the file 'SCRATCH.SCR' from disk:
	<pre>MODULE deleteFile; FROM Files IMPORT FILE, Open, Delete; VAR f: FILE; BEGIN IF Open(f,'SCRATCH.DAT') THEN Delete(f) END END deleteFile.</pre>
DELETE proc	edure (Strings) L
Description	Delete deletes a substring from a string.
Declaration	PROCEDURE Delete (VAR str. ARRAY OF CHAR.

Declaration **PROCEDURE** Delete(VAR str: ARRAY OF CHAR; inx,len: CARDINAL);

Usage Delete(str, from, length)

Delete must be imported from the library module Strings.

from and length must be of type CARDINAL.

str must be a character array variable.

Comments The counting starts from 0, so the user's strings should be declared starting from 0.

See Also

Insert Pos Strings

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Example

Delete (»Lover«, 0, 1) will yield the string »over«.

DeleteLine procedure (Terminal) L

Description DeleteLine deletes the cursor line completely and to fill the gap moves up all following lines by one.

Declaration **PROCEDURE** DeleteLine;

Usage DeleteLine;

DeleteLine must be imported from the library module Terminal.

Comments The current cursor line will be deleted. (This can be set by the procedure *GotoXY* in *Terminal*.) Since the cursor position on a screen is undefined after certain operations, the only way to determine the current cursor position is by keeping track of it yourself.

This function will work only if the Turbo Modula-2 system has been installed on your terminal.

A program can determine if the option has been installed by examining the set variable *Available* exported by *Terminal*. If *insertDelete* IN *Available* is TRUE, then these functions are available as installed on the current terminal.

See GotoXY for a map of the screen coordinates.

See Also

GotoXY InsertLine Terminal

Example Delete the twelfth line from the top:

GotoXY(0,11);
DeleteLine;

DeviceError exception (Files) L/E	
Description	DeviceError is raised by the <i>Files</i> module when a write opera- tion on a file is impossible because the disk has a bad sector.
Declaration	EXCEPTION DeviceError;
Usage	EXCEPTION <pre>DeviceError: WRITELN('File error');</pre>
(END
	DeviceError must be imported from the module Files.
Comments	Use the DeviceError exception to prevent your program from crashing when the program encounters a bad disk.
See Also	EndError
	StatusError
	UseError
	DiskFull
Example	MODULE WriteFile;
	FROM Files IMPORT
	FILE, Create, WriteWord, Close, EndError,
	StatusError, UseError, DeviceError;
	VAR f: FILE; c: CARDINAL;
	BEGIN
	Create(f,'testfile.dat');
	WriteWord(f,c);
	Close(f)
	EXCEPTION
	FrdError. WRITELN(IEnd of file reached !).

EndError: WRITELN('End of file reached.'); Close(f) | StatusError: WRITELN('Error file not opened');

I UseError : WRITELN('Disk not logged in.');

I DeviceError: WRITELN('Error writing disk:

bad sector');
END WriteFile.

DiskFull exception (Files) L/E

Description	DiskFull is raised by the <i>Files</i> module when a write or close operation on a file is impossible because the disk or directory is full.
Declaration	EXCEPTION DiskFull;
Usage	EXCEPTION DiskFull: WRITELN('File error'); END DiskFull must be imported from the module Files.
Comments	Use the DiskFull exception to prevent your program from crashing when the program encounters a full disk.
See Also	EndError StatusError UseError DeviceError

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Example

```
MODULE WriteFile;
FROM Files IMPORT
 FILE, Create, WriteWord, Close, EndError,
 StatusError, UseError, DeviceError, DiskFull;
VAR f: FILE; c: CARDINAL;
BEGIN
 Create(f,'testfile.dat');
 WriteWord(f,c);
 Close(f)
EXCEPTION
   EndError: WRITELN('End of file reached.');
   Close(f)
  StatusError: WRITELN('Error file not opened');
E
 UseError : WRITELN('Disk not logged in.');
  DeviceError: WRITELN('Error writing disk: bad
L
   sector');
  DiskFull: WRITELN('This disk is FULL, buddy!');
END WriteFile.
```

DISPOSE standard procedure (STORAGE) S

other way.

 Description
 DISPOSE deallocates a dynamic variable from the heap.

 Usage
 DISPOSE(p)

 or
 DISPOSE(p, tag1, tag2, ... tagn)

 To use this procedure, DEALLOCATE must be imported from the library module STORAGE, or it must be defined in some

p must be a pointer to a variable.

tagl,... tagn are relevant if the type of the variable is a tagged variant record.

Comments	DISPOSE is essentially an abbreviated DEALLOCATE com- mand. If, for example, p is of type POINTER TO LONGREAL, then DISPOSE(p) will be equivalent to DEALLOCATE(p, TSIZE(LONGREAL)).
	p must point to a variable that has been previously allocated using either ALLOCATE or NEW.
	Care must be taken when using DISPOSE and DEALLOCATE together with MARK and RELEASE.
	When variant records are allocated using a tag field, you should use the same tag when disposing of that record.
See Also	DEALLOCATE
	MARK
	NEW
	RELEASE
	STORAGE
Example	Allocate a variable and use it:
	MODULE Dispose;
	VAR
	p1, p2, p3: POINTER TO REAL;
•	BEGIN
	NEW(p1);
	NEW($p2$);
	NEW(p3);
	(* use them *)
	DISPOSE(p2);
	DISPOSE(p3);

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DISPOSE(p1) END Dispose.

DIV standard operator R

Description	DIV is an integer division operator; it is a binary operator that works on operands of the same type. The operands may be both CARDINAL, both INTEGER, or both LONGINT.
Usage	i := i DIV j;
	where <i>i</i> and <i>j</i> are of the same type.
(The result of the expression is the same type as the operands.
Comments	Integer division is useful when you do not care about the frac- tional parts of a quotient.
See Also	MOD
Example	MODULE IntegerDivision; VAR

i,j : INTEGER; c,d : CARDINAL; l,m : LONGINT; BECIN i := 1; c := 1; i := 30 DIV i; c := d DIV c; 1 := m **DIV** 344212L; **END** IntegerDivision.

Done procedure (InOut) L

Description Done checks for successful completion of input.

Declaration **VAR** Done: BOOLEAN;

Usage

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IF Done THEN DoSomething END ;

Done must be imported from the library module InOut.

Comments	Done allows a program to check for valid input b ceeding. Each of the input procedures in InOut set follows:	-
	ReadDone := Not past end of inputReadStringDone := The returned string is notReadIntDone := Integer was readReadCardDone := Cardinal was read	empty
See Also	Texts	
Example	Get a number from the user:	
	<pre>MODULE ReadInteger; FROM InOut IMPORT Done, ReadInt; BEGIN REPEAT WRITE('Gimme a number>'); ReadInt(i) UNTIL Done; END ReadInteger.</pre>	

Done procedure (Texts) L

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Description	Done checks for successful completion of numeric input.
Declaration	PROCEDURE Done(t: TEXT): BOOLEAN;
Usage	okay := Done(t)

Done must be imported from the library module Texts.

t must be of type TEXT imported from the library module Texts.

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Comments	<i>Done</i> allows the program to check for valid numeric input before proceeding.
	<i>Done</i> is a function returning TRUE if the numeric input is both syntactically correct and the input number is in the valid range for the type being read; otherwise FALSE is returned.
See Also	Texts
Example	Get a number from the user:
(MODULE DoneInput;
	FROM Texts IMPORT Done;
	BEGIN
	REPEAT
	WRITE('Gimme a number>');
	READ(num);
	UNTIL Done(input);
	END DoneInput.

DOUBLE standard function S

Description	DOUBLE converts the argument to type LONGREAL.
Usage	Y := DOUBLE(X)
,	Argument X is of type CARDINAL, INTEGER, LONGINT, or REAL.
(The result Y is of type LONGREAL.
Comments	Do not confuse this function with the LONGREAL type-

transfer function, which transfers data without converting it.

See Also

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<u>}</u>

FLOAT LONGREAL TRUNC

Example	MODULE Doubles; VAR Converted: LONGREAL;
	r: REAL; BEGIN
	<pre>r := 234.234; Converted := DOUBLE(r); END Doubles.</pre>

Doubles L	
Description	<i>Doubles</i> is a library module that provides string handling and I/O support for double-precision variables.
Declaration	DEFINITION MODULE Double FROM Texts IMPORT TEXT;
	VAR legal :BOOLEAN
	<pre>PROCEDURE ReadDouble (t: TEXT; VAR d: LONGREAL); PROCEDURE WriteDouble (t: TEXT; d: LONGREAL; width: CARDINAL; digits: INTEGER);</pre>
·	<pre>PROCEDURE StrToDouble(VAR s: ARRAY OF CHAR; d: LONGREAL); PROCEDURE DoubleToStr (s: ARRAY OF CHAR; VAR d: LONGREAL);</pre>
	END Doubles.

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This module provides conversions for LONGREALs, which are similar to the ones that *Convert* and *Texts* provide for the standard types in Modula-2.

DoubleToStr procedure (Doubles) L	
Description	<i>DoubleToStr</i> converts a double-precision variable to a string variable.
Declaration	<pre>PROCEDURE DoubleToStr (d: LONGREAL; VAR s: ARRAY OF CHAR; digits: INTEGER);</pre>
Usage	DoubleToStr(d, s, digits)
	DoubleToStr must be imported from the library module Doubles.
	s must be a character array variable.
	d must be of type LONGREAL.
See Also	Doubles StrToDouble
Example	Convert a double-precision number into a string:
	<pre>d := 2.99D10; DoubleToStr(d, str, 15);</pre>
END R	· ·
Description	END marks the end of the scope of a control structure, pro- cedure, or module.

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or

END pname

Comments	In the case of a control structure (IF, WITH, WHILE, or CASE), the END stands alone. In the case of a module or procedure, the END statement is followed by the name of the module of procedure it terminates. A semicolon is never needed before an END.
Example	MODULE endexample;
	BEGIN (* Main *)
	IF appropriate THEN DO

.

WITH SomeRecord DO (* code *) END END END endexample.

EndError exce	ption (Files) L/E
Description	EndError is raised by the <i>Files</i> module when an attempt is made to read past the end of the file.
Declaration	EndError;
Us age	EXCEPTION EndError: WRITELN('END OF FILE'); END
	EndError must be imported from the module Files.
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Comments Use the EndError exception to prevent your program from crashing from user input.

See Also

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StatusError UseError DeviceError DiskFull Example MODULE ReadFile; FROM Files IMPORT FILE, Open, ReadWord, Close, EndError; VAR f: FILE; c: CARDINAL; BEGIN IF Open(f,'testfile.dat') THEN LOOP ReadWord(f,c); END END; END; END; END; END EndError: WRITELN('End of file reached.'); Close(f) END ReadFile.

Entier function (MathLib, LongMath) L

Description	<i>Entier</i> returns the integer part of a real number rounded toward negative infinity.
Declaration	<pre>PROCEDURE Entier(x: REAL): INTEGER; PROCEDURE Entier(x: LONGREAL): LONGINT;</pre>
Usage	Y:= Entier(X)
	Argument X is REAL or LONGREAL.
	Result Y is INTEGER or LONGINT.
Comments	The Turbo Modula-2 predefined function <i>INT</i> can convert any numeric type to INTEGER; for example:
	Entier(-3.5) = -4

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INT(-3.5) = -3

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Example	MODULE EntierTest;
	IMPORT MathLib;
	IMPORT LongMath;
	VAR
	Round: INTEGER;
	Number: REAL;
	LongRound: LONGINT;
	LongNumber: LONGREAL;
	BEGIN
	Round:= MathLib.Entier(Number + 0.5);
	<pre>LongRound := LongMath.Entier(LongNumber + 0.5</pre>
	END EntierTest.

EOF function (Files) L	
Description	EOF returns true if the file pointer is at the end of the
Declaration	PROCEDURE EOF(f: FILE): BOOLEAN;
Usage	endOF := EOF(f)
	EOF must be imported from the library module File:
	f must be of type FILE imported from Files.
Comments	This is the normal way to detect the end of defined data a file.
See Also	Close Files Open

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Example	Open a file and process it:
	MODULE EndOfFile;
	FROM Files IMPORT FILE, Open, ReadRec, EOF;
	VAR
	f: FILE;
	data : ARRAY [099] OF REAL;
	BEGIN
	IF Opn(f, "Numbers.dat") THEN
	WHILE NOT EOF(f) DO
	ReadRec(f,data);
	(* Code to process data *)
	END
	END
	END EndOfFile.
EOL constant Description	(Texts) L EOL holds the value of the end-of-line character, 36C or 30 decimal.
Declaration 	CONST
	EOL = 36C;
Usage	ch := EOL;
	ch must be defined as a CHAR.
	EOL must be imported from the module Texts.
Comments	The procedures in the module <i>Texts</i> convert the carriage- return/line-feed sequence to and from the <i>EOL</i> character. When input, the carriage-return/line-feed sequence is con-

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onverted to an EOL character; and when output, the EOL character is converted to a carriage-return/line-feed pair. Thus in a program-processing text file, the end of line is marked with the EOL character.

See Also	Texts
Example	MODULE EndOfTheLine; FROM Texts IMPORT EOL; VAR ch: CHAR; BEGIN REPEAT READ(ch) UNTIL ch=EOL; END EndOfTheLine.

EOLN procedure (Texts) L

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Description	EOLN returns TRUE if the TEXT file is at the end of a line.
Declaration	PROCEDURE EOLN(t: TEXT): BOOLEAN;
Usage	endOL := EOLN (t)
	EOLN must be imported from the library module Texts.
	t must be of type TEXT imported from Texts.
	endOL must be of type BOOLEAN.
Comments	EOLN returns TRUE if the last character read from t is an EOL character.
See Also	EOT Texts
Evenale	Dead all abarrators will the and of the line is an asymptoted.

Example

Read all characters until the end of the line is encountered:

REPEAT ReadChar(t,ch); UNTIL EOLN(t);

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EOT procedure (Texts) L

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Description	EOT returns TRUE if the TEXT file is at its end.
Declaration	PROCEDURE EOT(t: TEXT): BOOLEAN;
Usage	EndOfText := EOT (t)
	EOT must be imported from the library module Texts.
(t must be of type TEXT imported from Texts.
	EndOfText must be of type BOOLEAN.
Comments	EOT returns TRUE if the last character read from t is an EOT character (for example, Control-Z or 32C).
	Notice there is no <i>EOT</i> character defined in Turbo Modula-2; it is reserved for the function described here. Note that sometimes the 32C character is referred to as <i>EOT</i> . Also note that the EOT character on other systems may not be 32C.
See Also	EOF EOLN Texts
Example	Read all characters until the end of the TEXT file t is encountered:
	REPEAT ReadChar(t,ch); UNTIL EOT(t)



EXCEPTION	R
Description	EXCEPTION is used to declare exception identifiers and t declare code to trap exceptions when they occur.
Usage	Exception Declarations
	MODULE deviceHandler; EXCEPTION ex1, ex2, ex3; (* Exception declaration *
	PROCEDURE dev1; BEGIN (* code with RAISEs *) END dev1;
	END devicehandler;
	Exception Handlers
•	<pre>MODULE deviceMonitor; IMPORT ex1,ex2,ex3; BEGIN dev1; (* Invoke a procedure with RAISEs *) EXCEPTION ex1: (* ex1 code *) ex2: (* ex2 code *) ex3: (* ex3 code *) ELSE (* other code *) ELSE (* other code *)</pre>

The first module declares exceptions and code that will ra the exceptions in error situations. The second module call:

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procedure that may raise an error; therefore, it declares exce tion handlers to catch and process the errors. Į

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Comments Exceptions are particularly useful in the event of a program crash; for instance, if you need to turn off a laser, or switch out of graphics mode. It is possible to do this with the Turbo Modula-2 system, because the runtime system can take over (in most cases) when something catastrophic happens to your logic. The ELSE clause in the exception handler catches all possible exceptions whether imported or not.

See Also RAISE

Example Declare *PowerFailureImminent* as an exception:

EXCEPTION PowerFailureImminent

Then raise it:

IF ((* some hint *)) THEN RAISE

PowerFailureImminent;

Then handle it:

EXCEPTION PowerFailureImminent: WRITE('Help !)'; **END** someMainModule;

EXCL standard procedure S

Description EXCL excludes element I from the set S.

Usage EXCL(S,I)

Argument S is of set type.

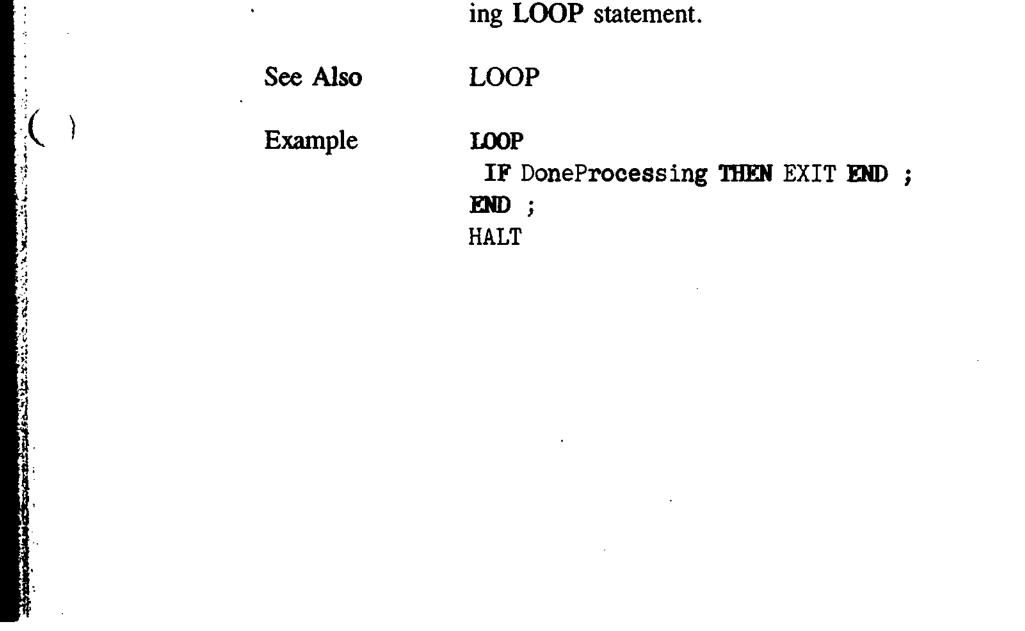
Argument I is of the set's base type.

Comments

This standard procedure allows you to remove an element from a set. This has the effect of turning off a bit in the word that represents the set.

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See Also	BITSET INCL SET
Example	<pre>MODULE Exclude; TYPE Day = (Sun,Mon,Tues,Wed,Thu,Fri,Sat);</pre>
	<pre>VAR Work: SET OF Day; BEGIN Work:= Day{MonFri}; (* Set Work contains five elements Mon to Fri *) EXCL(Work,Fri); (* Set Work contains four elements, Wed excluded</pre>

EXIT statement	R
Description	EXIT enables you to exit from a LOOP statement.
Usage	KXIT
Comments	EXIT jumps to the statement following the END of the encing LOOP statement.
See Also	LOOP
Example	LOOP IF DoneProcessing THEN EXIT END ; END ;



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}

ExitScreen procedure (Terminal) L		
Description	<i>ExitScreen</i> sends a terminal reset string after a series of screen operations, if needed.	
Declaration	PROCEDURE ExitScreen;	
Usage	ExitScreen;	
	ExitScreen must be imported from the library module Ter- minal.	
Comments	This function will work only if the Turbo Modula-2 system has been installed on your terminal.	
	Many terminals don't need or have a reset string. If this is the case with your terminal, the function will do nothing.	
Example	Send a terminal reset string:	
	BEGIN	
	(* Lots of screen operations *)	
	ExitScreen	
	END	
Exp function (M	IathLib, LongMath) L	
Description	Exp returns the natural exponential of X.	
Declaration	PROCEDURE Exp(x: REAL): REAL;	

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PROCEDURE Exp(x: LONGREAL): LONGREAL;

Usage

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Argument X and result Y are both REAL or both LONGREAL.

Comments	Be certain that argument X is less than 87.4 for single- preci- sion numbers and less than 710.47 for double-precision numbers; otherwise, the ArgumentError exception is raised.
	The inverse of the exponential function is the natural logarithmic function <i>Ln</i> .
	If you need to calculate X to the power of Y , you can use the <i>Exp</i> and <i>Ln</i> functions in the following expression:
	XPowerY:= Exp(Ln(X) * Y)
See Also	LongMath MathLib
Example	<pre>MODULE Exp; FROM MathLib IMPORT Exp; VAR Argument,Result:REAL BEGIN IF Argument < 87.4 THEN Result:= Exp(Argument) END ; END Exp.</pre>

EXPORT R

Description EXPORT specifies which identifiers inside a module are to b visible in the scope surrounding the module.

Usage EXPORT var1, var2, type1, type2, proc1, proc2

IMPORT and **EXPORT** lists must appear immediately after Comments the MODULE statement and before any constant, variable, type, or procedure declarations. Names identifying constants, variables, types, exceptions, and procedures may be exported. Modules may not be exported. Everything in a definition module is exported; thus no export list is required. Nothing in an implementation module may be exported, unless it has been previously exported by its definition module. Nothing may be exported by a main module since there is nothing to export to. Consequently, export lists really only make sense in local modules or in modules that are embedded inside of a main module, procedure, or an implementation module. Example local's beans is visible to main, but its rice is not: MODULE main; MODULE local; **EXPORT** beans; VAR rice, beans: BOOLEAN; BEGIN (* code to set rice and beans *) END local;

(* Any code here cannot see rice, only beans *)

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END main.

FALSE standard value S

Descriptio n	FALSE denotes the Boolean state of falsity.
Usage	Finished := FALSE;
	Finished is a variable of type BOOLEAN.
Comments	The ordinal value of FALSE is 0; thus, WRITE(CAR- DINAL(FALSE)) will print a 0. In contrast, the ordinal value of TRUE is 1; thus, truth is greater than falsity.
See Also	BOOLEAN TRUE
Example	<pre>MODULE Falsity; VAR b: BOOLEAN; BEGIN REPEAT b := FALSE UNITIL b; (* repeats forever *) END Falsity.</pre>

FILE type (Files) L

Description FILE is an opaque type representing a low-level file. Variables of type FILE may represent illegible streams and random access files.

Declaration **TYPE** FILE;

Usage

f: FILE;

VAR

FILE must be imported from the module Files.

Comments Use *FILE* when you are working with files that are not strictly ASCII characters or if you do not want to interpret the contents of the file.

See Also	Files TEXT Texts
Example	<pre>MODULE FileExists; FROM Files IMPORT FILE, Open, Close; VAR f: FILE; BEGIN IF Open(f,'testfile.dat') THEN Close(f); WRITELN('File exists.'); ELSE WRITELN('File does not exist.'); END ; END FileExists.</pre>

Files module	L	
Description	Files facilitates the ha	ndling of disk files.
Declaration	DEFINITION MODULE I FROM SYSTEM IMPORT	Files; BYTE WORD, ADDRESS;
	TYPE FILE;	
	PROCEDURE Open	(VAR f: FILE; name: ARRAY OF CHAR): BOOLEAN
	PROCEDURE Create	(VAR f: FILE; name: ARRAY OF CHAR);
(PROCEDURE Close	(VAR f: FILE);
(PROCEDURE Delete	(VAR f: FILE);
	PROCEDURE Rename	(VAR f: FILE; name:
		ARRAY OF CHAR);

.

PROCEDURE GetName (f: FILE; VAR name: ARRAY OF CHAR);

PROCEDURE	FileSize	(f: FILE): LONGINT;
PROCEDURE	EOF	(f: FILE): BOOLEAN;
PROCEDURE	ReadByte	(f: FILE; VAR b:BYTE);
PROCEDURE	ReadWord	(f: FILE; VAR w: WORD);
PROCEDURE	ReadRec	(f: FILE;
		VAR rec: ARRAY OF WORD);
PROCEDURE	ReadByt es	(f: FILE; buf: ADDRESS;
		<pre>nbytes: CARDINAL): CARDINAL;</pre>
PROCEDURE	WriteByte	(f: FILE; b:BYTE);
PROCEDURE	WriteWord	<pre>(f: FILE; w: WORD);</pre>
PROCEDURE	WriteRec	(f: FILE;
		VAR rec: ARRAY OF WORD);
PROCEDURE	WriteByte s	(f: FILE; buf: ADDRESS;
		nbytes:CARDINAL);
PROCEDURE	Flush	(f: FILE);
PROCEDURE	NextPos	(f: FILE): LONGINT;
PROCEDURE	SetPos	(f: FILE; pos:LONGINT);
PROCEDURE	NoTrailer	(f: FILE);
PROCEDURE	ResetSys()	;
		
EXCEPTION	-	tatusError, UseError,
	DeviceErroi	r, DiskFull;
END Files.	•	
This libror	module nort	orme low level dick access
rins norary	module per	forms low-level disk access.
Texts		
InOut		

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Comments

See Also

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Also see individual identifiers declared in the module Files.

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FileSize procedure (Files) L

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Description	FileSize gets the exact size of the file in bytes.
Declaration	<pre>PROCEDURE FileSize(f: FILE): LONGINT;</pre>
Usage	<pre>nbytes := FileSize(f)</pre>
	FileSize must be imported from the library module Files.
	nbytes must be of type LONGINT.
	f must be of type FILE imported from Files.
Comments	Turbo Modula-2 uses the last byte of the last record (all CP/M files have 128 bytes per record) to store the number of bytes actually used in this record. This number is added to the number of bytes in the previous records ((<i>nrecs-1</i>)*128) to determine the actual file size in bytes. This processing of the last byte can be turned off by a call to <i>NoTrailer</i> , but then <i>FileSize</i> will only return sizes in 128-byte multiples.
See Also	FILE Files NoTrailer
Example	To see just how big widgetFile is, do the following:
	<pre>MODULE FileSizes; FROM Files IMPORT FILE, Open; VAR nbytes: LONGINT; widgetFile: FILE;</pre>

```
widgetFile: FILE;
BEGIN
IF Open(widgetFile, "widgets.dat") THEN
nbytes := FileSize(widgetFile)
END
END FileSizes.
```

FILL procedure (SYSTEM) L

Description FILL fills a block of memory with a given byte.

Declaration PROCEDURE FILL(adr: ADDRESS; len: CARDINAL; val: BYTE);

Usage FILL(start, nbytes, ch)

FILL must be imported from the library module SYSTEM.

start must be of type ADDRESS imported from SYSTEM.

nbytes must be of type CARDINAL.

ch must be of type BYTE imported from SYSTEM.

Comments The block of memory between *start* and the address *start* + nbytes -l is filled with the byte value ch.

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Example Fill the array *Sieve* with the value TRUE:

VAR Sieve: ARRAY [0..8191] OF BOOLEAN; BEGIN

FILL(ADR(Sieve), 8192,TRUE);

firstDrive variable (Loader) L

Description

See Also

firstDrive contains the first disk drive to be searched when looking for overlay files.

Declaration

VAR

firstDrive: [0..15];

Usage	<pre>firstDrive := currentDrive;</pre>
	firstDrive must be imported from the module Loader.
	currentDrive is a CARDINAL in the range 0 to 15.
Comments	Once the location of the overlay files has been found you may speed up load time by ensuring that <i>firstDrive</i> is set to the correct drive number.
e Also	Loader
Example	<pre>MODULE LoadOverlay; FROM Loader IMPORT firstDrive, Call; BEGIN firstDrive := 13; (* Search ram disk (M:) first *) Call('overlay.fil') END LoadOverlay.</pre>
FLOAT standard	function S

Description	FLOAT converts argument X to REAL.
Usage	Y := FLOAT(X)
	Argument X can be of type INTEGER, CARDINAL, LONGINT, or REAL.
	The argument must be in the REAL range -1E38 to 1E38.
	Result Y is of type REAL.
Comment	

Comments

-6.80564E38 to +6.80564E38; otherwise, an overflow error will occur, causing the exception OVERFLOW to be raised.

Example	VAR Count:CARDINAL
	Time:REAL
	BEGIN
	<pre>Time:= Time + 0.1 * FLOAT(Count);</pre>
	FND

Flush procedure (Files) L

Description	Flush flushes the file's internal buffer to disk.
Declaration	PROCEDURE Flush(f: FILE);
Usage	Flush(f)
	Flush must be imported from the library module Files.
	f must be of type FILE imported from Files.
Comments	In order to speed up the input and output to disk files, most computers maintain a file buffer for each open file. In a write operation this buffer is not normally »flushed« until the buffer is full. The <i>Flush</i> command forces this process.
	This function can be used to detect write errors (like DiskFull) sooner than they would otherwise appear. (They do not usually appear until the internal file buffer is full and the Turbo Modula-2 sytem orders a flush.)
See Also	Files
Example	Force a DiskFull error at the record where it occurs:

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FOR i := 1 TO nrecs DO
 WriteRec(f, widget[i]);
 Flush(f);
END ;

FOR statement R

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Description FOR repeats the execution of a sequence of instructions a specified number of times.

Usage FOR ControlVar := StartExp TO EndExpr [BY Step] DO <Statement> {; <Statement> } END

ControlVar is of type CARDINAL, INTEGER, CHAR, enumeration, or subrange. It must not be imported, nor be a procedure parameter or a structured variable's component.

StartExp and EndExp are single values or expressions of the same type as the control variable.

Step is a constant expression of type CARDINAL or IN-TEGER.

Comments The FOR statement repeatedly executes the statement sequence for a progression of control variable values. It begins with the value of the start expression and increments by the value *Step* until the control variable is equal to or greater than the value given by the end expression. If you do not specify a step value, it is assumed to be 1.

As defined in the syntax section, the start and end values can be the results of expressions.

FOR Y:= X TO X + N BY Ramp DO

A FOR statement cannot be exited before its normal termination. If you want to do this, you can use the REPEAT or WHILE statements instead.

Example	FOR X:= 0 TO 10 BY 2 DO
	(* Some statement seque nce *)
	END

This example repeats the statement sequence six times, with X equal to the values 0, 2, 4, 6, 8, and 10. You can use X in the statement sequence, but you cannot alter its value. For example, you can do the following:

```
FOR Count:= 5 TO 3 BY -1 DO
T:= 2 * Count + 4
END
```

This example is repeated three times for descending values of *Count* equal to -5, -4, and -3.

FORWARD s	tatement R
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Description	FORWARD allows a procedure to be referenced before it is
	defined.

Usage PROCEDURE foo(): CARDINAL; FORWARD ;

foo is a procedure or a function heading followed by the reserved word FORWARD.

The body of *foo* is given after a normal procedure heading for *foo*.

CommentsThe FORWARD statement allows Turbo Modula-2 to imple-
ment mutual recursion in a one-pass compiler environment.
This statement was not defined in the original definition, but

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is needed for a one-pass implementation of the compiler.

Example

MODULE Recurring;
PROCEDURE one; FORWARD ;

PROCEDURE two;
BEGIN
one; (* Call of procedure before it is defined *)
END two;

PROCEDURE one;
BEGIN
two;
END one;

BEGIN

one; END Recurring.

FREEMEM procedure (STORAGE) L

Description FREEMEM finds out how much contiguous dynamic memory (heap space) is available.

Declaration **PROCEDURE** FREEMEM(): CARDINAL;

Usage freeman := FREEMEM()

FREEMEM must be imported from the pseudomodule STORAGE.

freeman must be of type CARDINAL.

Comments This function returns the number of bytes between the heap pointer and the current top of the runtime stack. The sizes of holes in the allocated heap is not taken into account.

See Also ALLOCATE DEALLOCATE STORAGE OUTOFMEMORY

Example	WRITELN('There are ',FREEMEM(),' bytes free on the heap');
	ALLOCATE(p, 2000); WRITELN('and now there are 2000 less:', FREEMEM());

GetName	procedure ((Files)	L
---------	-------------	---------	---

Description	GetName retrieves the name of an open file.
Declaration	<pre>PROCEDURE GetName(f: FILE; VAR name: ARRAY OF CHAR);</pre>
Usage	GetName(f, fname)
,	GetName must be imported from the library module Files.
	f must be of type FILE imported from Files.
	fname must be a character array variable.
Comments	This procedure allows library modules to determine the nam of a file when only the file variable has been passed.
See Also	Create FILE Files Open
Example	Get the name of file f:

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GotoXY procedure (Terminal) L		
Description	GotoXY positions the cursor on the screen.	
Declaration	<pre>PROCEDURE GotoXY(x,y: CARDINAL);</pre>	
Usage	GotoXY(col, row)	
	GotoXY must be imported from the library module 7	Terminal.
	col and row must be of type CARDINAL.	
Comments	This function will only work if Turbo Modula-2 has be perly installed on your system.	een pro-
	0, 0 is the upper left-hand corner 79,23 is the lower right-hand corner	
	(0,0) col	(79,0)
row		
	(0,23)	(79,23)
See Also	ClearScreen ClearToEOL DeleteLine	



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InsertLine Highlight Normal Terminal Example Put an 'X' in the upper right-hand corner:

GotoXY(79,0); WriteChar('X');

HALT standard procedure S

Description HALT stops program execution.

Usage HALT

Comments The *HALT* procedure terminates execution of the program and returns you to Turbo Modula-2 or the operating system, depending on where the program execution originated from.

HALT is a standard Modula-2 procedure; a nonstandard way to stop a program and deliver an error message to the terminal is available with the *RAISE* command.

See Also RAISE

Example VAR ErrorCondition:BOOLEAN BEGIN IF ErrorCondition THEN HALT END ;

haltOnControlC variable (Texts) L

Description haltOnControlC holds the current mode of operation o Control-C during console input and output.

DeclarationVARhaltOnControlC: BOOLEAN;

States and the

haltOnControlC := FALSE;
haltOnControlC is a predefined variable that must be imported from the module Terminal.
This variable is useful for preventing a user from stopping a program.
The default value of <i>haltOnControlC</i> is TRUE, which means that the user can press Ctrl C during an <i>input</i> statement or a <i>WRITELN</i> statement to halt the program.
Note that the only output procedure that checks for the Control-C character is the WriteLn procedure. Thus, programs that do not use a WriteLn (or WRITELN) statement cannot be interrupted.
Texts
<pre>MODULE HaltTheProgram; FROM Texts IMPORT haltOnControlC; VAR I: CARDINAL; BEGIN FOR I := 1 TO 20 D0 WRITELN('Press control C to stop the program ') END ; haltOnControlC := FALSE; FOR I := 1 TO 20 D0 WRITELN('You cannot stop me now ') END ; END ; END ; END HaltTheProgram.</pre>

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HIGH standard function S		
Description	To HIGH returns the high-index bound of array A.	
Usage	Y:= HIGH(A)	
	Argument A is an array of any index and component type.	
	Result Y is of the same type as the index type.	
Comments	This function allows you to find the upper index of any array for example, an array defined as	
	Move: ARRAY (Left,Right,Stop) OF INTEGER;	
	has an upper index Stop.	
	Note that for multidimensional arrays, the upper index of the first dimension is returned. For example, if you have define an array as	
	MultiDim: ARRAY [1020],(Left,Right,Stop) OF CHAR	
	the HIGH function will return the result 20, which is the hig index of the first dimension.	
	You can also find the other dimensions as well; for exampl if you have defined	
	MultiDim: ARRAY [010] OF ARRAY [020] OF WORD:	

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then HIGH(MultDim) = 10 and HIGH(MultiDim[0]) = 20

HIGH is very useful for finding the upper bound of an operarray parameter. The lower bound is always zero and the upp bound is HIGH(a) where a is an open array parameter.

See Also ARRAY

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Example

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MODULE High; TYPE Weather = (Clear, Rain, Wind, Snow); Day

= (Mon,Tue,Wed,Thu,Fri,Sat,Sun);

= [1..24]Hour

VAR

Forecast: ARRAY Day, Hour OF Weather;

HighForecast: Day;

HighHour: Hour

BEGIN

```
HighForecast:= HIGH(Forecast);
(* HighForecast is value Sun *)
HighHour:= HIGH(Forecast[Sun]);
```

```
(* HighHour is 23 *)
```

```
END High.
```

Highlight procedure (Terminal) L

Description Highlight turns on highlighting (brightens text) for terminal output.

Declaration PROCEDURE Highlight;

Usage Highlight

Highlight must be imported from the library module Terminal.

Comments Highlight is only possible on systems with screens capable of displaying text in at least two of the following modes: brightness, inverse video, or underlining.

> Highlight will work on your system only after the Turbo Modula-2 system has been properly installed.

Stand-alone programs can see if the terminal they are running on has this capability by checking OpSet for the element highlightNormal.

See Also	Normal Terminal OpSet highlightNormal		
Example	Highlight the words »This text is high«:		
	<pre>Highlight; WriteLn('This text is high '); Normal; WriteLn('And this text is normal ')</pre>		

highlightNormal enumerated value (Terminal) L

Description	highlightNormal is the third value of the enumerated type Ter- minal.SpecialOps.
Declaration	<pre>SpecialOps = (clearEol, insertDelete, highlightNor- mal);</pre>
Usa ge	IF highlightNormal IN available THEN Highlight END;
	SpecialOps must be imported from the library module Ter- minal.
Comments	If this value is a member of the set <i>Terminal.available</i> , then the program may use the procedure <i>Highlight</i> to enhance text written to the screen.
	To use this identifier, include <i>SpecialOps</i> in your import list. The identifiers of each of <i>SpecialOps</i> ' values become visible automatically.

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Highlight available insertDelete clearEol Terminal Example Write some enhanced text: MODULE CheckAvailableOperations; FROM Terminal IMPORT available, SpecialOps, Highlight, Normal; FROM Strings IMPORT CAPS; VAR s: ARRAY [0..20] OF CHAR; BEGIN IF highlightNormal IN available THEN Highlight; WRITELN(s); Normal; ELSE CAPS(s)WRITELN(s); END; END CheckAvailableOperations.

HLRESULT variable (SYSTEM) L

Description	HLRESULT holds the contents of the HL register after a BDOS or BIOS call.
Declaration	VAR HLRESULT: CARDINAL;
Usage	c := HLRESULT;
	HLRESULT must be imported from the pseudomodule SYSTEM.
	c must be of type CARDINAL;

Comments This variable is used to access the register after operating system calls.

See Also	BDOS
	BIOS
	HLRESULT
	SYSTEM
Example	MODULE OperatingSystemCalls;
-	FROM SYSTEM IMPORT BDOS, BIOS, IORESULT, HIRESULT;
	VAR ReadOnlyVector: CARDINAL;
	BEGIN
	BDOS(1,0); WRITE('The character read is
	',CHR(IORESULT));
	BDOS(29,0);
	ReadOnlyVector := HLRESULT;
	END OperatingSystemCalls.

IF statement	R
Description	IF executes a sequence of statements that depend on the result of a BOOLEAN expression.
Usage	<pre>IF BooleanExpression THEN StatementSequence { ELSIF BooleanExpression THEN StatementSequence } [ELSE StatementSequence] END</pre>
•	<pre>StatementSequence = Statement (; Statement)</pre>
Comments	Each Boolean expression is evaluated until one results in TRUE. The associated statement sequence is then executed and the statement ends. If none of the IF or ELSIF expressions yield a TRUE result, the optional ELSE statement sequence is executed.

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Note that Boolean expressions are only evaluated until one is TRUE.

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Example VAR XAxis,YAxis: REAL; BEGIN IF XAxis < 10.0 THEN YAxis:= 2.0 * XAxis ELSIF XAxis < 20.0 THEN YAxis:= XAxis < 20.0 THEN YAxis:= XAxis + 10.0 ELSE YAxis:= 30.0 END ;

IMPLEMENTATION declaration R

Description IMPLEMENTATION marks the begining of the implementation code of a module.

Usage IMPLEMENTATION MODULE moduleName; <declarations> BEGIN <body> END moduleName.



Comments An implementation module always has a definition module, and together they form a library module from which objects can be imported. The definition module contains the declarations of all the exported objects. The implementation module contains the actual code that defines the objects and procedures that are exported.

> An implementation module is a separate compilation unit. In general, it is possible to make a change to an implementation module and recompile it without changing the client modules. Other .MCD files that import objects from the changed module will incorporate those changes without having to be recompiled. This is possible because Turbo Modula-2 programs are linked at runtime when run from the menu shell.

> An implementation module is not normally a stand-alone program (though it can be); it is usually executed by importing its code into a so-called »main module«.

> The main body of code in an implementation module is executed at load time. This is referred to as the initialization section. It is used to set up variables before any client uses that library's services.

See Also

DEFINITION Linker MODULE

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Here's a definition module in the file COMPUTE.DEF: Example

> **DEFINITION MODULE** Compute; VAR PI: REAL;

PROCEDURE Add(Y,Z :INTEGER):INTEGER **PROCEDURE** Sub(Y,Z :INTEGER):INTEGER END Compute.

And here's the corresponding implementation module in file **COMPUTE.MOD:**

IMPLEMENTATION MODULE Compute;

PROCEDURE Add(Y,Z :INTEGER):INTEGER; **RETURN** Y + ZEND Add;

PROCEDURE Sub(Y,Z : INTEGER): INTEGER; **RETURN Y - Z** END Sub;

BEGIN

PI := 3.14159; **END** Compute.

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IMPORT declaration R **IMPORT** specifies which identifiers a module is able to »see Description from another module or the surrounding environment. Usage **IMPORT** identifiers; or FROM moduleName IMPORT identifiers; The first form of IMPORT imports identifiers as a whole.] the identifier is a module, then that module's identifiers mus be qualified. The second form de-qualifies identifiers as they are imported **Comments** IMPORT lists must come immediately after the MODUL declaration and before any constant, variable, type, or pro cedure declarations. In local modules, the IMPORT declarations must come befor the EXPORT declarations. Qualified identifiers can be accessed by prefixing the identific with the module name, followed by a ».«, as : ModuleName.IdentifierName. Note that you need not name the module the same as the fi name. However, the compiler, the linker, and the loader u the first eight characters of the name given in the MODUL heading when searching for symbol files, library code file

and linked overlay files. Thus, we recommend that you alway use the first eight letters of the module name for the actual finame.

See Also EXPORT QUALIFIED Example

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Input the Append procedure from Strings and use it in the following:

```
MODULE SayHello;
FROM Strings IMPORT Append;
VAR
s : ARRAY [0..20] OF CHAR;
BEGIN
s := 'Hello';
Append(' Folks', s);
WRITELN(s);
END SayHello.
```

Import all of Strings and do the same thing you did in the previous example:

```
MODULE SayHello;
IMPORT Strings;
VAR
s : ARRAY [0..20] OF CHAR;
BEGIN
s := 'Hello';
Strings.Append( ' Folks', s); (* Qualified *)
WRITELN(s);
END SayHello.
```

INC standard procedure S

Description INC returns a successor of argument X.

Usage INC(X[,N])

Argument X may be of type INTEGER, CARDINAL, CHAR, BOOLEAN or enumeration.

Optional argument N must be a CARDINAL; it is the increment that will be added to X.

Comments If you add 1 to a CARDINAL value, the result is the value immediately after the original value. With *INC*, you can do the exact same thing with any ordinal type. For example, suppose you have an enumeration variable

VAR Energy: (Kinetic, Potential, Heat);

You can assign any of the three named values to the variable *Energy*. To increment the value of *Energy* to a higher value, use *INC(Energy)*.

Now, you have performed an addition operation on the enumeration variable. You can increment by more than one value as shown in the following examples.

The reverse operation selecting the previous value is performed by the standard procedure *DEC*.

When incrementing a value, you may reach its MAX value; for example, the MAX(CARDINAL) is 65535. You may choose whether or not this situation generates an error by using the overflow compiler switch. This can be done globally or locally. Thus, with overflow checking turned off, as in

VAR

```
i: CARDINAL;
BEGIN
i := MAX(CARDINAL);
(*$0-*)
INC(1);
(*$0+*)
WRITELN(1);
```

END

the *i* would wraparound to *MIN(CARDINAL)*, which is zero, and no error will be generated. If overflow checking has been turned on, then the exception OVERFLOW will be raised. This can be trapped as follows: MODULE inc; FROM SYSTEM IMPORT OVERFLOW; VAR i: CARDINAL; BEGIN (*\$O+*) i := MAX(CARDINAL); INC(i); EXCEPTION OVERFLOW: WRITELN('Trapped overflow error'); END inc.

See Also

Example

TYPE Color = (Red,Orange,Yellow,Green,Blue, Indigo,Violet); VAR Rainbow: Color;

Increment:CARDINAL

BEGIN

DEC

Rainbow:= Red; INC(Rainbow); (* Rainbow has the value Orange *)

```
INC(Rainbow,2);
(* Rainbow has the value Green *)
Increment:= 1;
INC(Rainbow,Increment);
(* Rainbow has the value Blue *)
```



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INCL standard procedure S		
Description	INCL includes element I into the set S.	
Usage	INCL(S,I)	
	Argument S is of set type.	
	Argument I is of the set's base type.	
Comments	This standard procedure allows you to include an element into a set. It has the effect of turning on a bit that represents the element in the word representing the set.	
See Also	EXCL	
Example	<pre>TYPE Day = (Mon,Tues,Wed,Thu,Fri,Sat,Sun); VAR Work: SET OF Day;</pre>	
	BEGIN	
	Work:= Day{MonFri}; (* Set Work contains five elements Mon to Fri *)	
	<pre>INCL(Work,Sun); (* Set Work contains six elements, Sun included *)</pre>	

Init procedure (Processes)LDescriptionInit initializes a SIGNAL variable.DeclarationPROCEDURE Init(VAR s: SIGNAL);

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Init(s)

Init must be imported from the library module Processes.

s must be of type SIGNAL imported from Processes.

This is part of a module that gives a standardized set of cor-Comments outine facilities, as well as a rudimentary form of interprocess communications upon which to base scheduling.

> The three routines Init, SEND, and WAIT work together in the following way: Init initializes a queue belonging to a given signal. Every time a process calls the procedure WAIT with this signal, it will be entered in the queue. When a process calls the procedure SEND with this signal, the first process in the queue will be resumed and will be purged from the queue. A fourth routine, Awaited, returns TRUE if the queue is not empty.

The initialization of a SIGNAL by Init is mandatory.

See Also Awaited **Processes** SEND SIGNAL **StartProcess**

Example Initialize the signal *DonePrinting*:

INIT(DonePrinting)

L InitScreen procedure (Terminal)

Wait

Description InitScreen sends an initialization string to the terminal.

Declaration **PROCEDURE** InitScreen;

Usage

InitScreen

InitScreen must be imported from the library module Terminal.

Comments	InitScreen will send the initialization string specified by t user upon installation of the Turbo Modula-2 system. Ma terminals don't need an initialization string, in which ca nothing happens.				
See Also	EditScreen Terminal				
Example	Initialize the screen:				
	InitScreen;				
inName variable	inName variable (ComLine) L				
Description	inName is a string variable that contains a string found af the input redirection symbol $(<)$ on the command line.				
Declaration	VAR inName: ARRAY [019] OF CHAR;				
Usage	WRITE('Input redirected from ',inName);				
Comments	The redirection symbol and <i>inName</i> will not appear in the t <i>commandLine</i> .				
	inName contains the standard output string CON: if redirection argument has been found on the command lin				
See Also	ComLine inName				

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RedirectOutput

Example MODULE RedirectInput; FROM ComLine IMPORT inName, RedirectInput; FROM Texts IMPORT console; BEGIN RedirectInput; IF inName < > "CON:" THEN WRITE(console,'Input redirected from ',inName); END END RedirectInput.

InOut module L

Description	InOut	performs	input	and	output.
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Usage

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DEFINITION MODULE InOut;

CONST EOL=36C; **VAR** Done:BOOLEAN termCH: CHAR;

PROCEDURE OpenInput(defext: ARRAY OF CHAR);
PROCEDURE OpenOutput(defext: ARRAY OF CHAR);
PROCEDURE CloseInput;
PROCEDURE CloseOutput;

PROCEDURE Read(VAR ch: CHAR);
PROCEDURE ReadString(VAR s: ARRAY OF CHAR);
PROCEDURE ReadInt(VAR x: INTEGER);
PROCEDURE ReadCard(VAR x: CARDINAL);

PROCEDURE Write(ch: CHAR); PROCEDURE WriteLn; PROCEDURE WriteString(s: ARRAY OF CHAR); PROCEDURE WriteInt(x: INTEGER; n: CARDINAL); PROCEDURE WriteCard(x,n: CARDINAL); PROCEDURE WriteHex(x,n: CARDINAL); PROCEDURE WriteOct(x,n: CARDINAL);

PROCEDURE ReadReal(VAR x: REAL); PROCEDURE WriteReal(x: REAL; n,digits: CARDINAL);

END InOut.

Comments This is the original input and output module defined by Wirth It is postulated to be present in every implementation Modula-2 and is included here to maintain compatibility with other implementations.

The module *InOut* is usually implemented using the modu *Texts* with the *input* or *output* text streams.

WriteHex and WriteOct can sometimes prove useful for writin addresses.

IORESULT variable (SYSTEM) L

Description IORESULT holds the contents of the A register after a BDC or BIOS call.

Declaration VAR

IORESULT: CARDINAL;

Usage c := IORESULT;

IORESULT must be imported from the pseudomodu SYSTEM.

c must be of type CARDINAL;

Comments This variable is used to access the register after operati system calls.

See Also BDOS BIOS HLRESULT SYSTEM Ī

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Example MODULE OperatingSystemCalls; FROM SYSTEM IMPORT BDOS,BIOS,IORESULT,HLRESULT; VAR ReadOnlyVector: CARDINAL; BEGIN BDOS(1,0); WRITE('The character read is ',CHR(IORESULT)); BDOS(29,0); ReadOnlyVector := HLRESULT; END OperatingSystemCalls.

INP procedure (SYSTEM) L

Description	INP reads a byte from a given I/O port.
Declaration	PROCEDURE INP(port: WORD): CARDINAL;
Usage	<pre>inByte := INP(port)</pre>
	INP must be imported from the library module SYSTEM.
	inByte must be of type INTEGER or CARDINAL.
	port can be any scalar type compatible with WORD.
Comments	The port, whose number is given by <i>port</i> , is read and the value is placed in <i>inByte</i> .
See Also	OUT SYSTEM
Example	Get a byte by doing the following:

KbdStatus := INP(KbdStatusPort);

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input (Texts)	L
Description	Input is the standard TEXT variable that can be redefined.
Declaration	VAR input: TEXT;
Usage	input
	input must be imported from the library module Texts.
	input is used anywhere an input text is needed.
Comments	<i>input</i> is declared in <i>Texts</i> as a variable of type <i>TEXT</i> and read-only.
	<i>input</i> is always open and is connected to the terminal l default. It operates as if the call
	OpenText(input, CON:)
·	has taken place before the execution of every main modul The call
	CloseText(input)
	reestablishes this connection after input has been redirecte
·	READ and READLN always use input as their default to stream (users may use input without knowing it). On occasio when the user wants to explicitly manipulate the input to string, he will have to import input from Texts.
See Also	input

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See Also input console Texts Example Read aNumber from input: ReadInt(input, aNumber)

Insert procedure (Strings) L		
Description	Insert inserts a substring into a string.	
Declaratio n	<pre>PROCEDURE Insert(substr: ARRAY OF CHAR; VAR str: ARRAY OF CHAR; inx: CARDINAL);</pre>	
Usage	Insert(substr, str, at)	
	substr and str must be of type ARRAY OF CHAR. substr may be a literal, but str must be a variable.	
	at is the index of the destination byte and it must be of type CARDINAL.	
Comments	<i>Insert</i> actually inserts; the old data in <i>str</i> is not overwritten but is moved over in the string.	
See Also	Append Copy Delete Length Pos Strings	
Example	<pre>str := 'This is Modula-2'; substr := 'Turbo '; Insert(substr, str, 8) (* str now is 'This is Turbo Modula-2' *)</pre>	

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insertDelete is the second value of the enumerated type Terminal.SpecialOps.

Declaration SpecialOps = (clearEol, insertDelete, highlightNormal);

Usage	IF insertDelete IN available THEN InsertLine END ;
	SpecialOps must be imported from the library module Ter- minal.
Comments	If this value is a member of the set <i>Terminal.available</i> , then the program may use the procedures <i>InsertLine</i> and <i>DeleteLine</i> to manipulate text on the screen.
	To use this identifier, include <i>SpecialOps</i> in your import list. The identifiers of each of <i>SpecialOps</i> ' values become visible automatically.
See Also	InsertLine DeleteLine available highlightNormal clearEol Terminal

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Example	Insert and delete a line on the screen:
	MODULE CheckAvailableOperations;
	FROM Terminal IMPORT
	available,SpecialOps,
	InsertLine,DeleteLine,GotoXY;
	VAR
	s: ARRAY [020] OF CHAR;
	BEGIN
	IF insertDelete IN available THEN
	GotoXY(0,10);
	InsertLine;
	WRITELN(s);
	GotoXY(0,10);
	DeleteLine;
	ELSE
	GotoXY(0,10);
	(* Clear the line and move everything down *)
	WRITELN(s);
	GotoXY(0,10);
	(* Move everything back up one line *)
	END;
	END CheckAvailableOperations.
InsertLine pr	ocedure (Terminal) L

Description InsertLine inserts a blank line onto the screen at the current cursor position.

Declaration **PROCEDURE** InsertLine;

Usage InsertLine

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InsertLine must be imported from the library module Terminal.

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Comments	This operation is not available on all systems. To determine if the operation is on the current system, inspect the variable <i>Available</i> imported from <i>Terminal</i> . If <i>insertDelete</i> is an ele- ment of the set <i>Available</i> , then insertion and deletion of screen lines can be performed.
See Also	DeleteLine GotoXY Terminal
Example	Insert the text »Here I am« at the sixth line from the top of the screen.
	GotoXY(0,5) InsertLine; GotoXY(0,5); WRITE('Here I am');

INT standard function S

Description INT converts the argument to type INTEGER.
Usage Y:= INT(X)
Argument X can be of type INTEGER, CARDINAL, LONGINT, REAL, and LONGREAL.
The argument must be in the INTEGER range -32768 to 32767.
Result Y is type INTEGER.
Comments When you use this function with a REAL argument, the value

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is truncated (the fractional part removed); thus, a value 12.35 becomes 12.

Example **MODULE** ConvertToInteger; VAR r: REAL; i: INTEGER; BEGIN x := 39.489; i := INT(x) * 10; END ConvertToInteger.

NTEGER standard type S

Description INTEGER is a standard type with variables that can assume whole values between -32768 and 32767. In addition, IN-TEGER can be used as a type-transfer function.

Usage Variable declarations:

VAR

i,j: INTEGER;

Type transfer:

i := INTEGER(65535)

where *i* is an integer. This statement assigns -1 to the integer *i*.

Comments You can use INTEGER variables whenever you know that the possible values are limited to whole numbers. Note that when the possibilities include only positive whole numbers, you are better off using CARDINAL types. In practice, you rarely need to use INTEGER variables.

You may use any arithmetic operator in INTEGER expressions, and INTEGER variables may take part in relational expressions.

The INT standard function will convert other numeric data types into INTEGER.

	An INTEGER value requires 2 bytes for storage. The bytes as stored as two's complement, with the least-significant by stored first.
	INTEGER is compatible with WORD. Since BYTE is subrange of WORD, INTEGER is compatible with BYTE well. However, the exception BoundsError can occur if negative integer is assigned to a byte (or a positive integ greater than 255).
See Also	CARDINAL LONGINT WORD
Example	<pre>MODULE Integer; VAR Deviation: INTEGER; Angle: REAL; BEGIN FOR Deviation:= -3 TO 3 DO Angle:= 10.0 * Float(Deviation); END END Integer.</pre>

IntToStr	procedure	(Convert)	L	. ,

Description	IntToStr converts an integer variable to a string.		
Declaration	PROCEDURE IntToStr(i: INTEGER; VAR s: ARRAY OF CHAR);		
Usage	IntToStr(i.s)		

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IntToStr must be imported from the library module Conve

i must be of type INTEGER.

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s must be of type ARRAY OF CHAR.

Turbo Modula-2 Reference Directory

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Comments	The string will be right-justified, and the left-most characters padded with blanks.		
	If the number is too large to fit into the string, the exception TooLarge will be raised.		
See Also	CardToStr Convert Doubles LongToStr RealToStr StrToInt		
Example	Put the string '5000' into s:		
	i := 5000; IntToStr (i,s);		
IOTRANSFER	procedure (SYSTEM) L		
Description	IOTRANSFER sets up an interrupt vector to point to the next line of code and transfers control to another coroutine.		
Declaration	<pre>PROCEDURE IOTRANSFER(VAR source, dest: PROCESS; n: CARDINAL);</pre>		
Usage	IOTRANSFER(inthandler, background, intvector)		
	IOTRANSFER must be imported from the library module SYSTEM.		
	inthandler and background must be of type PROCESS im-		

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ported from SYSTEM.

intvector must be of type CARDINAL.

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Comments	<i>inthandler</i> and <i>background</i> must have been previously set u with calls to NEWPROCESS.		
	intvector must be a legal and available interrupt vector numbe		
See Also	SYSTEM TRANSFER		
Example	IOTRANSFER(KbdIntHandler,MainRoutine,KbdIntVec- tor);		
legal variable (E	Doubles) L		
Description	<i>legal</i> monitors the input of a LONGREAL during a call <i>ReadDouble</i> .		
Declaration	VAR legal: BOOLEAN;		
Usage	finished := legal;		
	finished must be of type BOOLEAN.		
Comments	The variable is usually checked after input of a LONGREA. <i>ReadDouble</i> is the only procedure that can affect it.		
See Also	Texts done		
Example	MODULE InvalidInput; FROM Doubles IMPORT legal, ReadDouble; FROM Texts IMPORT input;		

and the second se

VAR d: LONGREAL;
BEGIN
REPEAT
ReadDouble(input,d);
UNTIL legal;
END InvalidInput.

Length	procedure	(Strings)	L	
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Description	Length finds the current length of a string.		
Declaration	PROCEDURE Length (VAR str: ARRAY OF CHAR): CARDINAL;		
Usage	<pre>size := Length(str)</pre>		
	Length must be imported from the library module Strings.		
	size must be of type CARDINAL.		
	str must be a character array variable.		
Comments	Length returns the position of the first byte containing a zero, which is defined to be the end of the string.		
	size will not be greater than the originally declared size of str.		
See Also	Append Copy Delete Insert Pos		
Example	Find the length of str:		
	<pre>size := Length(str)</pre>		
LoadError excep	otion (Loader) L/E		

Description LoadError is raised by the module Loader when the loading of an overlay is unsuccessful.

Declaration

EXCEPTION LoadError;

Usage	EXCEPTION LoadError: WRITELN('Overlay Error');
	LoadError must be imported from the module Loader.
Comments	This exception is raised if the overlay file is not found, if there is not enough memory to hold the overlay, or if a version con- flict occurs.
See Also	Loader
Example	<pre>MODULE LoadOverlay; FROM Loader IMPORT firstDrive, Call, LoadError; BEGIN firstDrive := 13; (* Search ram disk (M:) first *) Call('overlay.fil') EXCEPTION LoadError: WRITELN(' Load error occured '); RAISE END LoadOverlay.</pre>

LongMath module L

Description	LongMath	provides	commonly	used	double-precision
	mathematical functions.		5.		

Declaration DEFINITION MODULE LongMath;

PROCEDURE	Sqrt	<pre>(x:LONGREAL):LONGREAL;</pre>
PROCEDURE	Exp	<pre>(x:LONGREAL):LONGREAL;</pre>
PROCEDURE	Ln	<pre>(x:LONGREAL):LONGREAL;</pre>
PROCEDURE	Cos	<pre>(x:LONGREAL):LONGREAL;</pre>
PROCEDURE	Arctan	<pre>(x:LONGREAL):LONGREAL;</pre>

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PROCEDURE Entier (x:LONGREAL):LONGINT;

EXCEPTION ArgumentError;

END LongMath.

Comments These routines are identical to the routines for single- precision real numbers.

The ArgumentError exception is raised when an argument is outside the permitted range. The following ranges apply:

- Sqrt Argument must be positive or zero
- Exp Argument must be less than 710.47
- Ln Argument must be positive (greater than zero)

If you want to use the same routine from MathLib and LongMath, the statements

FROM MathLib IMPORT Sqrt; FROM LongMath IMPORT Sqrt;

will lead to a conflict. Thus, qualified import must be used.
IMPORT MathLib,LongMath;
BEGIN
dSqr := LongMath.Sqrt(arg);

```
rSqr := MathLib.Sqrt( arg );
```

LONGREAL standard type S

Usage

Description LONGREAL is a standard type with variables that can assume any value between -3.5953862697246D+308 and +3.5953862697246D+308.

VAR x,y: LONGREAL;

.

Comments LONGREALs are particularly useful in arithmetic expressions that concern a small difference between large numbers or a sum that results from many (a 1000 or so) additions and subtractions. In both cases, the round-off error tends to accumulate; however, it can be kept smaller by using a LONGREAL. Don't use them indiscriminately, though, since your program will pay the price in slower execution times. You may use any arithmetic operator in LONGREAL expressions, and LONGREAL variables may take part in relational expressions.

The DOUBLE standard function will convert other numeric data types into LONGREAL.

String and I/O support for LONGREALs are provided by the library module *Doubles*.

Mathematical support similar to *MathLib* for REALs is provided by the library module *LongMath*.

Turbo Modula-2 uses the IEEE 8-byte, double-precision realnumber format; that is, in the order of their significance, 1 sign bit, 11 exponent bits, and 52 mantissa bits:

63	62		52	51	0
Is I		exponent	I	mantissa	!

The mantissa is in binary format but is offset by 1.0, representing only those digits to the right of the decimal point.

The bytes are stored with the least-significant bytes in the

lower-numbered addresses.

If the exponent is zero, the floating-point value is considered zero.

Sample hex real numbers:

3FF000000000000H = 1.04000000000000H = 2.0

See the example in WORD for printing out other values.

Example VAR SquareArea, SquareSide: LONGREAL; BEGIN SquareSide:= 4.21D0; SquareArea:= SquareSide * SquareSide;

Ln function (MathLib, LongMath) L

Description Ln returns the natural logarithm of X.

Declaration **PROCEDURE** Ln(x: REAL): REAL; **PROCEDURE** Ln(x: LONGREAL): LONGREAL;

Usage Y := Ln(X)

Argument X and result Y are either both REAL or both LONGREAL.

The argument X must be positive.

Comments You must always make sure that the argument X is a positive value; otherwise, the ArgumentError exception is raised. The inverse of the logarithmic function is the natural exponential function *Exp*.

See Alee Error

See Also

Exp LONGMATH MATHLIB

Example	MODULE LnTest; FROM MathLib IMPORT Ln; VAR
	Argument, Result: REAL; BEGIN
	IF Argument > 0.0 THEN
	Result:= Ln(Argument) END
	END LnTest;
	•

Loader module	L
Description	Loader is a library module that handles overlays.
Declaration	DEFINITION MODULE Loader;
	VAR firstDrive: [015];
	PROCEDURE Call(modName: ARRAY OF CHAR);
	EXCEPTION LoadError;
	END Loader.
Com ment s	Loader is used by a program to explicitly overlay certain modules. The overlay code may not export anything to the caller; however, the overlay code may communicate with the caller by importing from the caller a buffer where data and messages can be left.

See Also Refer to »The Loader Module« in Chapter 11.

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Description	LONG converts the argument to type LONGINT.
Usage	Y := LONG(X)
	Argument X can be of type INTEGER, CARDINAL, LONGINT, REAL, or LONGREAL.
	The argument must be in the range from $-(2^{31}-1)$ to $2^{31}-1$.
	The result Y is type LONGINT.
Comments	When you use this function with a REAL argument, the value is truncated (the fractional part removed); thus, the value 12.35 becomes 12.
	Do not confuse this function with the LONGINT-type transfer function, which transfers data without converting it.
See Also	FLOAT
	INT TRUNC
Example	VAR Convert: LONGINT;
	BEGIN Convert $= 2000001 \pm 1000(-12)$
	Convert:= 2000000L * LONG(-12); (* Convert is -24000000L *)
	END

LONGINT standard type S

Description LONGINT is a standard type with variables that can assume whole values between -2147483648 to 2147483647.

Comments You can use LONGINT types when you need a larger range of whole numbers than that offered by the CARDINAL and INTEGER types.

> You may use any arithmetic operator in LONGINT expressions, and LONGINT variables may take part in relational expressions.

> The LONG standard function will convert other numeric data to type LONGINT. Note that even INTEGERtypes must be converted.

A LONGINT value requires 4 bytes for storage. The bytes are stored as two's complement, with the least-significant byte stored first.

LONGINT is compatible with ARRAY OF WORD, but no with WORD or BYTE.

See Also

CARDINAL INTEGER WORD

Example

MODULE Longs; CONST N = 1000000L; VAR

BigNumber:LONGINT;

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BEGIN

BigNumber:= N;

BigNumber:= 2L * BigNumber; END Longs.

LongMath module

Description	Provides commonly used mathematical functions with double precision accuracy.	
Declaration	DEFINITION MODULE LongMath;	
	<pre>PROCEDURE Sqrt (x:LONGREAL): LONGREAL; PROCEDURE Exp (x:LONGREAL): LONGREAL; PROCEDURE Ln (x:LONGREAL): LONGREAL; PROCEDURE Sin (x:LONGREAL): LONGREAL; PROCEDURE Cos (x:LONGREAL): LONGREAL; PROCEDURE Arctan (x:LONGREAL): LONGREAL; PROCEDURE Entier (x:LONGREAL): LONGREAL;</pre>	
	EXCEPTION ArgumentError; END LongMath.	
	For a description of each of these procedures and exceptions, see Chapter 11 or the appropriate reference in this chapter.	
Comments	The LongMath module exports a number of mathematical pro- cedures and functions. You can import any of the procedure and exception identifiers into your own modules, which allows you to use the predefined facilities.	
	The ArgumentError exception is raised when an argument is outside the permitted range. The following ranges apply:	
	Sqrt Argument must be positive or zero.	

Exp Argument must be less than 710.475D00

Argument must be positive (greater than zero). Ln

Example If you want to call the Cos and Sin functions from a module called Problem, you would start the module with:

MODITLE Problem; FROM LongMath IMPORT Cos,Sin;

If Y,Z, Angle, and Radians are defined as LONGREAI variables then the library functions can then be used normally

Y:= Cos(Angle);
Z:= Sin(Radians);

LongToStr procedure (Convert) L	
Description	LongToStr converts a long integer variable to a string.
Declaration	<pre>PROCEDURE LongToStr(1: LONGINT; VAR s: ARRAY OF CHAR);</pre>
Usa ge	LongToStr(1, s)
	LongToStr must be imported from the library module Conver
	<i>l</i> must be of type LONGINT.
	s must be a character array variable.
Comments	The string will be right-justified, and the left-most characte will be padded out with blanks.

If the number is too large to fit into the string, the exception TooLarge will be raised.

See Also

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Doubles InToStr CardToStr RealToStr Strings StrToLong .

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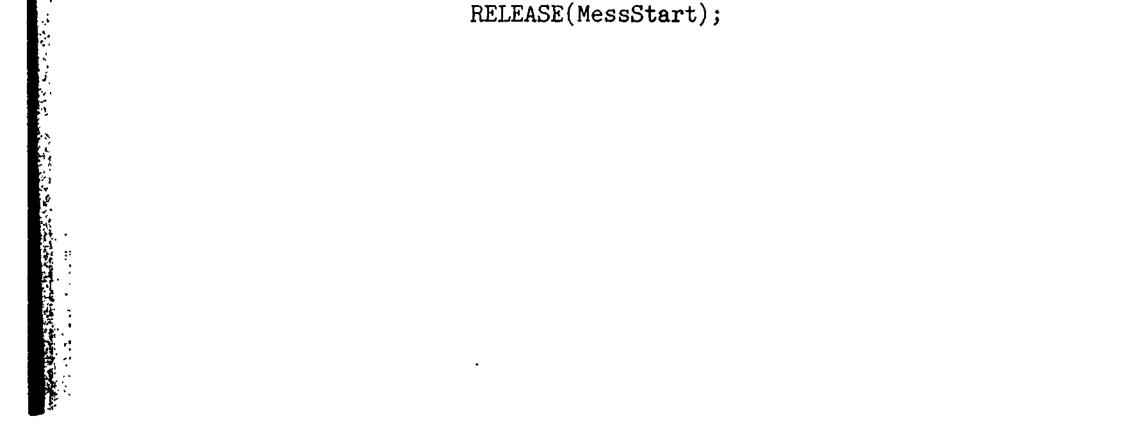
Example	Put the string '300000' into s:
	<pre>VAR s : ARRAY [06] OF CHAR; l :LONGINT; BEGIN l := 300000; LongToStr(l,s); END</pre>
LOOP statement	R
Description	LOOP repeatedly executes a statement sequence until terminated by an EXIT statement.
Usage	LOOP StatementSequence END
	<pre>StatementSequence = Statement (; Statement)</pre>
Comments	There are two main reasons for using a LOOP statement: (1) when programming a continually cycling process, such as many real-time systems and concurrent processes, or (2) when the FOR, REPEAT and WHILE statements are unsuitable because loop termination can only be determined in the middle of the loop.
	Termination of the loop requires an EXIT statement.
See Also	EXIT
Example	BEGIN LOOP

IF Found THEN EXIT END ;

•••

MARK procedure (STORAGE) L

Description	LOOP marks the beginning of a block of dynamic variables
Declaration	PROCEDURE MARK(VAR a: ADDRESS);
Usage	MARK(a)
	MARK must be imported from the library module STORAGE
	a must be compatible with type ADDRESS (any pointer).
Comments	MARK and RELEASE provide an alternate method of handlin heap data. The use of these procedures allows the heap to t treated in a stack-like manner.
	A call to <i>MARK</i> creates a new heap that consists of the space between the previous top of Heap and the stack pointer. A variables allocated on the heap prior to the call to <i>MARK</i> a no longer accessible until a <i>RELEASE</i> with the same point is called.
See Also	DISPOSE NEW RELEASE
Example	Allocate a mess of variables and then throw them away:
	<pre>MARK(MessStart); NEW(Mess1); NEW(Mess2); NEW(Mess3); BELEASE(MessStart);</pre>



Turbo Modula-2 Reference Directory

MathLib module L

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Description MathLib provides commonly used mathematical functions. Declaration **DEFINITION MODULE** MathLib; **PROCEDURE** Sqrt(x:REAL):REAL; **PROCEDURE** Exp(x:REAL):REAL; **PROCEDURE** Ln(x:REAL):REAL; **PROCEDURE** Sin(x:REAL):REAL; **PROCEDURE** Cos(x:REAL):REAL; **PROCEDURE** Arctan(x:REAL):REAL; **PROCEDURE** Entier(x:REAL):INTEGER; **PROCEDURE** Randomize(n:CARDINAL); **PROCEDURE** Random():REAL; **EXCEPTION** ArgumentError; END MathLib. For a description of each of these procedures and exceptions, see Chapter 11 or the appropriate reference in this chapter. The MathLib module exports a number of mathematical pro-Comments cedures and functions. You can import any of the procedure and exception identifiers into your own modules, allowing you to use the predefined facilities. The exception ArgumentError is raised when an argument is outside the permitted range. The following ranges apply: Argument must be positive or zero.

Argument must be less than 87.4. Exp

Sqrt

Argument must be positive (greater than zero). Ln

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Example

If you want to call the Cos and Sin functions from a called *Problem*, you would start the module with the fo

MODULE Problem; FROM MathLib IMPORT Cos,Sin;

The predefined functions can then be used normally,

Y:= Cos(Angle); Z:= Sin(Radians);

Description	MAX returns the largest element of type T .			
Usage	Y := MAX(T);			
	Argument T is of type CARDINAL, INTEGER, BO CHAR, enumeration, LONGINT, REAL, or LONGI short, any unstructured scalar type.			
	Result Y is of the same type.			
Comments	This function allows you to find the last element unstructured type. Note that the argument is the type a variable of the type.			
	The maximum values of the predefined types are			
	CARDINAL 65535			
	INTEGER 32767			
	BOOLEAN TRUE			

CHAR377CREAL2147483647LONGINT3.5953862697246D+308LONGREAL6.80565E+38

The smallest element of a type is returned y the MIN

Turbo	Modula-2	Refe rence	Directory

Example

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like so:

)LEAN, EAL; in

t in any and not MODULE Max; TYPE Weather = (Clear,Rain,Wind,Snow); VAR MaxWeather: Weather; MaxCardinal: CARDINAL BEGIN MaxWeather:= MAX(Weather); (* MaxWeather is value Snow *) MaxCardinal:= MAX(CARDINAL); (* MaxCardinal is value 65535 *) END Max.

MIN standard function S

DescriptionMIN returns the smallest element of type T.UsageY:= MIN(T);Argument T is of type CARDINAL, INTEGER, BOOLEAN,
CHAR, enumeration, LONGINT, REAL, or LONGREAL; in
short, any unstructured type.Result Y is of the same type.CommentsThis function allows you to find the first element in any
unstructured type. Note that the argument is the type and not
a variable of the type.CommentsThe minimum values of the predefined types are

CARDINAL 0

function.

 INTEGER
 -32768

 BOOLEAN
 FALSE

 CHAR
 0C

 REAL
 -6.80565E+38

 LONGINT
 -2147483648

 LONGREAL
 -3.5953862697246D+308

The largest element of a type is returned by the MAX function.

Example MODULE Min; TYPE Weather = (Clear,Rain,Wind,Snow); VAR MinWeather: Weather; MinCardinal:CARDINAL BEGIN MinWeather:= MIN(Weather); (* MinWeather is value Clear *) MinCardinal:= MIN(CARDINAL); (* MinCardinal is value 0 *) END Min.

MOD standard	operator	R
--------------	----------	---

Description MOD is an integer modulus operator; it is a binary operator that works on operands of the same type. The MOD operator returns the remainder of integer division. The operands may be both CARDINAL, both INTEGER, or both LONGINT.

Usage i := i MOD j;

where i and j are of the same type.

The result of the expression is the same type as the operands.

Comments The modulus operator can be used to insure that a variable remains within a certain defined range.

See Also DIV

Example	MODULE Modulus;
_	VAR
	i: INTEGER;
	BEGIN
	LOOP
	i := (i + 1) MOD 100; (* i will range from 0 to 99 *)
	END
	END Modulus.
()DULE de	eclaration R

Description MODULE serves to declare the beginning of a module.

Usage

MODULE moduleName

OF

DEFINITION MODULE libraryName

or

IMPLEMENTATION MODULE libraryName

Comments

The first form declares a main module, which is a stand-alone program. It can also start the beginning of a local module.

A local module limits visibility of global objects (variables, types, constants, procedures). Thus, an object buried inside a local module can retain its value throughout the program's lifetime, while simultaneously remain safe from outside tampering.

The second and third forms are for libraries, separately compiled sets of frequently used routines.

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See Also DEFINITION **IMPLEMENTATION** Example The following file is an example of a main module in 'MAIN.MOD':

MODULE main; FROM SimpleMath IMPORT add; BEGIN WRITELN(' 2 + 2 = ',add(2,2)); END main.

The next example is a local module in a main module:

MODULE Main; MODULE local; EXPORT p1;

PROCEDURE p1; BEGIN END p1;

PROCEDURE p2; BEGIN END p2;

END local;

BEGIN (* p1 is visible here, but not p2 *) **END** Main.

NEW standard procedure (STORAGE) S

Description NEW allocates a dynamic variable from the heap.



Usage	NEW(p);
	or
	NEW(p, tag1, tag2,, tagn);
	p must be of type POINTER.
	ALLOCATE must be imported from the pseudomodule STORAGE.
	tagl,, tagn are allowed in the case where p points to a variant record, and the tags are defined in that record.
Comments	NEW is translated into an appropriate call to ALLOCATE.
	Turbo Modula-2 expects ALLOCATE to be defined the way it is in the pseudomodule STORAGE; however, you may substitute your own allocation scheme by importing ALLOCATE from your own module instead of STORAGE.
See Also	ALLOCATE DISPOSE STORAGE
Example	Allocate a new Name:
	MODULE Allocate; FROM STORAGE IMPORT ALLOCATE; VAR n: POINTER TO Name; BEGIN
	NEW(n);

END Allocate.

The NEW(n) statement would be translated into a call of the form ALLOCATE(n, TSIZE(Name)).

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NEWPROCESS procedure (SYSTEM) L

NEWPROCESS sets up an independent process (or coroutine). Description **PROCEDURE** NEWPROCESS(p: PROC; a: ADDRESS; Declaration n: CARDINAL; VAR q: PROCESS); NEWPROCESS(newProc, wrkAdr, wrkSize, P); Usage NEWPROCESS must be imported from the pseudomodule SYSTEM. newProc must be of the standard type PROC (a parameterless procedure). wrkAdr must be compatible with type ADDRESS (any pointer). wrkSize must be of type CARDINAL. It specifies the number of bytes of storage. P must be of type PROCESS imported from SYSTEM. The procedure *newProc* contains the code for the new process. Comments The workspace must be big enough to accommodate any local stack and heap activity; 100 words is a good size to start with. Local stack activity consists of local variables, procedure parameters, and some space for working out expressions. Local heap activity consists of the user's calls to NEW and ALLOCATE and any file control blocks that are active. If the workspace enough, allocated the exception is not

OutOfMemory will be raised.

NEWPROCESS allocates space and sets the corresponding PROCESS variable, but it does not actually start up th routines--TRANSFER accomplishes that. The procedure StartProcess in Processes is implemented using this routine.

See Also Processes PROCESS PROC **TRANSFER SYSTEM**

Example

Start up a driver called Driver:

MODULE NewProcess;

FROM SYSTEM IMPORT ADR, PROCESS, NEWPROCESS, TRANSFER;

VAR

work: ARRAY [0..100] OF WORD;

M, P: PROCESS;

PROCEDURE Driver;

BEGIN

(* Driver's code *) **END** Driver;

BEGIN

```
NEWPROCESS(Driver, ADR(work), SIZE(work), P);
 TRANSFER(M,P); (* Driver now has control *)
END NewProcess.
```

NextPos procedure (Files) L

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Description NextPos returns the current byte position in a file.

Declaration

PROCEDURE NextPos(f: FILE): LONGINT;

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Usage	<pre>n := NextPos(f);</pre>
	NartPos must be imported from the library module Files
	NextPos must be imported from the library module Files.
	n must be of type LONGINT.
	f must be of type FILE imported from Files.
Comments	The result of <i>NextPos</i> is a LONGINT because file can be larger than MAX(CARDINAL).
See Also	FileSize
	SetPos
Example	Keep track of the percentage of file you have completed:
	MODULE NextPosPercent;
	FROM Files IMPORT FILE, Open, NextPos, ReadRec;
	VAR
	f:File;
	totsize: LONGINT;
	wreck: SomeRecord;
	BEGIN
	IF NOT Open(f, "reckfile") THEN HALT END ;
	<pre>totsize := FileSize(f);</pre>
	WHILE NOT EOF(f) DO
•	ReadRec(f, wreck);
	n := (100L*NextPos(f)) / totsize;
	WRITE('Finished ',n,'% of the file ')
	(* Process wreck *)
	END NovtBogBoncont
	END NextPosPercent.



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NIL standard value S

ferPtr := NIL; <i>ferPtr</i> is any pointer type. L is compatible with all pointer variables.
L is compatible with all pointer variables.
e actual value of NIL is zero; thus, WRITE(CAR- VAL(NIL)) will print a 0.
INTER
<pre>DULE NilList; DM STORAGE IMPORT ALLOCATE; PE DedePtr = POINTER TO Node; Dede = RECORD element: CARDINAL; Next: NodePtr; END ; R : NodePtr; GIN EW(1); 1 ^ .Next := NIL; D NilList.</pre>

Normal procedure (Terminal) L

Description Normal turns off highlighting.

Declaration PROCEDURE Normal;

Usage Normal;

Normal must be imported from the library module Terminal.

Comments	The highlighting will only work if Turbo Modula-2 has been properly installed. If highlighting has not been turned on, then the effect of <i>Normal</i> is undefined (it depends on your terminal, but it is probably harmless).
Example	Highlight the word 'high':
	WRITE('This is a example of ');
	Highlight;
	WRITE('High');
	Normal;
	WRITE('lighting'):

NoTrailer procedure (Files) L

Description	NoTrailer t	urns	off	the	special	Turbo	Modula-2	end-of-file
	handling.							

Declaration **PROCEDURE** NoTrailer(f: FILE);

Usage NoTrailer(f);

NoTrailer must be imported from the library module Files.

f must be of type FILE imported from Files.

Comments Turbo Modula-2 handles the last byte of the last record of a CP/M file so that a program can determine exactly how many bytes are in a file.

The last byte of the last record contains the length of the last record plus 128. Thus, if the last byte is 127 or less, then the record is completely filled; otherwise, the number of bytes in the last record is found by subtracting 128 from the last byte. This is how the procedure *FileSize* works.

If NoTrailer is used on a file, then FileSize will always return a multiple of 128.

	NoTrailer should be used immediately after Open when reading; it can be used immediately after Create as well.
	In general, this function should only be used if you are having trouble with file communication involving a non- Turbo Modula-2 program.
See Also	Files FileSize
(umple	Declare a file to have no trailer:
	<pre>IF Open(f,filename)THEN NoTrailer(f); (* process the file *) END ;</pre>
numCols variable	(Terminal) L
Description	numCols holds the number of columns available on the cur- rently installed terminal.
Declaration	VAR numCols: CARDINAL;
Usage	IF CurCol > numCols THEN CurCol := 0 END ;
(numCols must be imported from the module Terminal.
comments	This variable is useful for writing terminal-independent pro- grams. The value of <i>numCols</i> is set by the installation program INSTM2.



numRows Terminal Example MODULE ColumnNumber; FROM Terminal IMPORT numCols; VAR I: CARDINAL; BEGIN I := 0; WHILE I < numCols DO WRITE('-') END ; END ColumnNumber.

numRows vari	able (Terminal) L			
Description	numRows holds the number of rows available on the current installed terminal.			
Declaration	VAR numRows: CARDINAL;			
Usage	IF CurRowl > numRows THEN CurRow := 0 END ;			
	numRows must be imported from the module Terminal.			
Comments	This variable is useful for writing terminal-independent programs. The value of <i>numRows</i> is set by the installation programs. INSTM2.			
See Also	numCols Terminal			
Example	MODULE RowNumber; FROM Terminal IMPORT numRows; VAR I: CARDINAL; FROTN			

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BEGIN
I := 0;
WHILE I < numRows DO WRITELN('!') END;
END RowNumber.</pre>

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ODD standard function S		
Description	ODD returns TRUE if the ordinal value of X is odd.	
Usage	Y := ODD(X);	
	Argument X is of type CARDINAL or INTEGER.	
	Result Y is of type BOOLEAN.	
Comments	This function allows you to find out if a value is odd.	
	Note that for BOOLEAN types, the first value is FALSE with an ordinal value of 0.	
Example	<pre>MODULE Odd; TYPE Shift = (Early,Late,Night); VAR TimeSheet : ARRAY Shift OF CARDINAL ShiftToday : Shift; OddNumber :BOOLEAN; BEGIN TimeSheet[Early]:= 11; OddNumber:= ODD(TimeSheet[Early]); (* OddNumber is TRUE*) END Odd.</pre>	

Open procedure (Files) L

Description Open opens a binary disk file for input or output.

Declaration **PROCEDURE** Open(VAR f: FILE; name: ARRAY OF CHAR): BOOLEAN;

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Usage	<pre>okay := Open(f, name);</pre>
	Open must be imported from the library module Files.
	okay must be declared as type BOOLEAN.
	f must be declared as type FILE imported from Files.
	name must be declared as ARRAY OF CHAR.
Comments	f is the internal file identifier. Further operations on this file must specify f .
	name must represent a legal CP/M file name that is on the disk you are using or a standard CP/M device like RDR: or CON:.
	okay is returned TRUE when the file can be opened; it is FALSE if the file could not be found.
	Use Create to start a new file.
	Readable files are better handled using routines from the module Texts.
See Also	Close Create Files
Example	Open and close a disk file 'SCRATCH.SCR':
:	MODULE openandclose; FROM Files IMPORT FILE, Open, Close; VAR

:

f : FILE; BEGIN IF Open(f, 'SCRATCH.SCR') THEN Close(f) END END openandclose.

OpenInput Procedure (InOut) L

Description	OpenInput asks the user for a disk file name, then opens it as standard input.
Declaration	<pre>PROCEDURE OpenInput(defext: ARRAY OF CHAR);</pre>
Usage	OpenInput(ext);
	OpenInput must be imported from the library module InOut.
	ext must be a character array.
Comments	Notice that calling this procedure causes the program to halt and ask the user for a file name. The <i>ext</i> parameter will be us- ed only if the user does not specify an extension.
Example	<pre>MODULE Input; FROM InOut IMPORT OpenInput, CloseInput, ReadString, WriteString, WriteLn; VAR s: ARRAY [0255] OF CHAR; BEGIN (* Prompt user for filename *) (* Use default extention MOD *) OpenInput("MOD"); (* Read a string from the file *) ReadString(s); WriteString(s); (* Display it *) WriteLn; CloseInput; (* Sever the link to the file *)</pre>

(* Sever the link to the file *)
 (* Now input comes from the console *)
 ReadString(s);
 WriteString(s);
 (* Display it *)
 WriteLn;
END Input.

OpenOutput procedure (InOut) L

Description OpenOutput asks the user for a disk file name, then opens it as the standard output.

Declaration PROCEDURE OpenOutput(defext: **ARRAY OF** CHAR);

Usage OpenOutput(ext);

OpenOutput must be imported from the library module InOut.

ext must be a character array.

Comments Notice that calling this procedure causes the program to halt and ask the user for a file name. The *ext* parameter will be used only if the user does not specify an extension.

Example

FROM InOut IMPORT
 OpenOutput, CloseOutput, ReadString,
 WriteString, WriteLn;

VAR

s: ARRAY [0..255] OF CHAR; BEGIN

WriteString('Enter output file and then the data:');
WriteLn;
OpenOutput("MOD");

(* Read data from the console *)

ReadString(s);

MODULE Output;

(* Place it in the file *)

WriteString(s);

WriteLn;

CloseOutput; (* Sever the link to the file *)

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WriteString('The file has been closed.');
WriteLn;
END Output.

OpenText procedure (Texts) L

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Description	OpenText associates a TEXT with an external medium and opens it for reading.
Declaration	<pre>PROCEDURE OpenText(VAR t: TEXT; name: ARRAY OF CHAR): BOOLEAN;</pre>
Usage	okay := OpenText(t, fname);
	OpenText must be imported from the library module Texts.
	t must be declared as type TEXT imported from Texts.
	fname must be a character array.
	okay must be declared as type BOOLEAN.
Comments	<i>fname</i> must either be a valid CP/M file name and be present on the appropriate disk or represent an existing CP/M device like 'CON:'.
	okay is returned FALSE if the file is not found; otherwise, the file is sucessfully opened and okay is returned TRUE.
	t can only be used for input.
See Also	CreateText TEXT Texts

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Example Open a text file 'MYTEXT.TXT' and then close it:

```
MODULE openandclose;
FROM Texts IMPORT TEXT, OpenText, CloseText;
VAR
t : TEXT;
BEGIN
IF OpenText(t, 'MYTEXT.TXT') THEN
CloseText(t)
END
END openAndClose.
```

OpSet type (Te	erminal) L
Description	OpSet holds the set of screen operations available on the rently installed terminal.
Declaration	TYPE SpecialOps = (clearEol, insertDelete, highlightnor mal); OpSet : SET OF SpecialOps;
Usage	VAR available : OpSet;
	available is a predefined variable declared as type OpSe must be imported from the module Terminal.
Comments	This variable is useful for writing terminal-independent grams. The value of <i>available</i> is set by the installation proparation INSTM2 .

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See Also SpecialOps available Terminal

Example		<pre>MODULE TermStuff; FROM Terminal IMPORT available, SpecialOps, Highlight, Normal; BEGIN IF highlightNormal IN available THEN Highlight ELSE WRITE('"'); END; WRITELN('This is highlighted text!'); IF highlightNormal IN available THEN Normal ELSE WRITE('"');</pre>
OR R	WRITE('"'); END ; END TermStuff.	
Descr	iptio n	OR is a binary logical operator resulting in a Boolean value.
Usage	\$	IF InputError OR TimeIsUp THEN Beep END ;

OR is a reserved word.

InputError and TimeIsUp are Boolean expressions.

Comments OR is used to concatenate two logical expressions. An OR expression is TRUE if at least one of its subexpressions is TRUE.

Note that the second subexpression in an OR expression is only evaluated if the first subexpression is FALSE. This is called

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short-circuit evaluation.

See Also AND NOT

Example REPEAT statement using OR to test either of two terminatin conditions. MODULE Delay; FROM Terminal IMPORT BusyRead; VAR ch: CHAR; x : CARDINAL; BEGIN x := 0; REPEAT INC(x); BusyRead(ch); UNTIL ch # 0C OR x>1000; END Delay.

ORD standard functionSDescriptionORD returns the ordinal number of X.UsageY:= ORD(X);Argument X is of type enumeration, INTEGER, CARDINA
BOOLEAN, or CHAR..Result is of type CARDINAL.CommentsOrdinal types have an ordered sequence of values, with
position in the sequence being the ordinal number; thus,
first value has an ordinal of 0, the next has ordinal of 1, :
so forth.

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Note that INTEGER values are written in two's complex format so that the lower ordinals correspond to positive val and higher ordinals to negative values.

Ordinals	0 to 32767	Values	0 to 32
Ordinals	32768 to 65535	Values	-32768tr

For BOOLEAN types, the first value is FALSE with ordinal 0.

The inverse operation from ordinal to value uses the VAL function, or you can use the CHR function for character variables.

Example

```
TYPE Direction: (Forward,Backward,Up,Down);
VAR Move: Direction;
Value:INTEGER
Ordinal:CARDINAL
```

BEGIN

```
Move:= Up;
Ordinal:= ORD(Move);
(* Ordinal is value 2 *)
Value:= 10; Ordinal:= ORD(Value);
(* Ordinal is value 10 *)
```

```
Ordinal:= ORD("?")
(* Ordinal is value 63 *)
```

OUT procedure (SYSTEM) L

Description OUT outputs a word or a byte to a given I/O port.

Declaration PROCEDURE OUT(port, data: WORD);

Usage OUT(port, outWord);

OUT must be imported from the library module SYSTEM.

outWord must be compatible with type WORD imported from SYSTEM.

port can be any scalar type compatible with WORD.

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The value given by *outWord* is output to the port whose number is given by *port*.

MODU
INP SYSTEM
Output a byte to port 23 hex:
OUT(023H, outWord);
ble (ComLine) L
<i>outName</i> is a string variable that contains a string found a the output redirection symbol (>) on the command line.
VAR outName: ARRAY [019] OF CHAR;
WRITE('Output redirected to ',outName);
The redirection symbol and <i>outName</i> will not appear in text commandLine.
outName contains the standard output string »CON:« if redirection argument has been found on the command line
ComLine inName
RedirectOutput
MODULE RedirectOutput; FROM ComLine IMPORT outName, RedirectOutput; FROM Texts IMPORT console; BEGIN

:

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IF outName < > "CON:" THEN
 WRITE(console,'Output redirected to ',outName
 END
 END RedirectOutput

:

Description	OUTOFMEMORY is raised by the module SYSTEM when an allocation operation makes the stack and heap collide.
Declaration	EXCEPTION OUTOFMEMORY;
Usage	EXCEPTION OUTOFMEMORY: WRITELN('Out of memory.'); END
	OUTOFMEMORY must be imported from the module SYSTEM.
Comments	This exception may occur during explicit allocation or pro- cedure calls.
See Also	SYSTEM BADOVERLAY OVERFLOW REALOVERFLOW
Example	<pre>MODULE OutOfMemory; FROM SYSTEM IMPORT OUTOFMEMORY; FROM STORAGE IMPORT ALLOCATE, FREEMEM; VAR p: POINTER TO CHAR; BEGIN ALLOCATE(p,FREEMEM()+100); EXCEPTION</pre>

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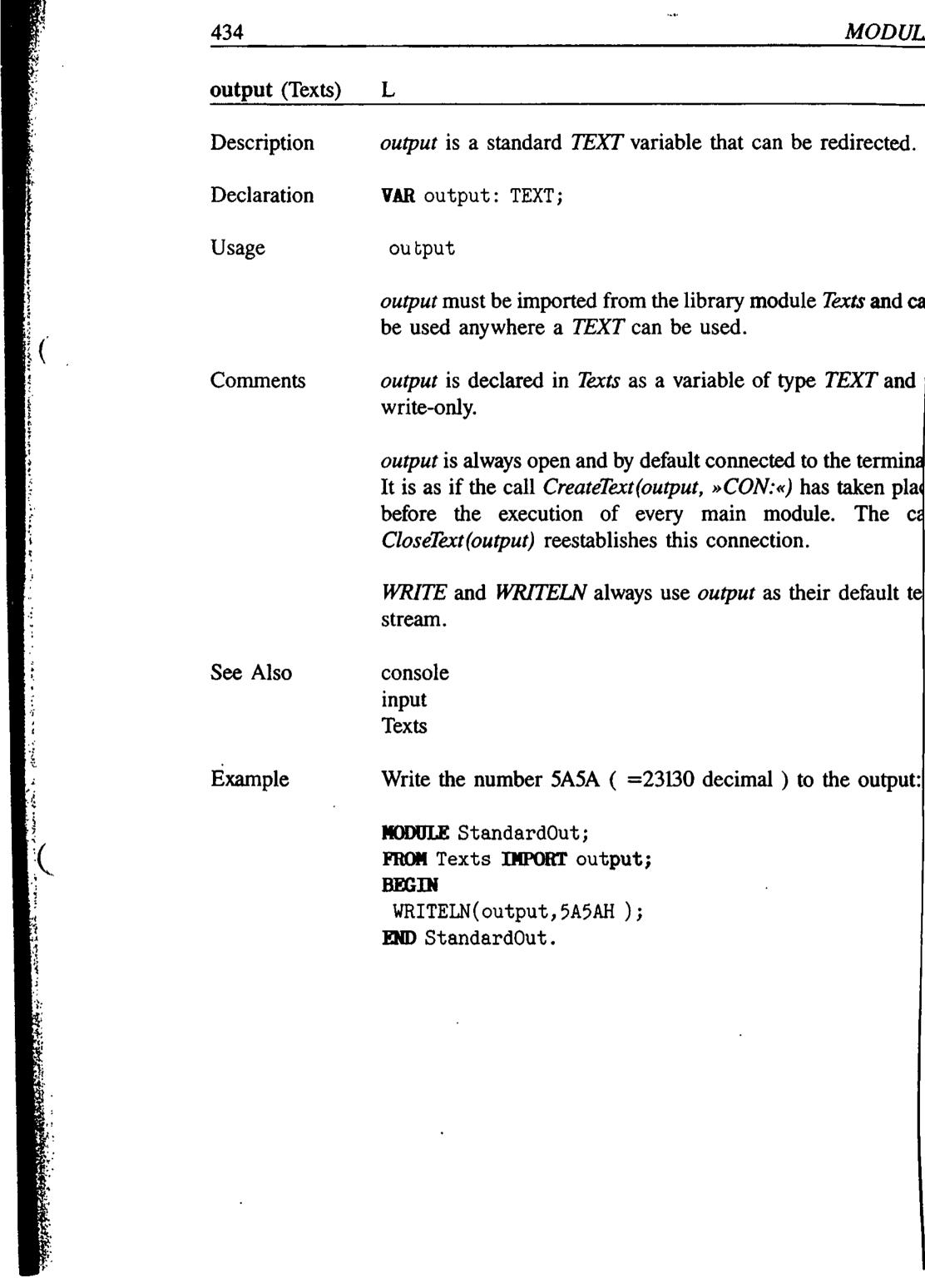
WRITELN('Out of memory.'); END OutOfMemory.

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output (Texts)	L
Description	output is a standard TEXT variable that can be redirected.
Declaration	VAR output: TEXT;
Usage	output
	<i>output</i> must be imported from the library module <i>Texts</i> and ca be used anywhere a <i>TEXT</i> can be used.
Comments	<i>output</i> is declared in <i>Texts</i> as a variable of type <i>TEXT</i> and write-only.
	output is always open and by default connected to the termina It is as if the call CreateText(output, »CON:«) has taken place before the execution of every main module. The ca CloseText(output) reestablishes this connection.
	WRITE and WRITELN always use output as their default te stream.
See Also	console input Texts
Example	Write the number 5A5A ($=23130$ decimal) to the output:
	MODULE StandardOut; FROM Texts IMPORT output; BEGIN WRITELN(output,5A5AH); END StandardOut.

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OVERFLOW	exception (SYSTEM) L/E
Description	OVERFLOW is raised by the module SYSTEM when an integer or cardinal expression results in a value that is too large or too small to be represented by the result type.
Declaration	EXCEPTION OVERFLOW;
Usage	EXCEPTION
	OVERFLOW:
	WRITELN('Overflow.');
	END
	OVERFLOW must be imported from the module SYSTEM.
Comments	This exception occurs only during evaluation of integer expres-
	sions. Real expressions generate the exception
	REALOVERFLOW.
See Also	SYSTEM
	BADOVERLAY
	OUTOFMEMORY
	REALOVERFLOW
Example	MODULE Overflow;
r	FROM SYSTEM IMPORT OVERFLOW;
	VAR
	r: REAL;
	BEGIN
	r := MAX(REAL) * 2.2;
	EXCEPTION
	OVERFLOW:
	UDTTTT N(1 Orrows or 1).

WRITELN('Overflow'); END Overflow.

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POINTER type	R
Description	A pointer references a dynamic variable that can be created, operated on, and discarded during program execution.
Usage	Pointer Type = POINTER OF Referenced Type;
	Referenced Type can be any type.
Comments	If the precise data structure can only be defined while running a program, you could use pointers to enable the program to create the data structure. For example, suppose you want to record the name and job of each employee in a company. Assuming there will never be more than 100 employees, you could declare a fixed data structure of 100 records, or you could use pointer variables. The program creates new employee records as you enter data at the keyboard.
	A pointer is bound to the referenced type and cannot point to any other type. For example, if a pointer type is declared as
	ArrayPointer = POINTER TO ARRAY [110] OF CHAR
	then a pointer of type ArrayPointer can only create, reference, and discard arrays of 10 CHAR components.
•	The standard procedures NEW and DISPOSE create and discard referenced variables.
	It should be noted that NEW and DISPOSE are translated into calls to the standard procedures ALLOCATE and DEALLOCATE, which must be imported from the module

STORAGE.

The referenced variable is designated by the ^ symbol, the dereferencing operator.

A pointer's reference can be assigned to another identical pointer; in fact, several pointers can reference the same variable. A pointer can also be given the value NIL, which means the pointer does not reference anything; this is not the same as discarding variables.

A pointer requires 2 bytes of memory. The value NIL corresponds to 2 zero bytes.

Dynamic variables are stored in the heap area that is handled by procedures in module STORAGE.

ample

MODULE Company; FROM STORAGE IMPORT ALLOCATE, DEALLOCATE;

TYPE

PersonPointer = POINTER TO Person; Person = RECORD Name: ARRAY [1..20] OF CHAR; Job: ARRAY [1..20] OF CHAR; Next: PersonPointer; END ;

VAR

FirstPerson,LastPerson,NewPerson:
 PersonPointer;
Name: ARRAY [1..20] OF CHAR;

BEGIN

FirstPerson:= NIL;
REPEAT
WRITE('Enter name: ');
READLN(Name);

IF Name < > '' THEN

```
(* Create a person record if name entered *)
    NEW(NewPerson);
    NewPerson ^ .Name:= Name;
    WRITE('Enter profession: ');
    READLN(NewPerson ^ .Job);
    WRITELN;
```

```
IF FirstPerson = NIL THEN
   FirstPerson:= NewPerson
(* FirstPerson references first in list *)
   ELSE
    LastPerson ^ .Next:= NewPerson
(* Reference to next in list *)
   END;
   LastPerson:= NewPerson;
(* LastPerson references last in list *)
   LastPerson ^ .Next:= NIL
  END
 UNTIL Name = '';
 WRITELN;
(* Write all records on screen *)
 WHILE FirstPerson < > NIL DO
  WITH FirstPerson ^ DO
   WRITELN(Name,' is a ',Job);
   FirstPerson:= Next;
  END
 END
END Company.
```

Pos procedure (Strings) L

DescriptionPos finds the position of a substring in a string.DeclarationPROCEDURE Pos(substr,str: ARRAY OF CHAR): CARDINAL



Usage	<pre>p := Pos(substr, str);</pre>
	Pos must be imported from the library module Strings.
	substr and str must be character arrays.
	p must be of type CARDINAL.
Comments	The first character has the position 0, the second 1, and so on.
	If the substring is not found, the value $HIGH(str)+1$ is returned.
See Also	Copy Delete Insert Length Strings
Example	<pre>VAR str: ARRAY [030] OF CHAR; index:CARDINAL BEGIN str := 'This is a little test string'; index := Pos('This', str); (* index now equals 0 *) index := Pos('little', str); (* index now equals 10 *) index := Pos('big', str); (* index now equals 31 *)</pre>

Description *PROC* is a predefined parameterless procedure type

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Usage PROC = PROCEDURE ;

Comments	 PROCESS is an opaque type used to represent an independent process. In reality, it is nothing more than a storage area for a program counter and local heap and stack pointers. The user can manipulate variables of type PROCESS only through routines exported from SYSTEM and Processes. Notice that the module Processes is implemented using the primitives defined in SYSTEM. The procedure NEWPROCESS sets up variables of type PROCESS, and the routines TRANSFER and IOTRANSFER provid cooperative and interrupt driven control functions.
See Also	TRANSFER NEWPROCESS Processes
Example	<pre>MODULE Process; VAR M,P: PROCESS; WorkSpace: ARRAY [099] OF CARDINAL; PROCEDURE PP; VAR i: CARDINAL BEGIN FOR i:= 1 TO 10000 DO END ; TRANSFER (P,M); END PP; BEC:IN NEWPROCESS(PP,ADR(WorkSpace),SIZE(WorkSpace),P) TRANSFER (M,P); END Process.</pre>

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Comments	PROCEDURE may be nested to any depth and may enclose modules. If a procedure has a local module, then that module is only in existence when the procedure is active. Thus, the module's initialization part is executed every time the procedure is called.
Example	A procedure:
	<pre>PROCEDURE AmI; BEGIN WRITELN ('I am '); END AmI; A function:</pre>
	PROCEDURE NotZero (i :INTEGER) :BOOLEAN BEGIN RETURN (i # 0); END NotZero;
	_

PROCEDURE type R

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Description	PROCEDURE allows procedures to be assigned to variables.
Usage	TYPE = PROCEDURE [Parameter Types] [:Result Type];
	Parameter types and the result type can be any type.
Comments	Procedure types allow you to assign arguments to a variable. You can use procedure-type variables if you want to call a pro- cedure that has another procedure as a parameter. For exam- ple, suppose you define a procedure type as

TYPE StringProc = **PROCEDURE(ARRAY OF** CHAR);

This declares a procedure type *StringProc*. Any variable of type *StringProc* can take as argument an **ARRAY OF** CHAR. Note that nothing is mentioned about the contents of the procedure.

Suppose you have a procedure with *StringProc* as an argument:

PROCEDURE Example(X:CARDINAL P: StringProc);

END Example;

This procedure expects two arguments: one is a CARDINAL, the other is a procedure of type *StringProc* with ARRAY OF CHAR parameter.

The procedure *Example* can be called with any parameters of these types. For example:

```
Example(12,OpenInput(".INP"));
```

```
Example(21,OpenOutput(".DTA"));
```

```
Example(3,WriteString("Input data: "))
```

These three examples all call procedure *Example* with the two expected arguments: a CARDINAL and a procedure with ar ARRAY OF CHAR argument. The procedures *OpenInput*. *OpenOutput*, and *WriteString* are from the module *InOut*.

Note that standard procedures such as *EXCL* or *HALT* cannobe assigned to procedure variables, nor can procedures that are local to other procedures.

The predefined procedure type *PROC* denotes a procedure with no parameters.



Example MODULE Procedures; FROM InOut IMPORT WriteCard, WriteHex; TYPE ListPointer = **POINTER TO** List; List = **RECORD** Key:CARDINAL Data:CARDINAL Next: ListPointer END; ProcType = PROCEDURE (CARDINAL, CARDINAL); **VAR** First: ListPointer; **PROCEDURE** Search(X:CARDINAL Q: ProcType); (* Search for record with Key X *) **VAR** P: ListPointer; BEGIN P:= First; WHILE (P # NIL) AND (P^.Key # X) DO $P := P^{\wedge} .Next$ END; IF P # NIL THEN $Q(P^{A}.Data,6)$ END **END** Search; BEGIN Search(3,WriteCard); (* Write data from record with Key 3 asCARDINAL*) Search(3,WriteHex); (* Write same data as a Hexadecimal value *) END Procedures.

Description **PROCESS** declares processes or coroutines.

Usage

p : PROCESS;

PROCESS must be imported from the library module SYSTEM.

Comments	PROCESS is an opaque type used to represent an independent process. In reality, it is nothing more than a storage area for a program counter and local heap and stack pointers. The use can manipulate variables of type PROCESS only throug routines exported from SYSTEM and Processes . Notice that the module Processes is implemented using the primitives defined in SYSTEM .
	The procedure NEWPROCESS sets up variables of type PROCESS, and the routines TRANSFER and IOTRANSFER provide cooperative and interrupt driven control functions.
See Also	TRANSFER NEWPROCESS Processes
Example	<pre>MODULE Process; VAR M,P: PROCESS; WorkSpace: ARRAY [099] OF CARDINAL; PROCEDURE PP; VAR i: CARDINAL BEGIN FOR i:= 1 TO 10000 DO END ; TRANSFER (P,M); END PP; BEGIN NEWPROCESS(PP,ADR(WorkSpace),SIZE(WorkSpace),P) TRANSFER (M,P); END Process.</pre>

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Processes module L		
Description	Processes provides standard multiprogramming capabilities.	
Declaration	DEFINITION MODULE Processes;	
	TYPE SIGNAL;	
	<pre>PROCEDURE StartProcess(P: PROC; n:CARDINAL; PROCEDURE SEND(VAR s: SIGNAL); PROCEDURE WAIT(VAR s: SIGNAL); PROCEDURE Awaited(s: SIGNAL):BOOLEAN; PROCEDURE Init(VAR s: SIGNAL);</pre>	
	EXCEPTION DeadLock;	
	END Processes.	
Comments	Notice that there are no scheduling facilities associated with this module; the burden of providing these falls on the programmer.	
	<i>Processes</i> is implemented using the type <i>PROCESS</i> and the routines <i>NEWPROCESS</i> and <i>TRANSFER</i> in pseudomodule <i>SYSTEM</i> .	
See Also	TRANSFER PROCESS NEWPROCESS Also see the individual identifiers exported from <i>Processes</i> .	

progName	variable	(ComLine)	L
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Description progName is a string variable that contains the name of program currently running. Declaration VAR progName: ARRAY [0..7] OF CHAR; Usage WRITE('The currently running program is ', progNa progName allows for an eight-character name (assum Comments .COM extension). progName is only valid if the program is started from w the Turbo Modula-2 shell. If the program is started from operating system, the string is empty. See Also ComLine Example HODULE RunFromTheShell; FROM ComLine IMPORT progName; VAR x,y: REAL; BEGIN IF progName < > '' THEN WRITELN('This program is called ', progName); END END RunFromTheShell.

PromptFor procedure (ComLine) L

Description *PromptFor* looks for an input string from the command if there is not one present, it prompts the user to provid

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if there is not one present, it prompts the user to provid

Declaration PROCEDURE PromptFor(prompt: ARRAY OF CHAR; VAR s: ARRAY OF CHAR);

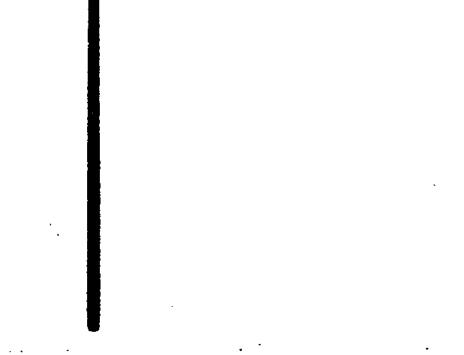
-		:
<u>ILA</u>	<u>Turbo Modula</u>	- Reference Directory 447
	Usage	PromptFor(prompt, answer);
the		PromptFor must be imported from the library module Com- Line.
		prompt and answer must be of type ARRAY OF CHAR.
1e); es a (Comments	This procedure essentially performs a <i>ReadString</i> from the <i>TEXT commandLine</i> exported by <i>ComLine</i> . If an <i>EOT</i> (32C) is encountered in <i>commandLine</i> , then the user is prompted with <i>prompt</i> to provide additional input.
ithin n the		Note that in the Turbo Modula-2 system a command line can be specified by the user with the Run command from inside the Turbo Modula-2 shell.
	Example	<pre>MODULE ptest; FROM ComLine IMPORT PromptFor; BEGIN FOR i := 1 to 3 DO BEGIN WRITE(i:3,' '); PromptFor('Need more > ', str); WRITELN(str); END ; END ptest.</pre>
		If the user starts the program with
		Run MCD file: Ptest arg1 arg2
(then the output will be as follows:
line; ; one.		1 ARG1 2 ARG2

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3 Need more> arg3

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QUALIFIED	R
Description	QUALIFIED forces an identifier exported from a lo module to be qualified in the surrounding environment.
Usage	EXPORT QUALIFIED this, that, theNextThing;
Comments	When an identifier is qualified, it means that every references must be prefixed by the name of the module it has been defin- in, followed by a period (.). For example, these identifiers qualified: <i>Texts.ReadChar</i> , <i>MathLib.Cos</i> , <i>Files.EOF</i> . A these are not: <i>ReadChar</i> , <i>Cos</i> , <i>EOF</i> .
	This command only makes sense for local modules, si main modules and implementation modules can't ex_j anything, and in definition modules everything is exp qualified by default.
Example	pl in local is EXPORT QUALIFIED:
	MODULE main;
	MODULE local; EXPORT QUALIFIED p1;
	PROCEDURE p1; BEGIN END ;
	END local;
	BEGIN

local.p1; (* p1 is visible, but must be qualific
END main.

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RAISE statement R/E

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RAISE causes an exception to be raised, passing control up the Description calling chain to an exception handler or the runtime system. Usage **RAISE** [SomeError] [, message]; message must be a character array. When an exception is raised, the current procedure is searched Comments for the appropriate handler. If one is found, the specified code is executed. If a handler for the exception is not found, the caller of the current procedure is searched. This search process continues until a handler is found or the runtime supervisor is reached. The supervisor prints the exception name on the terminal along with the optional message and the calling chain, control is then returned to the operating system. The short form of the exception statement is RAISE, which may only be used within an exception handler. If this statement occurs in an exception handler, then the same exception that the exception handler is currently handling will be raised again in the next highest procedure of the calling sequence. See Also EXCEPTION Example Raise an exception to be caught somewhere: **RAISE** MyError Raise an exception with a message:

RAISE TooLateAtNight, 'Turn me off and go home !'

Do a little bit of exception-handling and then pass it on:

EXCEPTION

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| DiskFull:
    WRITELN('DiskFull in thisProc');
    Close(f);
    RAISE ;
ELSE
    RAISE ;
END thisProc.
```

Random function (MathLib) L

Description Random returns a random number between 0 and 1.

Declaration PROCEDURE Random(): REAL;

Usage Y:= Random();

Result Y is REAL.

There is no argument, but the parentheses are required.

Comments The function returns the next element from a pseudo-rand number sequence. The same sequence is repeated each your program is executed unless you select a new sequ with the procedure *Randomize*.



Example	Two ways to randomize the random number generator:
	FROM MathLib IMPORT Randomize;
	VAR Sequence: CARDINAL
	BEGIN
	WRITELN('Input sequence number, 0 to 65535'); READ(Sequence);
	Randomize(Sequence);
	or
	i := 0;
	WRITE('Enter any character');
	REPEAT
	i := i + 1;
	BusyRead(ch);
	UNTIL ch $\#$ OC;
	Randomize(i);
Randomize pro	ocedure (MathLib) L
Description	<i>Randomize</i> initializes a pseudo-random-number sequence. The same random sequence can be reproduced by passing the same seed value to <i>Randomize</i> .
Declaration	PROCEDURE Randomize(n:CARDINAL);
Usage	Randomize(1986);
	Randomize must be imported from the module MathLib.
Comments	After randomizing the sequence, call Random to get the ran-

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dom numbers.

See Also

MathLib Random Example MODULE RandomMath; FROM MathLib IMPORT Randomize, Random; VAR x: REAL; BEGIN Randomize(1986); x := Random()*10.0/Random()*20.0; END RandomMath.

READ standar	d procedure S/E
Description	READ is a generalized read statement.
Usage	READ(t, vlist)
	or
	READ(vlist);
	t is of type TEXT imported from TEXTS. vlist is simply a of variables and constants.
Comments	READ will be translated by the compiler into the appropicalls to the module <i>Texts</i> .
	Notice that you do not have to import procedures from 2 in order to use these commands, but <i>Texts</i> must be somew on disk.
	Although <i>READ</i> , <i>READLN</i> , <i>WRITE</i> , and <i>WRITELN</i> are n the standard Modula-2 definition, programming without 1 is much more tedious. However, if a program is to be port do not use these commands. A good strategy would b

do not use these commands. A good strategy would t develop the program using these statements for debugging put and explicitly typed calls to *Texts* for the user's outpu move the program to another environment, only the mc *Texts* must be duplicated in the new environment.

See Also	READLN Texts WRITE WRITELN
Example	Read an integer i:
	READ(i)
	Read a string str followed by 4 integers i, j, k, l:
	READ(str, i,j,k,l)
	Read a real number r from TEXT t:
	READ(t, r)
ReadAgain proc	cedure (Terminal) L
Description	ReadAgain causes the last character read from the terminal to be repeated.
Declaration n	PROCEDURE ReadAgain;
Usage	ReadAgain;
	ReadAgain must be imported from the library module Ter- minal.
Comments	The last character read before this procedure is called will be picked up by the next read operation from the terminal.
	This procedure works with all the input procedures in Ter-

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This procedure works with all the input procedures in *Terminal*, but only works if at least one character has already been processed since the program began.

With this routine you can achieve a certain amount of lookahead without having to set up a global buffer and complicated logic to use is.

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See also	BusyRead ReadChar Terminal	
Example	Read a character and then read it again:	
	ReadChar(ch); ReadAgain; ReadChar(ch);	

ReadAgain procedure (Texts) L		
Description	<i>ReadAgain</i> causes the last character read from a <i>TEXT</i> to repeated.	
Declaration	<pre>PROCEDURE ReadAgain(t: TEXT);</pre>	
Usage	ReadAgain(t);	
	ReadAgain must be imported from the library module Ta	
	t must be of type TEXT imported from Texts.	
Comments	The last character read from t before this procedure is ca will be picked up by the next read operation from t .	
	This procedure works with all the input procedures in T_{c} but only works if at least one character has already been cessed since the program began.	
	With this routine, you can achieve a certain amoun lookahead without having to set up a global buffer and q	

plicated logic to use it.

See Also

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ReadChar Texts <u>LA</u>

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Example	Read a character from the IEAI I and then read it again:
	ReadChar (t, ch); ReadAgain(t);
	ReadChar (t, ch);
	Or, using the <i>ReadAgain's</i> potential lookahead to good advan- tage, you can read a value as an integer or a string depending on the first nonblank character:
	REPEAT ReadChar(t,ch);
	UNTIL ch # '' '' ;
	ReadAgain(t);
	IF (ch > = '' 0 '') and (ch < = '' 9 '') THEN ReadInt(t,x)
	ReadString(t,s)
	END;
ReadByte proc	
Description	<i>ReadByte</i> reads a variable of any type compatible with <i>BYTE</i> from <i>FILE</i> .
Declaration	<pre>PROCEDURE ReadByte(f: FILE; VAR ch: BYTE);</pre>
Usage	ReadByte(f, ch);
	ReadByte must be imported from the library module Files.
	f must be of type FILE imported from Files.

ch must be of a type compatible with BYTE.

Comments	Types compatible with <i>BYTE</i> are those whose storage uses exactly 1 byte. These include CHAR, BOOLEAN, and enumeration types with at most 256 elements; subrange types with bounds within the range 0 to 255, and word-sized variables as well (but only 1 byte is read).
See Also	Files ReadWord ReadRec WriteByte
Example	<pre>Open a file 'ONEBYTE.DAT' and write out a byte; close it, and read it back: MODULE writebyte; FROM Files IMPORT FILE, Create, Close, ReadByte,</pre>

ReadBytes procedure (Files) L

Description

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ReadBytes reads a number of bytes into a block of memory beginning at an address.

Declaration PROCEDURE ReadBytes(f: FILE; buf: ADDRESS; nbytes CARDINAL):CARDINAL;

Usage	<pre>nread := ReadBytes(f, bufadr, nbytes);</pre>
	ReadBytes must be imported from the library module Files.
	f must be of type FILE imported from Files.
	buf must be compatible with type ADDRESS (any pointer).
	nread and nbytes must be of type CARDINAL.
Comments	<i>ReadBytes</i> will attempt to read <i>nbytes</i> from <i>f</i> . It returns the number of bytes successfully read. It will not raise the esception <i>EndError</i> , even if the end of the file is encountered before <i>nbytes</i> bytes are processed.
	The variables are read into memory starting at the location specified in <i>bufadr</i> .
	<i>ReadBytes</i> and <i>WriteBytes</i> are low-level routines with which you can take snapshots of memory to and from the disk, copy files, and so on. They must be used with care, since you can easily destroy your program or its variables with them. When transferring variables, we recommend using an explicitly typed procedure like <i>ReadRec</i> , <i>ReadWord</i> , and the like.
See Also	FILE Files WriteBy tes
Example	Read 1024 bytes from f into memory starting at 8000 Hex:
	uread := ReadBytes(f, 8000H, 1024)

The previous example is not very safe since the programmer doesn't always know what is at a given address in memory. The following is more useful:

nbytes := ReadBytes(f, ADR(area), SIZE(area));

DescriptionReadCard reads a cardinal number from a TEXT fiDeclarationPROCEDURE ReadCard(t: TEXT; VAR c: CARDINAL)UsageReadCard(t, card);ReadCard must be imported from the library modut must be of type TEXT.card must be of type CARDINAL.CommentsIn general, READ is easier to use.This function works by reading a string into ar variable and then converting it via StrToCard in Co Leading blanks are skipped, and the range must be w to MAX(CARDINAL).The BOOLEAN variable Done (exported by Texts) ca to determine whether input was syntactically co within the legal range. If Done is FALSE, the number	
 Usage ReadCard(t, card); ReadCard must be imported from the library module t must be of type TEXT. card must be of type CARDINAL. Comments In general, READ is easier to use. This function works by reading a string into an variable and then converting it via StrToCard in Conduct Leading blanks are skipped, and the range must be w to MAX(CARDINAL). The BOOLEAN variable Done (exported by Texts) can to determine whether input was syntactically conducted by texts). 	le.
ReadCard must be imported from the library modulet must be of type TEXT.card must be of type CARDINAL.CommentsIn general, READ is easier to use.This function works by reading a string into an variable and then converting it via StrToCard in Converting it via StrToCard in Converting blanks are skipped, and the range must be we to MAX(CARDINAL).The BOOLEAN variable Done (exported by Texts) can to determine whether input was syntactically converted by	;
t must be of type TEXT.card must be of type CARDINAL.CommentsIn general, READ is easier to use.This function works by reading a string into ar variable and then converting it via StrToCard in Co Leading blanks are skipped, and the range must be w to MAX(CARDINAL).The BOOLEAN variable Done (exported by Texts) ca to determine whether input was syntactically co	
card must be of type CARDINAL.CommentsIn general, READ is easier to use.This function works by reading a string into ar variable and then converting it via StrToCard in Co Leading blanks are skipped, and the range must be w to MAX(CARDINAL).The BOOLEAN variable Done (exported by Texts) ca to determine whether input was syntactically co	le <i>Te</i>
 Comments In general, READ is easier to use. This function works by reading a string into an variable and then converting it via StrToCard in Converting blanks are skipped, and the range must be w to MAX(CARDINAL). The BOOLEAN variable Done (exported by Texts) can to determine whether input was syntactically converted by converte	
This function works by reading a string into an variable and then converting it via <i>StrToCard</i> in <i>Converting</i> Leading blanks are skipped, and the range must be w to <i>MAX(CARDINAL)</i> . The BOOLEAN variable <i>Done</i> (exported by <i>Texts</i>) can to determine whether input was syntactically converted by <i>Texts</i>) can be determine whether input was syntactically converted by <i>Texts</i> .	
variable and then converting it via StrToCard in Converting Leading blanks are skipped, and the range must be w to MAX(CARDINAL). The BOOLEAN variable Done (exported by Texts) can to determine whether input was syntactically con	
to MAX(CARDINAL). The BOOLEAN variable Done (exported by Texts) ca to determine whether input was syntactically cos	
to determine whether input was syntactically co	ithir
by <i>ReadCard</i> is undefined.	rec
See Also READ Texts WriteCard	
Example Read a cardinal number called c from the file t :	

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ReadCard(t, c)

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ReadChar pro	cedure (Terminal) L
Description	ReadChar reads a character from the terminal without echo.
Declaration	PROCEDURE ReadChar(VAR ch: CHAR);
Usage	ReadChar(c);
	ReadChar must be imported from the library module Ter- minal.
	c must be of type CHAR.
Comments	The character is not echoed to the screen.
·	Line ends are returned as carriage returns, CHR(13).
See Also	BusyRead Terminal
	WriteChar
Example	Read a character ch from the terminal without echo:
	ReadChar(ch)
ReadChar pro	cedure (Texts) L
Description	ReadChar reads a character from a TEXT file.
Declaration	PROCEDURE ReadChar(t: TEXT; VAR ch: CHAR);
Usage	ReadChar(t, c);

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ReadChar must be imported from the library module Texts.

- t must be of type TEXT.
- c must be of type CHAR.

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Comments	In general, READ is easier to use than this procedure.
	A single character is read in; if the stream is <i>input</i> , then the character is echoed to the screen. For input without echo, use <i>ReadChar</i> from the module <i>Terminal</i> .
	Input from the console must always be terminated with a return.
See Also	READ WriteChar
Example	Read a character c from the terminal with echo:
	ReadChar(input, c)
	Read a character from the TEXT file t:
	ReadChar(t, c)
ReadDouble pro	ocedure (Doubles) L
Description	<i>ReadDouble</i> reads a double-precision real variable from a <i>TEXT</i> file.
Declaration	<pre>PROCEDURE ReadDouble(t: TEXT; VAR d: LONGREAL);</pre>
Usage	ReadDouble(t, d);
	<i>ReadDouble</i> must be imported from the library module <i>Doubles</i> .

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t must be of type TEXT imported from Texts.

d must be of type LONGREAL.

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Comments	This procedure works by reading a string from t and then con- verting it to a LONGREAL using <i>StrToDouble</i> .
	The Boolean variable <i>legal</i> (exported from <i>Doubles</i>) is set to TRUE if a legal double-precision number is read from t.
	The <i>READ</i> and <i>READLN</i> procedures use <i>ReadDouble</i> to read LONGREALs.
See Also	WriteDouble
Example	Read a double-precision d out of a text t:
	ReadDouble(t, d);

ReadInt procedure (Texts)

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Description	ReadInt reads an integer from a TEXT file.
Declaration	<pre>PROCEDURE ReadInt(t: TEXT; VAR i: INTEGER);</pre>
Usage	ReadInt(t, i);
	ReadInt must be imported from the library module Texts.
	t must be of type TEXT.
	i must be of type INTEGER.

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Comments	In general, READ is easier to use than this procedure.
	This routine works by reading a string from text t and conver- ting it to an INTEGER using IntToStr in Convert.
	Leading blanks are skipped, and the range must be within MIN(INTEGER) to MAX(INTEGER).
	The BOOLEAN variable <i>Done</i> (exported by <i>Texts</i>) can be used to determine whether input was syntactically correct and within the legal range. If <i>Done</i> is FALSE, the number returned by <i>ReadInt</i> is undefined.
See Also	READ
	Texts WriteInt
Example	Read an integer from the text t:
	ReadInt(t, i)
ReadLine proced	ure (Texts) L
Description	ReadLine reads a whole line of text into a string variable.
Declaration	<pre>PROCEDURE ReadLine(t: TEXT; VAR s: ARRAY OF CHAR);</pre>
Usage	ReadLine(t, line);

ReadLine must be imported from the library module Texts.

t must be of type TEXT imported from Texts.

line must be an ARRAY OF CHAR.

Comments

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ReadLine and *ReadString* are similar except that *ReadString* skips over leading blanks and *ReadLine* doesn't, and *ReadLine* is only terminated by an EOL or an EOT.

ReadString Texts
Read from TEXT t a string str with leading blanks:
ReadLine(t, str)
lure (Terminal) L
ReadLine reads a line of text into a string variable.
PROCEDURE ReadLine (VAR s: ARRAY OF CHAR);
ReadLine(line);
ReadLine must be imported from the library module Terminal.
line must be an ARRAY OF CHAR.
<i>ReadLine</i> is similar to <i>Texts. ReadLine</i> , but <i>ReadLine</i> 's input is terminated by a carriage return instead of an EOT character.
Terminal Texts
Read a string str from the console:
<pre>MODULE ReadLineEx; FROM Terminal IMPORT ReadLine; VAR s: ARRAY [020] OF CHAR; BEGIN WRITELN('Enter a string and press return ');</pre>

ReadLine(str);
WRITELN('The string you entered is ',str);
END ReadLineEx;

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Description	<i>READLN</i> is a generalized read statement that terminates with a new line.
Us age	READLN({t}, vlist)
	or
	READLN(vlist);
	t is an optional TEXT file; the default is input.
	vlist is simply a list of variables.
Comments	If t is omitted, the standard input will be used.
	READLN will be translated by the compiler into the appropriate calls to the module <i>Texts</i> . Thus do not change the definition of the module <i>Texts</i> if you want to use this sort of input and output.
	READLN works just like READ except it skips over the text file being read until an EOL is encountered.
See Also	READLN Texts WRITE WRITELN
Example	Get a number from the user at the terminal:
	WRITE('Gimme a number, doesn't matter which one > ');

READLN(number);

Read a bunch of numbers from a TEXT file:

READLN(t, num1, num2, num3, numlast);

ReadLong procedure (Texts) L

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Description	ReadLong reads a long integer from a TEXT file.
Declaration	PROCEDURE ReadLong(t: TEXT; VAR 1: LONGINT);
Usage	ReadLong(t, 1);
	ReadLong must be imported from the library module Texts.
	t must be of type TEXT.
	l must be of type LONGINT.
Comments	In general, READ is easier to use than this procedure.
	<i>ReadLong</i> works by reading a string from a <i>TEXT</i> file and converting it to a LONGINT using the procedure <i>StrToLong</i> from <i>Convert</i> .
	Leading blanks are skipped, and the range must be within MIN(LONGINT) to MAX(LONGINT).
	The BOOLEAN variable <i>Done</i> (exported by <i>Texts</i>) can be used to determine whether input was syntactically correct and within the legal range. If <i>Done</i> is FALSE, the number returned by <i>ReadLong</i> is undefined.
See Also	READ Texts WriteLong
Example	Read from TEXT file t a long integer l:

.

•

ReadLong(t, 1)

ReadReal procedure (Texts) L Description ReadReal reads a real number from a TEXT file. Declaration **PROCEDURE** ReadReal(t: TEXT; VAR r: REAL); ReadReal(t, r); Usage ReadReal must be imported from the library module Texts.

t must be of type TEXT.

r must be of type REAL.

In general, READ is easier to use than this procedure. Comments

> Leading blanks are skipped, and the range must be within the legal real-number range MIN(REAL) to MAX(REAL).

> The BOOLEAN variable Done (exported by Texts) can be used to determine whether input was syntactically correct and within the legal range. If Done is FALSE, the number returned by *ReadLong* is undefined.

See Also READ Texts **WriteReal**

Example Read a real number r from text file t.

ReadReal(t, r)

ReadRec procedure (Files)

Description ReadRec reads a record, array, or real from a FILE (a binary disk file).

Declaration PROCEDURE ReadRec(f: FILE; VAR rec: ARRAY OF WORD);

Turbo Modula-2 Reference Directory

Usage	ReadRec(f, r);
	ReadRec must be imported from the library module Files.
	f must be of type FILE imported from Files.
	r can be of any type.
Comments	This routine can read any variable not covered by <i>ReadByte</i> and <i>ReadWord</i> . It reads variables compatible with ARRAY OF WORD; for example, REAL, LONGREAL, LONGINT, AR-RAY, or RECORD.
See Also	Files ReadByte ReadWord WriteRec
Example	Open a file 'SOMEWREK.DAT' and write out this record, then read it back:
•	<pre>MODULE writefile; FROM Files IMPORT FILE, Create, Close, WriteRec, ReadRec; FROM wreck IMPORT wreckRec; VAR f : FILE;</pre>
(<pre>wr : wreckRec; BEGIN Create(f, 'SOMEWREK.DAT'); WriteRec(f, wr); Close(f); IF Open(f, 'SOMEWREK.DAT') THEN</pre>

```
ReadRec(f, wr);
  (* wr has whatever it had before in it *)
  Close(f);
  END ;
 END writefile.
```

'.

ReadString procedure (Texts) L

Description	<i>ReadString</i> reads a string, which in this case is a sequence of characters that does not contains blanks or control characters.
Usage	ReadString(t, s);
	ReadString must be imported from the library module Texts.
	t must be of type TEXT imported from Texts.
	s must be of type ARRAY OF CHAR.
Comments	In general, READ is easier to use than this procedure.
	The routine works by skipping over blanks until it gets to a nonblank character, at which point it starts to read. Input is then terminated by a blank or a control character (like EOL or EOT). Thus, strings cannot be separated by commas.
	If you want to read in a line as it is, with leading blanks and all, use <i>ReadLine</i> .
See Also	ReadLine TEXTS WriteString
Example	Read a string, ignoring leading blanks, from a TEXT file t:
	ReadString(t, str)

Description ReadWord reads a variable of any type compatible with WORD from a FILE.

Declaration **PROCEDURE** ReadWord(f: FILE; **VAR** w: WORD);

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Usage	ReadWord(f, w);
	ReadWord must be imported from the library module Files.
	f must be of type FILE imported from Files.
	w must be of a type compatible with WORD.
Comments	Types compatible with WORD are those whose storage uses exactly one word (2 bytes); these include INTEGER, CAR- DINAL, BITSET and all pointers (ADDRESS is a pointer).
See Also	Files ReadByte ReadRec WriteWord
Example	Open a file 'SOMEYEAR.DAT' and write out this year for later:
	<pre>MODULE writefile; FROM Files IMPORT FILE, Create, Open, Close, WriteWord, ReadWord; VAR f : FILE; okay :BOOLEAN y : CARDINAL; BEGIN</pre>
(Create(f, 'SOMEYEAR.DAT'); WriteWord(f, 1985);
	Close(f);
	<pre>IF Open(f, 'SOMEYEAR.DAT') THEN ReadWord(f, v);</pre>

ReadWord(f, y);
 (* y now has the value 1985 *)
 END ;
 END writefile.

•

REAL standard type S

DescriptionREAL is a standard type with variables that can assume any
value between -6.80565E+38 and 6.80565E+38.CommentsYou will use REAL variables whenever your computation is
likely to produce a fraction. For example, to record the mass
of liquid emitting from a pipe, use MassLiquid:= RateOfFlow
* Density.

In this case, none of the variables are likely to be whole numbers so REAL types are appropriate.

It should be remembered that REAL computations are not always exact; a certain amount of rounding occurs. For example, an expression such as Y = 3.0 * (1.0/3.0) will not give the expected result of 1.0, but a value slightly less. In practice, the error is so small that it can usually be ignored. But don't make the following mistake:

```
Y:= 3.0 * (1.0/3.0);
IF Y = 1.0 THEN
:
```

The correct solution is

```
IF (Abs(Y) - 1.0) < 0.01 THEN :
```

If Y is between 0.99 to 1.01, the statement sequence will be executed.

You may use any arithmetic operator in REAL expressions,

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and REAL variables may take part in relational expressions.

The FLOAT standard function will convert other numeric data types into REAL.

It should be noted that the REAL type is not an ordinal type and cannot be used to index arrays, define subranges or sets,

control FOR or CASE statements, or take arguments in any procedure expecting an ordinal type.

Turbo Modula-2 uses the IEEE 4-byte real-number format; that is, in the order of their significance, 1 sign bit, 8 exponent bits, and 23 mantissa bits.

31 3	0	23	22		0
ls l	exponent	I		mantissa	l

The mantissa is in binary format but offset by 1.0, representing only those digits to the right of the decimal point. Thus,

000000H = 1.04000C0H = 1.57FFFFFH = 1.99999999

The exponent is in binary format but with a 80H offset. For example, an exponent 84H indicates the mantissa is to be multiplied by

 $2^{(84H - 80H)} = 2^{4} = 16$

If the exponent is zero, the floating-point value is considered zero.

The least-significant bytes are stored first, at the lower addresses.

Sample Hex real numbers:

3F800000H = 1.04000000H = 2.040490FDBH = 3.141**592**

See the example in WORD for printing out other values.

Example

VAR
SquareArea, SquareSide: REAL;
BEGIN
SquareSide:= 4.21;
SquareArea:= SquareSide * SquareSide;

REALOVERFLOW exception (SYSTEM) L/E

Description REALOVERFLOW is raised by the module SYSTEM when a real expression results in a value that is too large or too small to be represented by the result type.

Declaration **EXCEPTION** REALOVERFLOW;

Usage

EXCEPTION

REALOVERFLOW:
 WRITELN('Overflow.');

END

REALOVERFLOW must be imported from the module SYSTEM.

Comments

This exception occurs only during evaluation of real expressions. Integer and cardinal expressions generate the exception OVERFLOW.

See Also

SYSTEM BADOVERLAY OUTOFMEMORY OVERFLOW

Example MODULE RealOverflow; FROM SYSTEM IMPORT REALOVERFLOW; VAR r: REAL; BEGIN r := MAX(REAL) * 2.2; EXCEPTION REALOVERFLOW: WRITELN('Real Overflow'); END RealOverflow.

RealToStr procedure (Convert) L

Description	RealToStr writes a real number into a string.
Declaration	<pre>PROCEDURE RealToStr(r: REAL; VAR s: ARRAY OF CHAR; digits: INTEGER);</pre>
Usage	RealToStr(r, s, digits);
	RealToStr must be imported from the library module Convert.
	r must be of type Real.
	s must be of type ARRAY OF CHAR.
	digits must be of type CARDINAL.
Con(its	The number r will be converted to the string s . This procedure is similar in form and action to <i>WriteReal</i> in <i>Texts</i> . Here, the declared length of s is substituted for the width parameter in <i>WriteReal</i> .

The *digits* parameter indicates the number of digits to the right of the decimal point. The sign of digits determines whether or not scientific notation will be used, with plus for normal notation and minus for scientific.

	If digits is zero, the decimal point will be dropped.
	If s is too small to contain the string representing r, the excep- tion TooLarge will be raised.
See Also	CardToStr
	Convert
	Doubles
	IntToStr
	LongToStr
	StrToReal
Example	Convert a real to a string:
	VAR sstr : ARRAY [04] OF CHAR; lstr : ARRAY [09] OF CHAR;
	r :REAL
	BEGIN
	r := 3.14159;
	RealToStr(r, sstr, 3);
	(* sstr now has the value ' 3.141' *)
	RealToStr(r, sstr, 1);
	(* sstr now has the value ' 3.1' *)
,	RealToStr(r, sstr, 0);
	(* sstr now has the value ' 3' *)
	RealToStr(r, sstr, -3); (* causes the exception TooL arge to be rais ed *)
	RealToStr(r, lstr, -3); (* lstr now has the value '3.141E+00' *)

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RECORD type R

Description A record consists of a fixed number of bytes that contain *fields* of possibly different types. Each field has a name, the *field identifier*, which is used to select the field. A record may have variant parts that allow the record to have more than one field occupying the same memory.

Usage

RecordType = **RECORD** Field sequence **END**

Field sequence = Field { ; Field }

A field can be either a fixed field or a variant field.

Fixed field = Field identifier: Field type

```
Variant field = CASE [Tag identifier]: Tag type OF
      [Case label: Field sequence] {
      [Case label: Field sequence] }
```

[KLSE Field sequence]

The *field type* can be any type.

The tag type can be of type INTEGER, CARDINAL, BOOLEAN, CHAR, or enumeration.

Each *case label* can be either a single value or a range of values of the tag variable separated by commas.

Comments	You can use a record to handle several related items of different
	types; for example, a record of the date could be

Date : **RECORD** Day: [1..31]; Month: (Jan Feb M

```
Month: (Jan,Feb,Mar,Apr,May,June,
July,Aug,Sept,Oct,Nov,Dec);
Year: [1900..1999]
END
```

Each field in a record has an identifier that is used to access the field. Thus, in the example, a field is specified as *Date.Day, Date.Month*, and so on.

A field can take values defined by the field type. In the previous example, the field *Month* can take any value from the enumeration *Jan* to *Dec*.

For variant records, the tag variable is used to select the different cases depending on its value. For example:

```
TYPE
```

```
Lights = (Red,Orange,Yellow,Green,Blue);
```

VAR

```
Example: RECORD
```

```
Name: ARRAY [1..20] OF CHAR;
CASE Color: Lights OF
Red..Yellow: Test : CARDINAL |
Green, Blue: Today: Date |
END
END
```

In this example, the value of *Color* selects the form of the record. Thus, if *Select* is a record of type *Example*, altering the value of the tag *Select.Color* changes the record's structure. If the tag has a value of *Red*, *Orange*, or *Yellow* and the record is accessed, the field *Select.Test* exists and can be given a value.

No operators are directly applicable to records (except assignment), but any operator applicable to a field type can operate on that field. Thus, if a record *Value* has a field *RealNumbers* of type REAL, then the following is valid:

```
Value.RealNumbers:= 2.31 * Value.RealNumbers
```

The assignment of values to record fields can either be explicitly stated, specifying both the record identifier and the field:

```
Value.CardNumbers:= 34
```

or can use a WITH statement:

```
WITH Value DO
CardNumbers:= 34;
RealNumbers:= 2.31 * RealNumbers
END
```

The memory requirements for a record with fixed fields is the sum of the individual field lengths, but the fields that have 1 byte types are allocated in 2 bytes. For example, a record with two character fields actually occupies 4 bytes. A variant field requires enough memory for the largest of the cases.

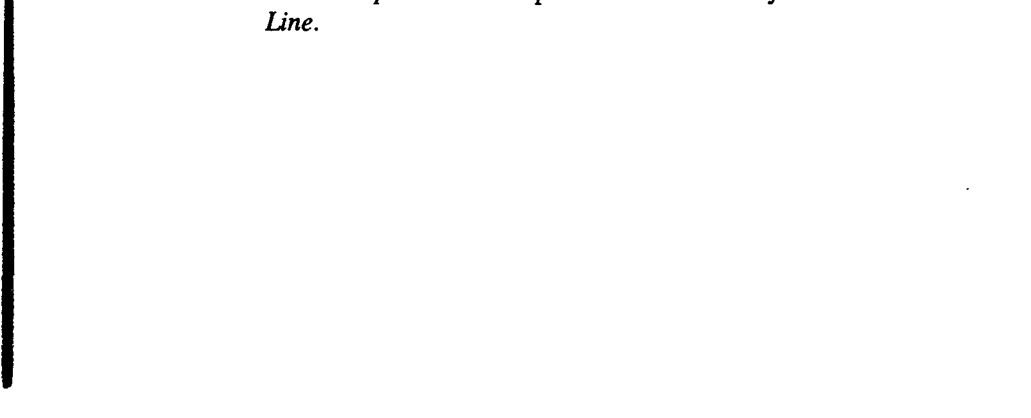
```
Example
                MODULE Records;
                TYPE
                 Origin = (Citizen,Alien);
                 Name
                        = ARRAY [1..20] OF CHAR;
                        =RECORD
                 Date
                         Day: [1..31];
                         Month: (Jan, Feb, Mar, Apr, May, June,
                                July,Aug,Sept,Oct,Nov,Dec);
                         Year: [1900..1999]
                        END;
                Person = RECORD
                          PersonName: Name;
                          BirthDate: Date;
                          CASE CitizenShip: Origin OF
                           Citizen: BirthPlaceName: Name
                           Alien:
                                    CountryOfOrigin: Name;
                                    DateOfEntry: Date
                          END
                         END;
```



VAR Passenger: Person; BEGIN WITH Passenger DO WITH BirthDate DO Day:= 15; Month:= Sept; Year:= 1958 END; CASE CitizenShip OF | Citizen: BirthPlaceName:= 'New Orleans' | Alien: CountryOfOrigin:= 'UK'; WITH DateOfEntry DO Day:= 22; Month:= Aug; Year:= 1984 END END END ; WRITELN(Passenger.BirthDate.Year); END Records.

RedirectInput procedure (ComLine) L

DescriptionRedirectInput allows a filename defined in the command line
to be designated as standard output.DeclarationPROCEDURE RedirectInput;UsageRedirectInput;RedirectInput must be imported from the library module Com-



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Comments	The file name preceded by a $* < *$ in the command line will be reassigned to the standard stream <i>input</i> . No space is allowed between the $* < *$ and the file name.
	If no standard input file is specified in the command line, then the standard input is defined to be at the terminal console.
	The name of the file specified to be the standard input stream is retrievable in the variable <i>inName</i> exported by <i>ComLine</i> .
See Also	Comline
	RedirectOutput
Example	Redirect the input:
	MODULE RedirectTheInput;
	FROM ComLine IMPORT RedirectInput, RedirectOutput;
	BEGIN
	RedirectInput;
	<pre>(* Now input may be redirected from the command line *)</pre>
	END RedirectTheInput.

RedirectOutput procedure (ComLine) L

Description	<i>RedirectOutput</i> allows a filename defined in the command line to be designated as standard output.
Declaration	PROCEDURE RedirectOutput;
Usage	RedirectOutput;

RedirectOutput must be imported from the library module ComLine.

Comments	The file name preceded by a $\gg < \infty$ in the command line will be reassigned to the standard stream <i>output</i> .
	If no standard output file is specified in the command line, then output is defined to be the terminal screen.
	The name of the file specified to be the standard output stream is retrievable in the variable outName exported by ComLine.
See Also	Comline
(RedirectInput
Example	Redirect the output:
	MODULE RedirectTheOutput;
	FROM ComLine IMPORT RedirectInput, RedirectOutput;
	BEGIN
	RedirectOutput;
	(* Now output can be redirected from the command line *)
	·

RELEASE procedure (STORAGE) L

Description	RELEASE releases a block of allocated memory from the heap.
Declaration	PROCEDURE RELEASE(VAR a: ADDRESS);
Usage	RELEASE(a);
(RELEASE must be imported from the pseudomodule STORAGE.

a must be compatible with type ADDRESS (any pointer).

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Comments	All of the memory from address <i>a</i> to the top of the heap will be released; <i>a</i> will become the new top of the heap.
	You can only release a block of memory that has been previously specified with MARK.
	After the call to <i>RELEASE</i> , the value of <i>a</i> will be set to <i>NIL</i> , and any variable allocated on the heap prior to the <i>MARK</i> call will again be accessible.
	<i>RELEASE</i> should be used with care in conjuction with <i>DISPOSE</i> , <i>DEALLOCATE</i> , and file handling.
See Also	MARK NEW STORAGE
Example	Allocate a block of variables and then throw them all away:
	MARK(blockStart); NEW(blockVar1); NEW(blockVar2); NEW(blockVar3);
	(* Now use these variables, and when done: *)
•	RELEASE(blockStart);
Rename procedu	re (Files) L

Description Rename changes the name of an open file and then closes it. Declaration PROCEDURE Rename (VAR f: FILE; name: ARRAY OF CHAR);

`

Usage	Rename(f, newname);
	Rename must be imported from the library module Files.
	f must be a variable of type FILE, imported from the module Files.
	newname must be a character array.
Comments	The file f must have already been opened under its old name.
	newname must be a valid CP/M file name.
	This function has the side effect of closing the renamed file. If you want to use it again, you must reopen it with the new name.
See Also	Close Delete Files Open
Example	<pre>MODULE renameExample; FROM Files IMPORT FILE, Open, Rename, Close VAR f : FILE; newname : ARRAY [012] OF CHAR; oldname : ARRAY [012] OF CHAR; BEGIN oldname := 'oldtest.txt'; newname := 'newtest.txt'; IF Open(f, oldname) THEN Rename(f, newname)</pre>

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END ; END renameExample.

REPEAT state	ment R
Description	REPEAT repeatedly executes a sequence of statements until a Boolean expression returns a TRUE result.
Usage	REPEAT Statement sequence UNTIL BooleanExpression Statement sequence = Statement {; Statement}
Comments	The Boolean expression is evaluated only after the statement sequence has been executed at least once. The repetition is terminated when the expression gives a TRUE result.
Example	<pre>MODULE Repeats; VAR Answer: CHAR; BEGIN REPEAT WRITE('Enter "Q" and <ret> to continue '); READ(Answer); UNTIL CAP(Answer) = 'Q'; END Repeats.</ret></pre>

ResetSys procedure (Files) L

Description ResetSys resets the disk drive system.

Declaration **PROCEDURE** ResetSys();



ResetSys;

ResetSys must be imported from the library module Files.

Comments	ResetSys asks CP/M to update the file directory. Thus, after a call to ResetSys, it is possible to write to drives where disks have been swapped, but all open output files will then be lost. Consequently, make sure all your disk files are closed before using this procedure.
See Also	Files
Example	Get the user to change disks:
	WRITELN('Change disk and type return when ready'); READLN(ch); ResetSys;
RETURN stat	ement R
Description	RETURN terminates execution and specifies the return value of a function procedure.
Usage	RETURN ;
	or
	RETURN answer;
	answer must be compatible with the type with which the func- tion procedure has been declared.
Comments	Normally, there will be only one RETURN in a function pro-

Comments Normally, there will be only one RETURN in a function procedure, just before the final END. However, it is allowable to put as many RETURNs as you like throughout the procedure. When a RETURN is encountered, the procedure will terminate, and the value specified at that point will be returned to the calling procedure.

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Example PROCEDURE maxi3(i1, i2, i3 :INTEGER) :INTEGER BEGIN IF ((i1>i2) & (i1>i3)) THEN RETURN i1 ELSIF (i2>i3) THEN RETURN i2 ELSE RETURN i3 END END maxi3;

SEND procedure (Processes) L

Description	SEND transfers control to any process waiting for a given signal.
Declaration	PROCEDURE SEND(VAR s: SIGNAL);
Usage	SEND(s);
	SEND must be imported from the library module Processes.
	s must be of type SIGNAL imported from Processes.
Comments	SEND is used in conjunction with the other routines in the module Processes: Init, StartProcesses, Wait, and Awaited.
	If no process is waiting for signal s, then SEND has no effect.
•	If a process is waiting for s (that is, has terminated execution with the routine WAIT), then control will be transferred to it.
	If according a construction that the first and in the groups

If several processes are waiting, then the first one in the queue will get control.

Before a signal is used it must be initialized using the procedure Init in Processes.

To find out if processes are waiting for a signal, use the routine Awaited in Processes.

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	See Also	Awaited Init Processes StartProcess WAIT
	Example	Send the signal done:
		SEND(done);
(SET type R	
	Description	A set-type variable can assume as a value a set of up to 16 dif- ferent elements with ordinal values in the range of 0 to 15.
	Us age	Set Type = SET OF Base Type;
		Set Assignment := Base Type ø{ø Base Type Elements ø}ø ;
		Base type can be enumeration or subrange.
		Base-type elements are elements of the base type.
	Comments	A set is a collection of elements that you handle as a whole.
(Besides assigning a value to a set, you can also include another element from the base type into the set, or exclude (or remove) an element from the set using the standard procedures <i>INCL</i> and <i>EXCL</i> .
		The operators applicable to set expressions are the set operators and the relational operator IN. These operators

allow you to check if a particular element is present in a set, to find the difference between two sets, and so forth.

There is a predefined set type called BITSET that is defined as $BITSET = SET \ OF \ [0..15]$. With this set type, you can define sets with values made up of combinations of CAR-DINAL numbers in the range 0 to 15. A set type value requires 2 bytes for storage in memory.

See Also INCL EXCL

Example Suppose you are an automobile manufacturer and wish to record the state of completion of each vehicle. You could define a set of the main parts required, like so:

TYPE

Components = (Body,Engine,Chassis); Compset = SET OF Components

VAR

State: Compset

The enumeration *Components* is called the base type of the set *State*. The set *State* can take as a value any combination of elements from the base type. For example, all of the following are possible assignments:

```
State:= Compset{Body,Chassis};
(* State has two elements Body and Chassis *)
State:= Compset{Body..Chassis};
(* State has all three elements *)
State:= Compset{};
(* State has no elements *)
MODULE Sets;
TYPE
Components = (Body,Engine,Chassis);
Compset= SET OF Components;
VAR
State: Compset;
BEGIN
State := Compset{Body,Engine};
END Sets.
```

SetCol procedure (Texts) L

Description	SetCol advances the write position of a TEXT file to a given column.
Declaration	<pre>PROCEDURE SetCol(t: TEXT; column: CARDINAL);</pre>
Usage	SetCol(t, column);
	SetCol must be imported from the library module Texts.
	t must be of type TEXT imported from Texts.

column must be of type CARDINAL.

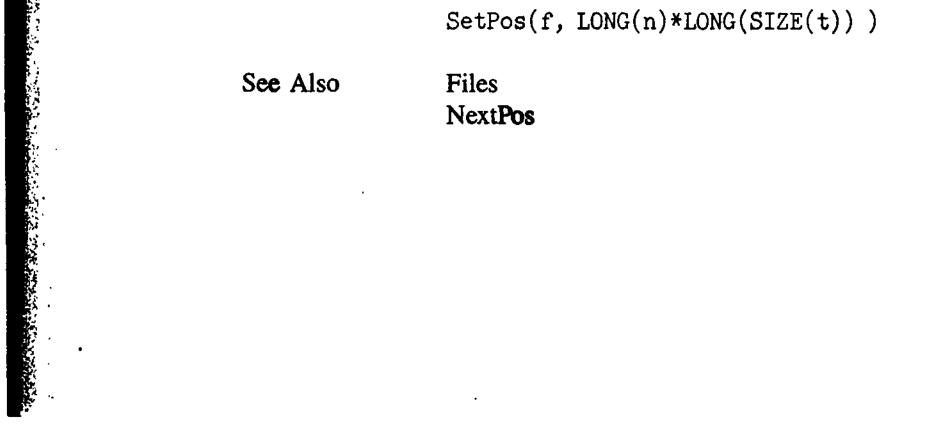
Comments

SetCol has no effect on input. The current column can be queried by use of the function Col exported from Texts.

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See Also	Col Texts
Example	Cause the string »Hello world !« to be output in the twentiet column:
	<pre>SetCol(output, 20); WRITE("Hello world !");</pre>
	Example of tabbing to next multiple of 10:
	SetCol(output, (Col(output) DIV 10 + 1) * 10)
SetPos procedure	e (Files) L
Description	Sets the current byte position of a file.
Declaration	<pre>PROCEDURE SetPos(f: FILE; pos: LONGINT);</pre>

Usage SetPos(f, bytepos); SetPos must be imported from the library module Files. f must be of type FILE imported from Files. bytepos must be of type LONGINT. Comments The procedure is used for random access of data. If all the fil elements of a certain file are of type t, then the file can be positioned at the *n*th element by the call

SetPos(f, LONG(n)*LONG(SIZE(t)))



Example Read the fifteenth widget from a file that has a header:

```
MODULE RandomAccess;
TYPE
widget = RECORD .... END ;
header = RECORD .... END ;
VAR
currentWidget : widget;
pos : LONGINT;
BEGIN
pos := 15L*LONG(SIZE(widget)) + LONG(SIZE(header));
SetPos(widgetFile, pos);
ReadRec(widgetFile, currentWidget);
END RandomAccess.
```

SIGNAL type (Processes) L

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Description	SIGNAL references control loosely coupled processes or cor- outines. A SIGNAL may be Sent or Awaited.
Declaration	TYPE SIGNAL;
Usage	VAR s: SIGNAL;
	SIGNAL must be imported from the module Processes.
Comments	It is mandatory that a SIGNAL variable be initialized by a call to the procedure <i>Init</i> in <i>Processes</i> .
See Also	Processes

SYSTEM

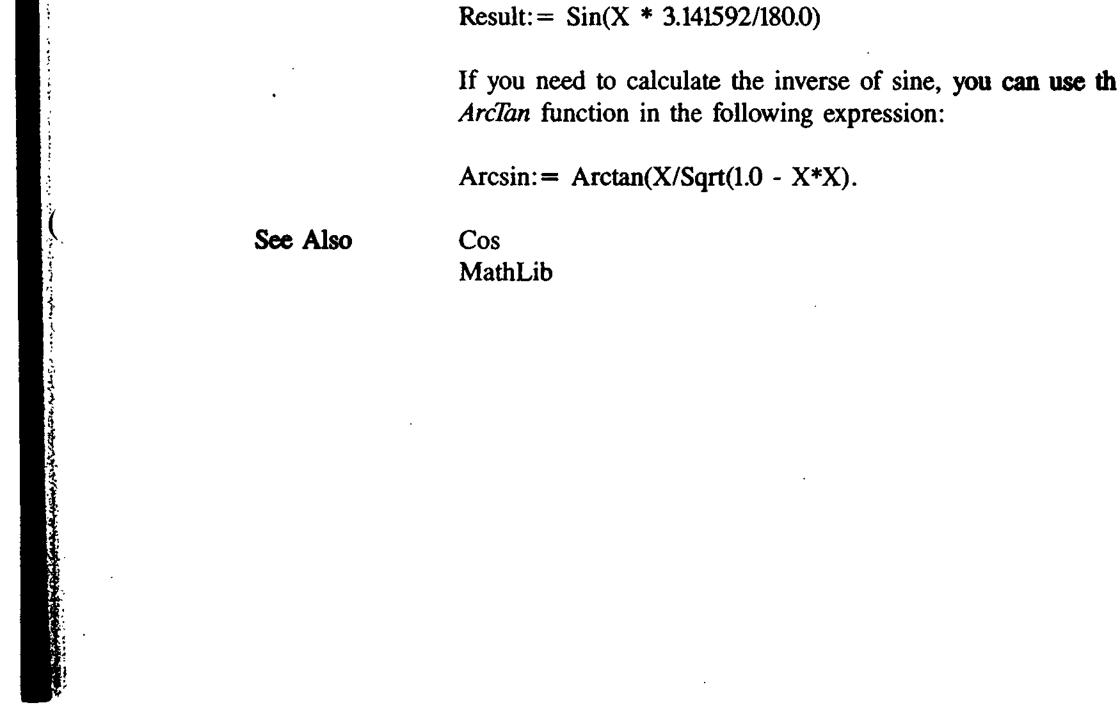
Example MODULE Signals; FROM Processes IMPORT Init, SIGNAL; **VAR** s: SIGNAL; BEGIN Init(s); END Signals.

Sin function (MathLib, LongMath) L Description Sin returns the sine of X, where X is expressed in radians. Declaration **PROCEDURE** Sin(x: REAL): REAL; **PROCEDURE** Sin(x: LONGREAL): LONGREAL; Usage Y := Sin(X);Argument X and result Y are either both REAL or bot LONGREAL. Comments If you want the argument expressed in degrees instead of ra dians, use the expression Result: = Sin(X * 3.141592/180.0)If you need to calculate the inverse of sine, you can use th ArcTan function in the following expression: $\operatorname{Arcsin}:=\operatorname{Arctan}(X/\operatorname{Sqrt}(1.0 - X^*X)).$

See Also

Cos **MathLib**

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Example	MODULE Sine;
•	FROM MathLib IMPORT Sin;
	CONST
	DegsToRads = 3.141592/180.0;
	VAR
	Degs, Radians, sinAngle: REAL;
	BEGIN
	Radians:= Degs * DegsToRads;
	<pre>sinAngle:= Sin(Radians);</pre>
	END Sine.

SIZE standard procedure S

Description	SIZE returns the minimum required storage in bytes of a type or variable.
Usage	SIZE(x);
	x can be a variable of any type or a type identifier.
Comments	The SIZE of a CHAR, BOOLEAN, or BYTE variable is 1; WORD, INTEGER, and CARDINAL variables are 2; REAL and LONGINT variables are 4; LONGREAL variables are 8.
	Note that byte-size variables are only packed in arrays and thus always take up one word of storage, unless they are in an array.
See Also	TSIZE

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The output is

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which shows that arrays are packed and records are not.

SpecialOps type (Terminal) L	
Description	SpecialOps is an enumeration of terminal operations that are not available on all terminals. It is used to describe a set of operations available on the currently installed terminal.
Declaration	TYPE SpecialOps = (clearEol, insertDelete, highlightnor- mal); OpSet : SET OF Special O ps;

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Example



VAR

available : OpSet;

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available is a predefined variable declared as type OpSet; it must be imported from the module Terminal.

Comments	This variable is useful for writing terminal-independent pro- grams. The value of <i>available</i> is set by the installation program INSTM2.
See Also	available
	OpSet
	Terminal
Example	MODULE TermStuff;
	FROM Terminal IMPORT
	available, SpecialOps, ClearToEOL, GotoXY, numCols;
	VAR I, CurCol, CurRow: CARDINAL;
	BEGIN
	IF clearEol IN available THEN ClearToEOL
	ELSE
	FOR I := CurCol TO numCols DO WRITE(' ') END ;
	GotoXY(CurCol,CurRow)
	END;
	WRITE('A line of text.');
	END TermStuff.

Sqrt function (MathLib, LongMath) L

Description	Sqrt returns the square root of positive X.
Declaration	PROCEDURE Sqrt(x: REAL): REAL; PROCEDURE Sqrt(x: LONGREAL): LONGREAL;
Usage	Y := Sqrt(X);
	Argument X and result Y are either both REAL or both LONGREAL.

The argument must be positive or zero.

Comments The argument X must be positive or zero; otherwise, the exception ArgumentError is raised.

See Also	MathLib LongMath
Example	MODULE SquareRoot;
-	FROM MathLib IMPORT Sqrt;
	CONST
	Pi = 3.141592;
	VAR
	CircleArea, CircleRadius: REAL;
	BEGIN
	READ (CircleArea);
	IF CircleArea $> = 0.0$ THEN
	CircleRadius:= Sqrt(CircleArea/Pi)
	END

END SquareRoot.

StartProcess	procedure	(Processes)	L
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Description	StartProcess allocates space to a process and transfers control to it.
Declaration	<pre>PROCEDURE StartProcess(P: PROC; n: CARDINAL);</pre>
Usage	<pre>StartProcess(proc, workSpaceSize);</pre>
	StartProcess must be imported from the library module Pro- cesses.
	proc must be of type PROC.

workSpaceSize must be of type CARDINAL.



Comments	<i>proc</i> is a procedure without RETURNs . Normally, its statements will be enclosed in a LOOP statement without EX-ITs. Control passes to and from the process by calls to SEND and WAIT.
	This routine is implemented using the procedures NEWPROCESS and TRANSFER of the pseudomodule SYSTEM.
See Also	Awaited Init Processes SEND
Example	WAIT Start the process servicel:
	<pre>StartProcess(service1,200);</pre>
StatusError ex	ception (Files) L/E
Description	StatusError is raised by the <i>Files</i> module when a <i>FILE</i> variable is used incorrectly; for example, when reading a unopened file or opening a file twice.
Declaration	EXCEPTION StatusError;
Us age	EXCEPTION StatusError: WRITELN('File error'); END

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StatusError must be imported from the module Files.

Comments Use the StatusError exception to prevent your program from crashing due to user input.

See Also	EndError UseError DeviceError DiskFull
Example	<pre>MODULE ReadFile; FROM Files IMPORT FILE, Open, ReadWord, Close, EndError, StatusError; VAR f: FILE; c: CARDINAL; BEGIN IF Open(f, 'testfile.dat') THEN ReadWord(f,c); END ; ReadWord(f,c); Close(f) EXCEPTION EndError: WRITELN('End of file reached.'); Close(f) StatusError: WRITELN('Error file not opened'); END ReadFile.</pre>

STORAGE pseudomodule L

Description STORAGE is a pseudomodule for managing heap memory in general and dynamic variables in particular.

Declaration **DEFINITION MODULE** STORAGE; FROM SYSTEM IMPORT ADDRESS;

PROCEDURE ALLOCATE(VAR A:ADDRESS; Size: CARDINAL);
PROCEDURE DEALLOCATE(VAR
A:ADDRESS; Size: CARDINAL);

PROCEDURE MARK(VAR A: ADDRESS);
PROCEDURE RELEASE(VAR A: ADDRESS);

PROCEDURE FREEMEM():CARDINAL

END STORAGE.

Comments The procedures NEW and DISPOSE can be considered abbreviated forms of ALLOCATE and DEALLOCATE. To use the standard procedures NEW and DISPOSE, ALLOCATE and DEALLOCATE, respectively, must be imported.

See Also MARK NEW RELEASE

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type (Strings) L

Description	String is a predefined array of characters.
Declaration	TYPE String = ARRAY [080] OF CHAR;
Usage	VAR s1, s2: String;
	String must be imported from the library module Strings.
Comments	Since <i>String</i> is a character array, a variable of this type may be assigned and compared with any other character array variable.
	Even though the module <i>Strings</i> exports the type <i>String</i> none of the procedures require this type. Instead, they use open array parameters that will accept any array of characters.
See Also	Strings
Example	vl and v2 are defined as strings:

FROM Strings IMPORT String; VAR v1,v2: String;

StringError exception (Strings) L/E

Description	StringError is raised by the module Strings when the destina-
	tion of a string operation is not large enough to hold the result.

Declaration **EXCEPTION** StringError;

Usage EXCEPTION StringError WRITELN('String error'); END

StringError must be imported from the module Strings.

Comments This exception occurs only during calls to the procedures exported by *Strings*.

See Also Strings

Example NODULE StringTooShort; FROM Strings IMPORT StringError, Append;

VAR

s1, s2 : ARRAY [0..12] OF CHAR;

BEGIN

s1 := 'Hello there';

s2 := 'everyone';

Append(s2,s1);

EXCEPTION

StringError:

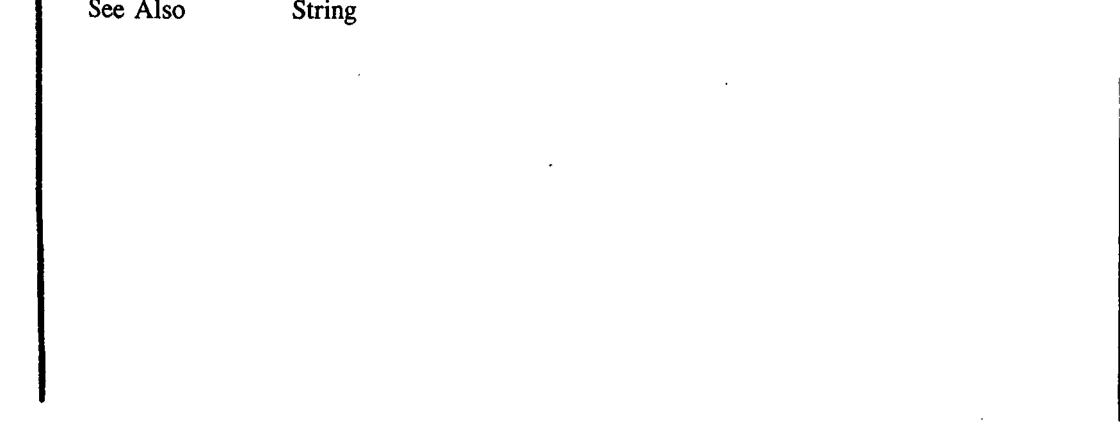
WRITELN('Destination string too short.'); END StringTooShort.

Turbo Modula-2 Reference Directory

Strings module L

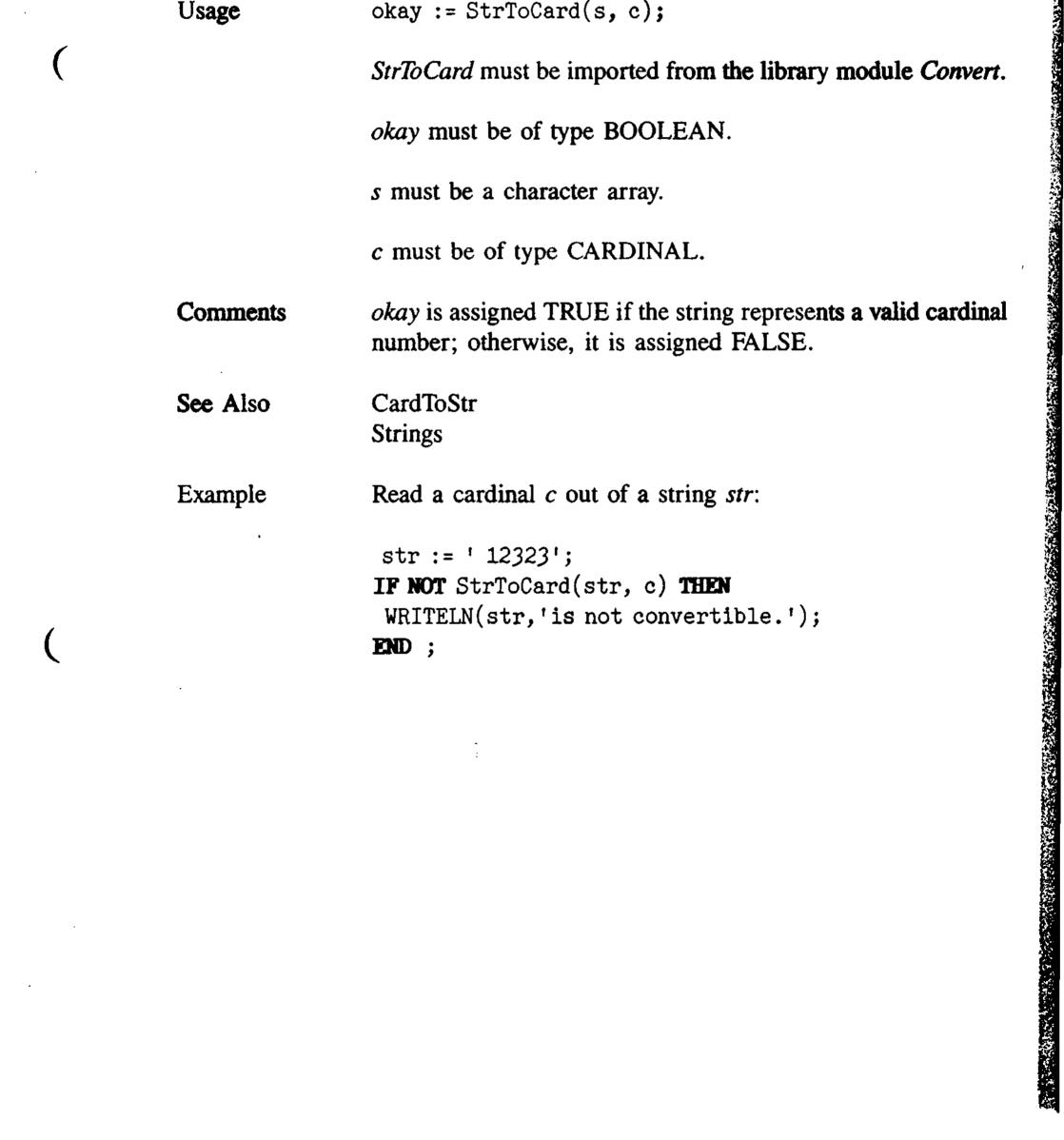
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Description	Strings is a module	for the manipulation of strings.
Declaration	DEFINITION MODULE Strings; TYPE String = ARRAY [080] OF CHAR;	
	—	(VAR str: ARRAY OF CHAR): CARDINAL;
	PROCEDURE Pos	(substr, str: ARRAY OF CHAR): CARDINAL;
	PROCEDURE Insert	(substr: ARRAY OF CHAR; VAR str: ARRAY OF CHAR; inx:CARDINAL);
	PROCEDURE Delete	
	PROCEDURE Append	(substr: ARRAY OF CHAR; VAR str: ARRAY OF CHAR);
	PROCEDURE Copy	<pre>(VAR str: ARRAY OF CHAR; inx,len: CARDINAL; VAR result: ARRAY OF CHAR);</pre>
	PROCEDURE CAPS EXCEPTION StringE END Strings.	(VAR str: ARRAY OF CHAR);
Comments	_	ported from Strings work on any array of on variables declared as type String.
	You should, however	e open arrays; that is, arrays of any size. c, restrict yourself to arrays with indexing the various <i>inx</i> parameters listed earlier o.
See Also	String	



Description	<i>StrToCard</i> performs conversion from a string variable to a car- dinal variable.
Declaration	PROCEDURE StrToCard(VAR s: ARRAY OF CHAR; VAR CARDINAL): BOOLEAN;
Usage	okay := StrToCard(s, c);
	StrToCard must be imported from the library module Convert.
	okay must be of type BOOLEAN.
	s must be a character array.
	c must be of type CARDINAL.
Comments	okay is assigned TRUE if the string represents a valid cardinal number; otherwise, it is assigned FALSE.
See Also	CardToStr Strings
Example	Read a cardinal c out of a string str:
	<pre>str := ' 12323'; IF NOT StrToCard(str, c) THEN WRITELN(str,'is not convertible.'); END ;</pre>

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StrToDouble procedure (Doubles) L

Description	StrToDouble performs conversion from a string variable to a double-precision real variable.
Declaration	PROCEDURE StrToDouble(VAR s: ARRAY OF CHAR; VAR d: LONGREAL): BOOLEAN;
Usage	<pre>okay := StrToDouble(s, d);</pre>
(StrToDouble must be imported from the library module Doubles.
	okay must be of type BOOLEAN.
	s must be a character array.
	d must be of type LONGREAL.
Comments	okay is assigned TRUE if the string represents a valid real number; otherwise, it is assigned FALSE.
See Also	Doubles DoubleToStr
Example	Read a double-precision d out of a string str:
	str := ' 2.99D10';
(<pre>IF NOT StrToDouble(str, d) THEN Writeln (str,'is not convertible'); END ;</pre>

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Description	<i>StrToInt</i> performs conversion from a string variable to an integer variable.
Declaration	PROCEDURE StrToInt (VAR s: ARRAY OF CHAR; VAR i: INTEGER): BOOLEAN;
Usage	<pre>okay := StrToInt(s, i);</pre>
	StrToInt must be imported from the library module Conver
	okay must be of type BOOLEAN.
· · · ·	s must be a character array.
	i must be of type INTEGER.
Comments	okay is assigned TRUE if the string represents a valid intege otherwise, it is assigned FALSE.
See Also	IntToStr Strings
Example	Read an integer called i out of a string:
	<pre>str := " 30000 - This number is almost too big "; okay := StrToInt(str, i);</pre>
	(* i has got 30000 now *)

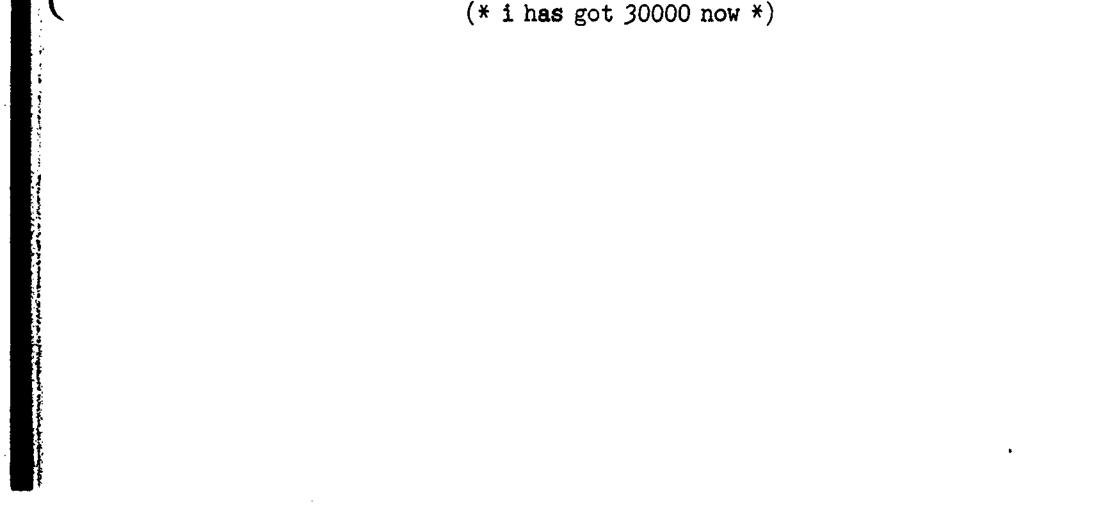
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Turbo Modula-2 Reference Directory

StrToLong procedure (Convert) L

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Description	StrToLong performs conversion from a string variable to a long integer variable.
Declaration	PROCEDURE StrToLong(VAR s: ARRAY OF CHAR; VAR 1: LONGINT): BOOLEAN;
Usage	<pre>okay := StrToLong(s, 1);</pre>
	StrToLong must be imported from the library module Convert.
	okay must be of type BOOLEAN.
	s must be a character array.
	l must be of type LONGINT.
Comments	okay is assigned TRUE if the string represents a valid long in- teger; otherwise, it is assigned FALSE.
See Also	LongToStr Strings
Example	Read a longer integer (see the example in StrToInt) out of a string:
	<pre>VAR str: ARRAY [020] OF CHAR; l: LONGINT; BEGIN str := "40000"; okay := StrToLong(str, 1);</pre>



Description	<i>StrToReal</i> performs conversion from a string variable to a real number variable.
Declaration	PROCEDURE StrToReal(VAR s: ARRAY OF CHAR; VAR r: REAL): BOOLEAN;
Usage	okay := StrToReal(s, r);
	StrToReal must be imported from the library module Convert
	okay must be of type BOOLEAN.
	s must be a character array.
	r must be of type REAL.
Comments	okay is assigned TRUE if the string represents a valid real otherwise, it is assigned FALSE.
See Also	RealToStr Strings
Example	Make Pi out of a string:
	<pre>stringyPi := "3.14159265"; okay := StrToReal(stringyPi, Pi); (* Pi is now Pi *)</pre>

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SYSTEM pseudomodule L

فالتركم والمحتر أوراقه بشاراة والمتنقم والمحتمانين الارمو المقالمات والمعتبا كالمقدارك مردا والعمام لعن

Description SYSTEM is a pseudomodule that provides low-level support.

Declaration **DEFINITION MODULE** SYSTEM

TYPE

WORD; BYTE; ADDRESS; PROCESS; VAR IORESULT, HLRESULT: CARDINAL;

PROCEDURE ADR(VAR v: AnyType): ADDRESS; **PROCEDURE** TSIZE(AnyType): CARDINAL;

PROCEDURE TRANSFER(VAR source, dest: PROCESS);
PROCEDURE IOTRANSFER(VAR source, dest: PROCESS;
n: CARDINAL);

PROCEDURE NEWPROCESS(p: PROC; a: ADDRESS; n: CARDINAL; VAR q: PROCESS);

PROCEDURE BIOS(n:CARDINAL w: WORD): CARDINAL;
PROCEDURE BDOS(n:CARDINAL w: WORD): CARDINAL;
PROCEDURE CODE(AnyStringLiteral);

PROCEDURE MOVE(source, destin: ADDRESS; nbytes: CARDINAL); PROCEDURE FILL(start: ADDRESS; nbytes: CARDINAL; ch: BYTE); PROCEDURE INP(port: WORD): CARDINAL; PROCEDURE OUT(port: WORD; outByte: WORD);

EXCEPTION OVERFLOW, READOVERLOW, OUTOFMEMORY, BADOVERLAY;

END SYSTEM.

Comments For explanations of the various procedures, see the specific en-

tries. In general, use of these procedures make a program much less portable.

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termCH variable (InOut) L		
Description	termCH always contains the last character read by the module InOut.	
Declaration	VAR termCH: CHAR;	
Usage	LastChar := termCH;	
	termCH must be imported from the module InOut.	
Comments	termCH contains the last character read by any of the five read procedures in InOut.	
See Also	InOut Done Texts	
Example ,	<pre>MODULE LastChar; FROM InOut IMPORT ReadCard, termCH; VAR ch: CHAR; c: CARDINAL; BEGIN ReadCard(c); WRITELN('The cardinal read is ',c); WRITELN('The last character of the cardinal is ',termCH); END LastChar.</pre>	

Terminal module L

Description *Terminal* provides input/output to the terminal.

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```
DEFINITION MODULE Terminal;
Declaration
                (* Terminal Input *)
                PROCEDURE ReadChar(VAR ch: CHAR);
                PROCEDURE BusyRead (VAR ch: CHAR);
                PROCEDURE ReadAgain;
                PROCEDURE ReadLine (VAR s: ARRAY OF CHAR);
                (* Screen output *)
                VAR numRows, numCols:CARDINAL
                PROCEDURE WriteChar(ch: CHAR);
                PROCEDURE WriteLn;
                PROCEDURE WriteString(s: ARRAY OF CHAR);
                PROCEDURE ClearScreen;
                PROCEDURE GotoXY(col,row:CARDINAL);
                PROCEDURE InitScreen;
                PROCEDURE ExitScreen;
                TYPE
                 SpecialOps = (clearEol, insertDelete,
                 highlightNormal);
                 OpSet = SET OF SpecialOps;
                VAR
                 available: OpSet;
                PROCEDURE ClearToEOL;
```

PROCEDURE DeleteLine; PROCEDURE Highlight; PROCEDURE Normal;

PROCEDURE InsertLine;

END Terminal.

Comments This module, or at least the screen manipulation procedures, will work correctly only if Turbo Modula-2 has been properly installed on your terminal.

TEXT data structure (Texts) L		
Description	TEXT is a type that represents legible disk files.	
Declaration	TYPE TEXT = [116];	
Usage	VAR t: TEXT;	
	TEXT must be imported from the library module Texts.	
Comments	A TEXT is a character stream. For example, a WordStar document file is better handled as a FILE, while a nondocument file can be manipulated as a TEXT.	
	There are a variety of procedures to handle TEXT objects.	
See Also	Texts	

Simulate the CP/M TYPE utility: Example **MODULE** type; FROM ComLine IMPORT PromptFor; FROM Texts **IMPORT** TEXT, ReadString, OpenText, EOT, ReadChar, WriteChar, output; VAR textName: ARRAY [0..20] OF CHAR; : TEXT; t : CHAR; C :BOOLEAN; okay BEGIN PromptFor("File to type: ",textName); IF OpenText(t, textName) THEN WHILE NOT EOT(t) DO ReadChar(t, c); WriteChar(output, c); END ELSE WRITELN(textName, ' not found'); END END type.

TextDriver type (Texts) L

Description *TextDriver* must be used when installing your own character device drivers. A procedure of this type may be passed to *ConnectDriver*.

Declaration TYPE TextDriver = PROCEDURE (TEXT, VAR CHAR);

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VAR

MyDriver: TextDriver;

TextDriver must be imported from the module Texts.

Comments

You do not need to import the type *TextDriver*, but the procedure you pass to *ConnectDriver* must match it.

See Also	Texts ConnectDriver
Example	<pre>MODULE CharDriver; FROM Texts IMPORT TEXT, ConnectDriver, TextDriver; VAR t:TEXT;</pre>
	<pre>PROCEDURE MyDriver(t: TEXT; VAR ch: CHAR); BEGIN END MyDriver;</pre>
	BEGIN ConnectDriver(t,MyDriver); END CharDriver.

TextFile	procedure	(Texts)	L
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Description	<i>TextFile</i> returns a value of type <i>FILE</i> , as described in the module <i>Files</i> . Since a text file is implemented as a <i>Files</i> . <i>FILE</i> , you may obtain this handle to perform »file« operations on a <i>TEXT</i> .
Declaration	PROCEDURE TextFile(T:TEXT): FILE;

Usage f := TextFile(t);

TextFile must be imported from the module Texts.

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t must be of type TEXT.

f must be of type FILE.

Comments If the file has not been opened, TextFile returns NIL.

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See Also

Texts Files Example MODULE SizeOfAText; FROM Texts IMPORT TEXT, TextFile; FROM Files IMPORT FileSize; VAR t: TEXT; BEGIN WRITE('The size of the text file is '); WRITELN(FileSize(TextFile(t)),' bytes.'); END SizeOfAText.

TextNotOpen exception (Texts) L/E

Description	TextNotOpen is raised by the module Texts when an attempt is	
	made to use an unopened text.	

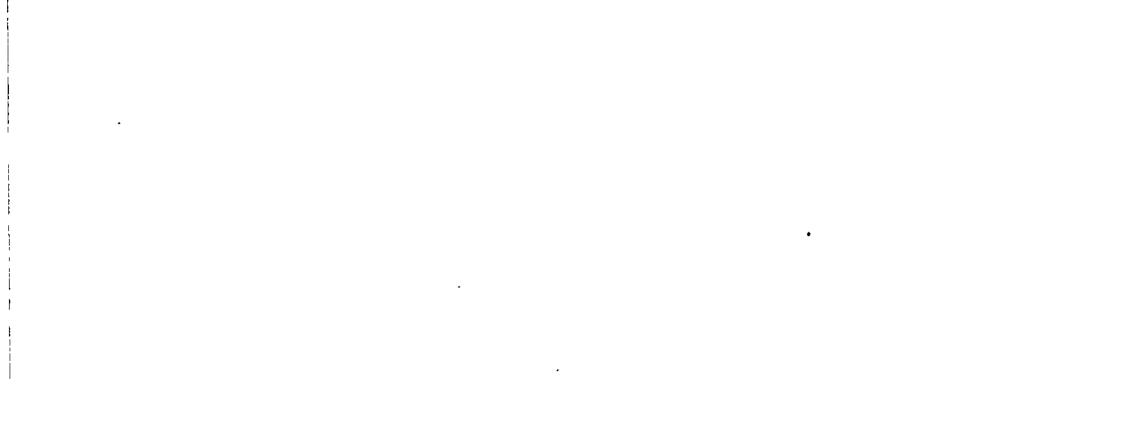
Declaration **EXCEPTION** TextNotOpen;

Usage EXCEPTION TextNotOpen: WRITELN('Text not open'); END

TextNotOpen must be imported from the module Texts.

Comments This exception can be raised by all input/output procedures and the procedure *SetCol*.

See Also Texts TooManyTexts



Example	MODULE TextNotOpen;
	FROM Texts IMPORT TEXT, OpenText, TextNotOpen;
	VAR
	t : TEXT;
	filename : ARRAY [015] OF CHAR;
	x : REAL;
	BEGIN
	<pre>IF OpenText(t,filename) THEN END ;</pre>
	READ(t,x);
	EXCEPTION
	<pre>TextNotOpen: WRITELN("Can't read an unopen text.");</pre>
	END TextNotOpen.

Texts module	L		
Description	Texts manipulates legible disk files.		
Declaration	DEFINITION MODULE Texts; FROM Files IMPORT FILE;		
	CONST EOL=36C; TYPE TEXT = [116]; VAR input,output,console: TEXT;		
•	<pre>PROCEDURE ReadChar (t: TEXT; VAR ch: CHAR); PROCEDURE ReadString (t: TEXT; VAR s: ARRAY OF CHAR);</pre>		
	PROCEDURE ReadInt(t: TEXT; VAR i:INTEGER); PROCEDURE ReadCard(t: TEXT; VAR c:CARDINAL); PROCEDURE ReadLong(t: TEXT; VAR 1:LONGINT); PROCEDURE ReadReal(t: TEXT; VAR r:REAL);		
	PROCEDURE ReadLine (t. TEXT: VAR s. ARRAY OF		

CHAR); **PROCEDURE** ReadAgain (t: TEXT); **PROCEDURE** ReadLn (t: TEXT);

PROCEDURE WriteChar (t: TEXT; ch: CHAR);
PROCEDURE WriteString(t: TEXT; s: ARRAY OF CHAR);

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PROCEDURE WriteInt	<pre>(t: TEXT; i:INTEGER; n:CARDINAL);</pre>			
PROCEDURE WriteCard	(t: TEXT; c, n:CARDINAL);			
PROCEDURE WriteLong	(t: TEXT; 1:LONGINT;			
	n:CARDINAL);			
PROCEDURE WriteReal	(t: TEXT; r:REAL; n:CARDINAL;			
	digits:INTEGER);			
PROCEDURE WriteLn	(t: TEXT);			
PROCEDURE Done	(t: TEXT):BOOLEAN;			
PROCEDURE EOLN	(t: TEXT):BOOLEAN;			
PROCEDURE EOT	(t: TEXT):BOOLEAN;			
DEOCEDIER ODODTOXt	(VAR t: TEXT; name: ARRAY OF			
PROCEDURE OpenText	CHAR):BOOLEAN;			
PROCEDURE CreateText	(VAR t: TEXT; name: ARRAY OF			
	CHAR);			
PROCEDURE CloseText	(VAR t: TEXT);			
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PROCEDURE Col	(t: TEXT): CARDINAL;			
PROCEDURE SetCol	(t: TEXT; column:CARDINAL);			
	· · · · · · · · · · · · · · · · · · ·			
PROCEDURE TextFile	(t: TEXT): FILE;			
TYPE TextDriver = PROCEDURE(TEXT, VAR CHAR);				
PROCEDURE ConnectDriv	ver (VAR t: TEXT; p: Text			
	Driver);			
,				
PROCEDURE Init; (* used only by system *)				
VAR haltOnControlC:B	OOLEAN; (*TRUE by default *)			

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EXCEPTION TextNotOpen, TooManyTexts;

END Texts.

Comments Rather than use the various read and write procedures in this module directly, the user is encouraged to use the standard procedures *READ*, *READLN*, *WRITE*, and *WRITELN*. These are translated by the compiler into calls to the appropriate procedures in *Texts*.

TooLarge exception (Convert) L/E

CommentsRather than use the various read and write procedures in this
module directly, the user is encouraged to use the standard
procedures READ, READLN, WRITE, and WRITELN. These
are translated by the compiler into calls to the appropriate pro-
DescriptionDescriptionTedUrespininDicates that a conversion from a number to a string
cannot be done because the string representation of the number
is too long for the destination string.

Declaration EXCEPTION TooLarge;

Usage **EXCEPTION**

TooLarge: WRITELN('could not convert the number to string'); END

Comments This exception eliminates the necessity to check user input after every user entry. A common exception handler can be written that will trap all such conversion errors.

See Also Convert

Example MODULE InputTooLarge; FROM Convert IMPORT IntToStr, TooLarge; VAR

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i: CARDINAL; s: ARRAY [0..2] OF CHAR;

BEGIN

```
WRITE('Give me an cardinal less than 100');
READLN(i);
CardToStr(i,s);
WRITELN('The string is ',s);
EXCEPTION
TooLarge: WRITELN('That was too large!');
END InputTooLarge.
```

oManyTexts exception (Texts) L/E

Description	TooManyTexts is raised by the module <i>Texts</i> when an attempt is made to open a text and there are already 16 open.
Declaration	EXCEPTION TooManyTexts;
Usage	EXCEPTION TooManyTexts: WRITELN('Too many text files'); END
	TooManyTexts must be imported from the module Texts.
Comments	There are three texts that are always open: console, input, and output. These three texts are part of the 16 allowable texts.
See Also	Texts TextNotOpen
(مندxample	MODULE TooManyTextFiles; FROM Texts IMPORT TEXT, CreateText, TooManyTexts; VAR

t: ARRAY [0..15] OF RECORD

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t: TEXT;
filename: ARRAY [0..15] OF
CHAR;
END;

I: CARDINAL;

BEGIN

FOR I := 0 TO 15 DO
 CreateText(t[I].t,t[I].filename);
END
EXCEPTION
TooManyTexts: WRITELN("Can't open another text.");
END TooManyTextFiles.

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TRANSFER procedure (SYSTEM) L

Description TRANSFER allows cooperative control between processes.

Declaration **PROCEDURE** TRANSFER(VAR source, dest: PROCESS);

Usage TRANSFER(source, destination);

TRANSFER must be imported from the pseudomodule SYSTEM.

source must be of type PROCESS imported from SYSTEM.

destination must be of type PROCESS imported from SYSTEM.

Comments The *source* variable will be assigned to the process where the TRANSFER call is made. This permits the called process to return control to the caller, if desired.

Before you transfer to a process it must have first been set up by a call to *NEWPROCESS*.

We recommend using the module Processes where possible.

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since it provides rudimentary signaling support upon which to base scheduling.

See Also IOTRANSFER NEWPROCESS PROCESS

Example Mark time:

MODULE TickTock; FROM SYSTEM IMPORT NEWPROCESS, TRANSFER, ADDRESS, PROCESS, WOFD; VAR tickProcess, tockProcess, main: PROCESS; tickWork, tockWork : POINTER TO ARRAY [0..99] OF WORD; PROCEDURE tick; BEGIN WRITELN('tick'); TRANSFER(tickProcess, tockProcess);

END;

```
PROCEDURE tock;
BEGIN
WRITELN('tock');
TRANSFER(tockProcess, tickProcess);
END tock;
```

BEGIN

```
NEWPROCESS(tick, tickWork, SIZE(tickWork^),
tickProcess);
NEWPROCESS(tock, tockWork, SIZE(tockWork^),
tockProcess);
TRANSFER(main, tickProcess); (* Start of
tick-tock *)
(* This routine can be hard to stop *)
END TickTock.
```

Description TRUE denotes the Boolean state of truth.

Usage

Finished := TRUE;

Finished is a variable of type BOOLEAN.

Comments	The ordinal value of TRUE is 1; thus, WRITE(CAR- DINAL(TRUE)) will print a 1. In contrast, the ordinal value of FALSE is 0; thus, truth is greater than falsity.
See Also	BOOLEAN FALSE
Example	<pre>MODULE Truth; VAR b: BOOLEAN; BEGIN REPEAT b := TRUE UNTIL b; (* does not repeat *) END Truth.</pre>

TRUNC standar	rd function S
Description	TRUNC converts from REAL type to CARDINAL type.
Usage	Y := TRUNC(X);
	Argument X is of type REAL. The argument must be in the CARDINAL (0 to 65535) range.
	Result Y is of type CARDINAL.
Comments	You must make sure that the argument is in the CARDINAL range, otherwise an overflow error will occur.
	The argument is truncated (any fractional part is removed); for example, the number +16.74 will become a CARDINAL +16.
	Note that truncating a number is not the same as rounding the

number to the nearest whole value; for example, 9.99999 will be truncated to 9, not rounded to 10. If you wish to round a REAL value to the nearest whole value, use the expression Rounded := TRUNC(X + 0.5).

The inverse conversion from CARDINAL or INTEGER to REAL uses the FLOAT function.

TRUNC returns a CARDINAL result; therefore, its argument must be nonnegative. The result can be assigned to INTEGERs as well, since INTEGER and CARDINAL are assignment compatible.

Example	VAR
	Values: ARRAY 110] OF REAL;
	Rounded: ARRAY [110] OF CARDINAL;
	I: CARDINAL;
	BEGIN
r	FOR I := 1 TO 10 DO
x	Rounded[I]:= TRUNC(Values[I] + 0.5)
	END ;

TSIZE procedure (SYSTEM) L

Description	TSIZE returns the storage requirements of a data type in bytes.
Declaration	PROCEDURE TSIZE(AnyType): CARDINAL;
Usage	<pre>bytes := TSIZE(t);</pre>
	TSIZE must be imported from the pseudomodule SYSTEM.
	bytes must be of type CARDINAL.
	t may be any type identifier.
Comments	This function returns the size of a type; if you want the size of a specific variable, use SIZE.
See Also	SIZE

SYSTEM

TYPE declaration R

Description	TYPE signals the start of a data-type definition section in the declaration part of a procedure or module.
Usage	TYPE newtype = oldTypeList;
	newtype can be any valid identifier.
	oldTypeList is a combination of previously defined data types.
Comments	This declaration allows you to define objects whether they comprise sets like Red, Green, Blue; subranges of basic types like all integers between 1950 and 2000; or combinations of any length.
Example	Define an age type:
	TYPE ageRange = [0114]; Define a customer record:
	TYPE personRec = RECORD firstName, middleName: ARRAY [012] OF CHAR; lastName : ARRAY [020] OF CHAR; age : ageRange; married : BOOLEAN; company : ARRAY [030] OF CHAR;

:

Define colors for an RGB monitor:

END;

TYPE

pixelColors = (redPix, greenPix, bluePix); color = SET OF pixelColors;

CONST

black	= color{ };
red	= color{ redPix };
green	<pre>= color{ greenPix };</pre>
blue	= color{ bluePix };
yellow	<pre>= color{ redPix, greenPix };</pre>
purple	<pre>= color{ redPix, bluePix };</pre>
cyan	<pre>= color{ greenPix, bluePix };</pre>
white	<pre>= color{ redPix, greenPix, bluePix };</pre>

VAR

```
currentColor: color;
```

BEGIN

```
currentColor := red; (* etc *)
```

c >

UseError exception (Files) L/E

Description	UseError is raised by the Files module when an operation on
	a file is impossible because the disk is write-protected.

Declaration **EXCEPTION**

UseError;

Usage EXCEPTION

UseError: WRITELN('File error');

END

UseError must be imported from the module Files.

Comments Use the UseError exception to prevent your program from crashing when the user swaps disks unexpectedly.

See Also

EndError StatusError DeviceError DiskFull

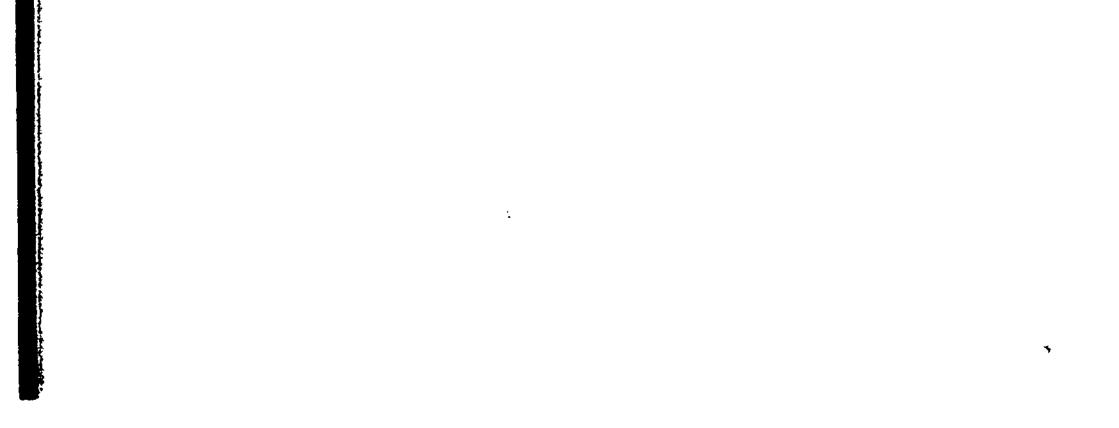
Example	<pre>MODULE WriteFile; FROM Files IMPORT FILE, Create, WriteWord, Close, EndError, StatusError, UseError; VAR f: FILE; c: CARDINAL; BEGIN Create(f,'testfile.dat'); WriteWord(f,c); Close(f) EXCEPTION EndError: WRITELN('End of file reached.'); Close(f) StatusError: WRITELN('Error file not opened'); UseError: WRITELN('Disk net legged in ');</pre>
	UseError : WRITELN('Error file not opened'); UseError : WRITELN('Disk not logged in.'); END WriteFile.

VAL standard function S		
Description	VAL returns the value of type T with ordinal number X .	
Usage	Y:= VAL(T,X);	
	Argument X is of CARDINAL type.	
	Argument <i>T</i> is a CARDINAL, INTEGER, CHAR, BOOLEAN, or enumeration-type identifier.	
	Result Y is of type T.	
Comments	Note that $VAL(T, ORD(X)) = X$ for any type T.	

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Example	TYPE
	<pre>Direction: (Forward,Backward,Up,Down);</pre>
	VAR
	Move: Direction;
	Value: CARDINAL;
	Character: CHAR;
	BEGIN
	Move:= VAL(Direction,2);
	(* Move is value Up *)
	Value:= 43;
	Character:= VAL(CHAR,Value);
	(* Character is value '+' *)
	Notice that this example is equivalent to type conversion. The last example could have been accomplished just as well with Character:= $CHR(Value)$;). VAL provides a generic method for all ordinal types.
VAR declaration	R

Description	VAR signals the start of a declaration section for variables in- side the declaration part of a module or a procedure.
	In the parameter list of a procedure, VAR specifies that a variable is a variable parameter.
Usage	VAR vlist : anytype;
	vlist is simply a list of identifiers.

anytype is any standard, imported, or user-defined type.

Comments Variable declarations may appear anywhere in the declaration section of procedures and modules.

Example Declare an integer *i*:

VAR i :INTEGER;

Declare a couple of characters:

VAR : carney,gleason : CHAR;

WAIT procedu	re (Processes) L
Description	WAIT causes the currently executing process to stop and wait for a signal.
Usage	WAIT(siggy);
	WAIT must be imported from the library module Processes.
	siggy must be of type SIGNAL imported from Processes.
Comments ,	WAIT is used in conjunction with the other routines in Pro- cesses.
	When <i>WAIT</i> is called from an executing <i>Process</i> , it causes the execution of that <i>Process</i> to pause. It is then inserted into a queue associated with the signal <i>siggy</i> . It will not be revived again until the signal <i>siggy</i> is sent with the procedure <i>SEND</i> .
See Also	Awaited Init SEND StartPro cess WAIT



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Wait for a signal:

WAIT(signal)

Turbo Modula-2 Reference Directory

Description	WHILE repeatedly executes a sequence of statements as long as a Boolean expression returns a TRUE result.
Usage	WHILE BooleanExpression DO
	Statement sequence
	END;
	<pre>Statement sequence = Statement {; Statement };</pre>
Comment	The Boolean expression is evaluated before the statement se- quence is executed; thus, the sequence is not necessarily ex- ecuted.
	The repetition is terminated by an expression that returns a FALSE result.
Example	MODULE While;
-	CONST
	N = 10;
	VAR
	I, Find: CARDINAL;
•	DataArray: ARRAY [0N] OF CARDINAL;
	BEGIN
	WRITE("Input value to find: ");
	READ(Find);
	I:= 0;
	<pre>WHILE (I < N) & (DataArray[I] # Find) DO I:= I + 1</pre>
	END While.

Description	WITH aids access to record fields.
Usage	WITH Designator DO Statement sequence END ;
	Designator is of record type.
	<pre>Statement sequence = Statement {; Statement } ;</pre>
·	There are two ways to access the values of record fields.
	The first method states explicitly both the record identifier and the field:
	Person.Name:= øAlfred Smithø
	The other method uses the WITH statement:
	WITH Person DO Name := "Alfred Smith"; Age := 34; END ;
	This second mothed approvides a cleaner motation consciolly for

This second method provides a clearer notation, especially for large records or records with nested record fields.

}

```
Example
               MODULE With;
                TYPE
                PersonRecord = RECORD
                                 Name: ARRAY [1..20] OF CHAR;
                                 Age: [0..200]
                                END;
                VAR
                Patient: PersonRecord;
               BEGIN +
                WITH Patient DO
                  WRITE("Enter patient's name: ");
                 READ(Name);
                  WRITE("Enter patient's age: ");
                  READ(Age)
                END;
                WITH Patient DO
                 WRITE(Name, " is ", Age, " years old.")
                END
               END With.
```

WORD type (SYSTEM) L

Description	WORD is a low-level type with variables that occupy one word (2 bytes) of memory. All variables occupying one word of storage are assignment-compatible with type WORD.
Usa ge	PROCEDURE p1 (w : WORD);
	WORD must be imported from the pseudomodule SYSTEM.
Comments	WORD is compatible with INTEGER, CARDINAL, BITSET, SET, enumeration types, POINTER types (including AD-DRESS), POOLEAN, and CHAR

DRESS), BOULEAN, and CHAR.

Because BYTE is a subrange of WORD, those variables compatible with BYTE are also compatible with WORD. ARRAY OF WORD is compatible with every type. It may be used as a special open array parameter type that allows any variable to be passed as the actual parameter.

Only assignment operations are allowed on variables of type *WORD*; however, type-transfer functions may be applied to type *WORD*.

Dump a variable:

MODULE LowLevelDump;
FROM InOut IMPORT WriteHex;
FROM SYSTEM IMPORT WORD,ADR;

PROCEDURE DumpVar(VAR v:ARRAY OF WORD);
VAR

i :INTEGER

BEGIN

WRITELN('There are ',HIGH(v)+1,' words allocated for v'); FOR i := 0 TO HIGH(v) DO WRITE(' Address: \$'); WriteHex(ADR(v[i]),4); WRITE(i:3,' Value: \$'); WriteHex(v[i],4); WRITELN; END ;

END DumpVar;

VAR

```
r: REAL;
rec: RECORD
a,b,c,d: REAL;
```

Example

END ; BEGIN

DumpVar(r); DumpVar(rec); END LowLevelDump.

WRITE standa	
Description	WRITE is a generalized write statement.
Usage	WRITE(vlist)
	or
	WRITE(t, vlist);
	t must be of type TEXT imported from Texts.
	<i>vlist</i> is simply a list of variables or constants and optional for- matting parameters.
Comments	If t is not specified, the standard output text output will be used.
	WRITE will be translated by the compiler into the appropriate calls to the module <i>Texts</i> .
	WRITELN is the same as WRITE, except WRITELN starts a new line when the output is complete.
	Although WRITE, WRITELN, READ, and READLN are not in- cluded in the Modula-2 definition, programming without them can be very tedious; however, they are not portable.
	One strategy might be to develop the code using these statements for debugging and development output, and use the explicit calls to <i>Texts</i> for the actual programmed output.
See Also	READ

READLN Texts WRITELN Example Write out the variable *nthingys* with an explanation:

WRITE('Number of things: ', nthingys)

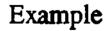
In scientific notation, write out pi in a field 12 spaces wide with 7 digits in the mantissa.

```
pi := 4.0*ArcTan(1.0);
WRITE(' pi =', pi:12:-7);
```

WriteByte procedure (Files) L

Description	<i>WriteByte</i> writes one byte to a file, which is compatible with the type <i>BYTE</i> .
Declaration	<pre>PROCEDURE WriteByte(f: FILE; ch: BYTE);</pre>
Usage	<pre>WriteByte(f, b);</pre>
	WriteByte must be imported from the library module Files.
	f must be of type FILE imported from Files.
•	b must be of a type compatible with BYTE imported from SYSTEM.
Comments	With this routine you can write out a file in small pieces.
	<i>WriteByte</i> is appropriate with types that require only 1 byte of storage, namely BOOLEAN, CHAR, subrange types in the range 0 to 255, and enumeration types with at most 256 elements.

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Write out a boolean value okay to a file f:

WriteByte(f, okay)

Turbo Modula-2 Reference Directory

WriteBytes procedure (Files) L

Description	WriteBytes writes a specified number of bytes to a file.
Declaration	<pre>PROCEDURE WriteBytes(f: FILE; buf: ADDRESS; nbytes: CARDINAL);</pre>
Usage	<pre>WriteBytes(f, bufStart, nbytes);</pre>
	WriteBytes must be imported from the library module Files.
	f must be of type FILE imported from Files.
	bufStart must be of type ADDRESS imported from SYSTEM.
	nbytes must be of type CARDINAL.
Comments	<i>nbytes</i> from the file f will be written from the block of memory starting from the address <i>bufStart</i> and extending to <i>bufStart</i> + <i>nbytes</i> - 1.
	This is a low-level routine that should only be used for special purposes. When writing out variables, we recommend using the routines WriteByte, WriteWord, and WriteRec.
Example	Take a snapshot of the entire memory (except for the last byte):
	WriteBytes(snap, 0, 65355);

WriteCard procedure (Texts) L

Description WriteCard writes out a cardinal number to a TEXT file.

Declaration **PROCEDURE** WriteCard(t: TEXT; c, n: CARDINAL);

Usage	WriteCard(t, c, width);
	WriteCard must be imported from the library module Texts.
	t must be of type TEXT imported from Texts.
	c must be of type CARDINAL.
	width must be of type CARDINAL.
Comments	The number is output right-justified and blank-padded in a field width characters wide.
See Also	CARDINAL ReadCard Texts WRITE
Example	Write the number <i>n</i> to the standard output:
	WriteCard(output, n, 6)
WriteChar proc	edure (Terminal) L
Description	Write Char writes a character to the console.
Declaration	PROCEDURE WriteChar(ch: CHAR);
Usage	WriteChar(ch);
	WriteChar must be imported from the library module Ter- minal.

ch must be of type CHAR.

Comments WriteString does the same thing for a string.

Example Write out a character X to the screen:

WriteChar("X")

Turbo Modula-2 Reference Directory

WriteChar procedure (Texts) L

Description	WriteChar writes a character to a TEXT file.
Declaration	<pre>PROCEDURE WriteChar(t: TEXT; ch: CHAR);</pre>
Usage	WriteChar(t, ch);
	WriteChar must be imported from the library module Texts.
(t must be of type TEXT imported from Texts.
X X	ch must be of type CHAR.
Comments	In general, the WRITE statement is easier to use than WriteChar.
	WriteString will do the same thing for a whole string.
See Also	ReadChar Texts WRITE WriteString
Example	Write out character MrMouse to text comix:
	<pre>MODULE WriteCharacter; FROM Texts IMPORT TEXT, WriteChar; VAR MrMouse: CHAR; comix: TEXT;</pre>
	BEGIN (* other code *)

WriteChar(comix, MrMouse) END WriteCharacter.

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Description	<i>WriteDouble</i> writes a double-precision real variable to a <i>TEXT</i> file.
Declaration	<pre>PROCEDURE WriteDouble(t: TEXT; d: LONGREAL; n: CARDINAL; m: INTEGER);</pre>
Usage	<pre>WriteDouble(t, d, width, digits);</pre>
	WriteDouble must be imported from the library module Doubles.
	t must be of type TEXT imported from Texts.
	d must be of type LONGREAL.
	width must be of type CARDINAL.
	digits must be of type INTEGER.
Comments	The number <i>d</i> is output right-justified in a field width characters wide with <i>digits</i> digits after the decimal point.
• .	If <i>digits</i> is negative, then the number is output in scientific notation with <i>digits</i> digits after the decimal point.
	If digits is zero, the decimal point is omitted.
	The WRITE and WRITELN procedures use this procedure to write LONGREALs with a default for width of 21 and a default for digits of -14.

See Also Doubles ReadDouble

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Example

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	WriteDouble(t, 2.99, 5, 2); yields " 2.99" WriteDouble(t, 2.99, 5, 0); yields " 3"
	WriteDouble(t, 2.99, 9, 0); yields " 3" WriteDouble(t, 2.99, 9, -2); yields " 2.99D+01"
WriteHex procee	lure (InOut) L
Description	WriteHex writes a hexadecimal number out to output.
Declaration	<pre>PROCEDURE WriteHex(x,n: CARDINAL);</pre>
Usage	WriteHex(num, digits);
	WriteHex must be imported from InOut.
	num must be of type CARDINAL.
	digits must be of type CARDINAL.
Comments	The number will be converted to hexadecimal and printed out in a field that is at least <i>digits</i> wide. If the number doesn't need that many digits, it will be blank-padded.
	This and <i>WriteOct</i> are useful procedures to print out addresses and storage requirements in their natural form.
See Also	InOut WriteOct
Example	Write in hex the number 32 in a field four digits wide:

Write a double-precision d to a text t:

WriteHex(32, 4) yields ' 20'

Description	WriteInt writes out an integer number to a TEXT file.
Declaration	PROCEDURE WriteInt(t: TEXT; i: INTEGER; n: CARDINAI
Usage	<pre>WriteInt(t, i, width);</pre>
	WriteInt must be imported from the library module Texts.
	t must be of type TEXT imported from Texts.
	i must be of type INTEGER.
	width must be of type CARDINAL.
Comments	The number is output right-justified and blank-padded in field width characters wide.
See Also	INTEGER ReadInt Texts WRITE
Example	Write the number <i>n</i> to the standard output:
•	WriteInt(output,n,6)

WRITELN standard procedure S/E

Description WRITELN is a generalized write statement that starts a ne line when it is done.

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WRITELN(elist); Usage

or

WRITELN(t, elist);

t must be of type TEXT imported from Texts.

elist is simply a list of expressions and optional formatting parameters.

If t is not specified, the standard output stream output will be Comments used.

> WRITELN will be translated by the compiler into the appropriate calls to the module Texts. Thus, a change in the definition module of Texts could lead to WRITELN not working.

> WRITELN is the same as WRITE, except WRITELN starts a new line when the output is complete.

> Although WRITE, WRITELN, READ, and READLN are not included in the Modula-2 definition, programming without them can be very tedious; however, they are not portable.

> A way around this is to develop code using these statements for debugging and development output, and use the explicit calls to Texts for the actual programmed output.

See Also

READ READLN Texts WRITE

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Example Write out the variable *nthingys* with an explanation, then start a new line:

WRITELN('Number of things: ', nthingys)

In scientific notation, write out e in a field 12 spaces wide with 7 digits in the mantissa, and start a new line:

e := Exp(1.0); WRITELN(' e =', e:12:-7);

WriteLn procedure (Terminal) L

Description WriteLn starts a new line on the screen.

Declaration **PROCEDURE** WriteLn;

Usage WriteLn;

WriteLn must be imported from the library module Terminal.

Comments The *Terminal* routines provide input and output to the screen without the overhead of the stream abstraction in *Texts*.

See Also Terminal WriteChar WriteString

Example Write out an error message:

WriteString('Help !'); WriteIn;

WriteLn procedure (Texts) L

Description	WriteLn writes an EOL to a TEXT file.
Declaration	<pre>PROCEDURE WriteLn(t: TEXT);</pre>
Usage	WriteLn(t);
	WriteLn must be imported from the library module Texts.
(t must be of type TEXT imported from Texts.
Comments	The WRITELN statement is easier to use than this procedure.
	WriteLn(t) is equivalent to WriteChar(t,EOL).
See Also	Texts WRITELN
Example	Write an EOL to the text console:
	WriteLn(console);

WriteLn procedure (InOut) L

Description	Starts a new line on the current output device.
Declaration	PROCEDURE WriteLn;
Usage	WriteLn;

WriteLn must be imported from the library module InOut.

Comments *WriteLn* provides a standard new line routine.

This procedure is defined in terms of the Texts module.

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See Also	Terminal Texts WRITELN
Example	Write out an error message:
	<pre>MODULE WriteMessage; FROM InOut IMPORT WriteString, WriteLn; BEGIN WriteString('Help !'); WriteLn; END WriteMessage.</pre>

	WriteLong	procedure	(Texts)	L
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Description	WriteLong writes out a long integer number to a TEXT file	
Declaration	<pre>PROCEDURE WriteLong(t: TEXT; 1: LONGINT; n: CARDINAL);</pre>	
Usage	WriteLong(t, 1, width);	
	WriteLong must be imported from the library module Text.	
	t must be of type TEXT imported from Texts.	
•	l must be of type LONGINT.	
	width must be of type CARDINAL.	
Comments	In general, the WRITE statement is easier to use th WriteLong.	

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The number is output right-justified and blank-padded in field width characters wide.

See Also	LONGINT
	ReadLong
	Texts
	WRITE

Example Write the number *n* to the standard output:

WriteLong(output, n, 6)

WriteOct procedure (InOut) L

Description WriteOut writes an octal number out to output.

Declaration **PROCEDURE** WriteOct(x,n: CARDINAL);

Usage WriteOct(num, digits);

WriteOct must be imported from InOut.

num must be of type CARDINAL,

digits must be of type CARDINAL.

Comments The number will be converted to octal and printed out in a field at least *digits* wide. If the number doesn't need that many digits, it will be blank-padded.

This and WriteHex are useful procedures to print out addresses and storage requirements in their natural form.

See Also InOut WriteHex

Example

Write out the number 8 in octal in a field four digits wide:

WriteOct(8, 4) yields ' 10'

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WriteReal procedure (Texts) L

Description	WriteReal writes out a real number to a TEXT file.
Declaration	<pre>PROCEDURE WriteReal(t: TEXT; r: REAL; n: CARDINAL; digits: INTEGER);</pre>
Usage	<pre>WriteReal(t, r, width, digits);</pre>
	WriteReal must be imported from the library module Texts.
	t must be of type TEXT imported from Texts.
	r must be of type REAL.
	width must be of type CARDINAL.
	digits must be of type INTEGER.
Comments	In general, the WRITE statement is easier to use than WriteReal.
	The number is output in a field width characters wide, and the mantissa is digits long.
See Also	REAL ReadReal Texts WRITE
Example	Write the number pi to the TEXT file doc:
	WriteReal(doc, pi, 5, 2) yields " 3.14" WriteReal(doc, pi, 12, 2) yields " 2.14"

WriteReal(doc, pi, 12, 2) yields "3.14" WriteReal(doc, pi, 5, 0) yields " 3" WriteReal(doc, pi, 10, -3) yields " 3.141E+00" WriteRec procedure (Files) L

Description	WriteRec writes a record or an array to a disk file declared as FILE.	
Declaration	<pre>PROCEDURE WriteRec(f: FILE; VAR rec: ARRAY OF WORD);</pre>	
Usage	WriteR ec (f, r);	
(WriteRec must be imported from the library module Files.	
	f must be of type FILE imported from Files.	
	r is any type.	
Comments	This routine should be used for writing any structure larger than a byte or a word (see WriteByte and WriteWord).	
See Also	Files, ReadRec, WriteByte WriteWord	
Example	Write the record widget[i] to newFile:	
	<pre>WriteRec(newFile, widget[i])</pre>	
(WriteString procedure (Terminal) L		
Description	WriteString writes a string to the terminal at the current cursor position.	

Declaration **PROCEDURE** WriteString(s: **ARRAY OF** CHAR);

Usage	WriteString(s);	
	WriteString must be imported from the library module Ter- minal.	
	s must be of type ARRAY OF CHAR.	
Comments	There is no stream (like console, input, or output) associated with <i>Terminal</i> procedures; thus, output goes directly to the console and redirection is not possible.	
See Also	ReadString Terminal	
Example	Write a string prompt to the terminal:	
	WriteString(prompt)	
WriteString procedure (Texts) L		

Description	WriteString writes out a string to a file declared as TEXT.
Declaration	<pre>PROCEDURE WriteString (t: TEXT; s: ARRAY OF CHAR);</pre>
Usage	WriteString(t, s);
	WriteString must be imported from the library module Texts.
	t must be of type TEXT imported from Texts.
	s must be a character array.

Comments In general, the WRITE statement offers easier output than WriteString.

All of the characters in the string are output up until the first zero byte or the end of the string is encountered.

See Also ReadString Texts WRITE

Example Write the string *name* to the *TEXT* file *doc*:

WriteString(doc, name)

WriteWord procedure (Files) L

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Description	WriteWord writes a variable compatible with WORD to a disk file declared as FILE.
Declaration	<pre>PROCEDURE WriteWord(f: FILE; w: WORD);</pre>
Usage	<pre>WriteWord(f, w);</pre>
	WriteWord must be imported from the library module Files.
	f must be of type FILE imported from Files.
	w must be of a type compatible with WORD, which is imported from the pseudomodule SYSTEM.
Comments	Types compatible with WORD are those with storage of nomore than one word (2 bytes); these include INTEGER, CAR-DINAL, BITSET, all pointers (ADDRESS is a pointer).
See Also	Files ReadWord
Example	Write the cardinal nwidgets to newFile:

WriteWord(newFile, nwidgets)

APPENDIX A Turbo Modula-2 and Turbo Pascal

This appendix examines the differences between Turbo Pascal and Turbo Modula-2 in a detailed manner. First, we will point out some of the features found only in Turbo Modula-2 and then we will compare the differences in the features of both languages.

In general, Turbo Modula-2 and Turbo Pascal are quite similar. Some features found in Turbo Modula-2 will be more familiar to Turbo Pascal programmers than they will be to regular Pascal programmers. This is because Turbo Pascal provides a rich set of standard procedures and useful extensions that are defined directly in the Turbo Modula-2 language.

Modula-2's separate compilation and library facilities provide a full and extensible set of primitives. The differences between the language implementations range from simple items like case sensitivity to complex issues involving type- and version-checking across compilation units.

Modula-2 can be used for large program development and for expressing operating system concepts like concurrency and interrupt handling. Rather than using Include files, Modula-2 separates programs textually into modules. Like Pascal procedures, modules can be used to control the scope of identifiers. Unlike procedures, the walls around a module are opaque in both directions, with only explicitly defined changes in scope. This control of scope occurs in both local (nested) and library (separately compiled) modules. In the case of a library identifier, any identifier needed from another module must be requested. And both local and library modules must explicitly make the identifier visible.

Library modules can be separately compiled. Though some other languages allow separate compilation, Modula-2 does full type- and version-checking. This helps prevent errors that occur because the program is textually broken into pieces. Thus you have the same safety as Turbo Pascal's Include files without having to recompile support procedures all the time.

Two new low-level features found in Turbo Modula-2 are coroutines and inter-

rupt handlers. As described in Chapter 8, coroutines simulate concurrent processes by using their own data space and sharing the processor.

While some people have expressed interrupt handlers in Turbo Pascal using inline code, Modula-2 allows interrupt handlers to be defined in a high-level manner. This is done by initializing the machine and then having the interrupt handler install itself at some predetermined vector. The rest is handled by Turbo Modula-2.

What's the Difference?

The following overview compares the elements of Turbo Modula-2 to Turbo Pascal and should quickly acquaint the Turbo Pascal programmer with Turbo Modula-2. (For a complete explanation of any feature, refer to the body of this manual.)

To start, let's consider the following Pascal and Modula-2 programs:

```
PROGRAM prime( OUTPUT );
CONST
                                     CONST
 size = 8190;
VAR
                                    VAR
 i,k,prime,count : INTEGER;
 flags : ARRAY [0..size] OF
BOOLEAN;
                                   BOOLEAN;
BEGIN
                                    BEGIN
 count := 0;
 FOR i := 0 TO size DO
  flags[i] := TRUE;
                                     END;
 FOR i := 0 TO size DO BEGIN
  IF flags[i] THEN BEGIN
```

```
MODULE prime;
CONST
size = 8190;
VAR
i,k,prime,count : INTEGER;
flags : ARRAY [0..size] OF
BOOLEAN;
BEGIN
count := 0;
FOR i := 0 TO size DO
flags[i] := TRUE;
END;
FOR i := 0 TO size DO
IF flags[i] THEN
```

```
prime := i + i + 3;
k := i + prime;
WHILE k <= size DO BEGIN
flags[k] := FALSE;
k := k + prime;
END ;
count := count + 1;
```

prime := i + i + 3; k := i + prime; WHILE k <= size DO flags[k] := FALSE; k := k + prime; END ; count := count + 1; END; END; WRITELN(count,' Primes'); END (* prime *). END; END; WRITELN(count,' Primes'); END prime.

Vocabulary

There are minor differences in the vocabularies of the two language implementations. For the most part, it is simple to convert a Turbo Pascal program into Turbo Modula-2.

Identifier Names

Turbo Modula-2's identifiers are written in the same manner as Pascal's. There are two major differences: (1) Turbo Modula-2 does not allow underscores in identifier names, and (2) it is case-sensitive. The latter has been made optional with a compiler switch. The following are some legal and illegal modula identifiers:

Legal	Illegal
AnotherIndent	An_Indent
n	
N	

Characters

Character constants may either be denoted by the character enclosed in single or double quotes or by the character's ordinal number written in octal notation and followed by the letter C. For example:

32C	A character constant representing a Control-Z
101C	The letter 'A'

'B' The letter 'B''C' The letter 'C'

Numbers

The numbers of Turbo Modula-2 are a superset of those allowed in Pascal. In ad-

dition to the integers and reals in Turbo Pascal, Turbo Modula-2 has an unsigned integer, called a CARDINAL, and two double-precision types, an integer (LONGINT) and a real (LONGREAL).

Like Turbo Pascal, Turbo Modula-2 allows you to specify the base and type of a constant number. In Turbo Pascal, a hexadecimal number is written starting with a dollar sign, such as OF; but in Turbo Modula-2 hex numbers are written starting with a decimal digit and ending with the letter H, such as OFH. The various classes are Octal, Hexadecimal, Character, Real, and Long. The following are examples of numeric constants in Turbo Modula-2:

23B	Octal cardinal	(19 decimal)
023H	Hexadecimal cardinal	(35 decimal)

Real constants are written the same as they are in Turbo Pascal--a decimal point must be present. The scale factor is preceded by E. For example:

1.1414 A single-precision real approximating the square root of 23.02E9 A single-precision real in scientific notation

Double-precision constants are just like real constants with a scale factor, but with a D in place of the E. For example:

0.0D0 A double-precision real that is a very precise zero

In the same way a C following a octal number makes a CHAR constant, an L following a integer makes a LONGINT constant. Of course, the integer can be larger than normal integers if followed by an L, as shown in the following:

1483236283LA long integer over a trillion (1,483,236,283).-1LInternally, this long integer is 4 bytes of ones.

C....

Strings

The two differences between strings in Turbo Pascal and Turbo Modula-2 are (1) strings can be enclosed in either single or double quotes, and (2) the quote used to enclose the string may not appear in the string.

In Pascal, to have a quote within a string you would write the quote twice. In

Turbo Modula-2, you may include whichever quote you are not using to enclose the string. Thus, the following strings yield the same result:

Modula-2	Pascal
ntn	f F F F
1 11 1	T 11 T

Here are other examples of legal strings in Modula-2

/ ">bba " 'The language "Modula-2"' "Peter's programs"

Set Constants

Sets in Turbo Modula-2 are substantially different than those in Turbo Pascal. In Turbo Modula-2, sets are represented by one machine word and thus are very efficient. Tests for set membership are much faster. However, there is one drawback: A machine word has only enough bits to represent a set of 16 elements. Pascal programmers who are used to using SET OF CHAR may miss it; however, there are other ways to obtain the same results.

The syntactic differences are that sets are delimited by curly brackets instead of the square brackets used in Pascal. A set must be preceded by its type identifier when used in expressions, otherwise, it is assumed to be the predefined set type BITSET. For example:

TYPE UserSet = SET OF (red, green, blue); CONST hibit = {7}; CurrentColor = UserSet{green};

Comments

In Turbo Pascal, comments can only be nested one level deep by using one of the two forms within the other. In Turbo Modula-2, the only form of comment uses the delimiters (* and *). (As previously shown, the curly braces, { and }, are used to denote sets.) In contrast to Turbo Pascal, Turbo Modula-2 comments may be nested to any depth. This is especially useful for debugging programs. For example:

```
c = 2.997925E8; (* the speed of light in meters per second *)
(*D WriteReal(c); (* printout for debugging *) D*)
```

Declarations

In contrast to standard Pascal, Turbo Modula-2's order of declarations (like Turbo Pascal's) is not fixed. Constant, type, variable, and procedure declarations can be written in any order. This gives the programmer more freedom to group related items together. Of course, every declaration section must be preceded by the appropriate CONST, TYPE, VAR, or PROCEDURE symbol.

Constant Declarations

There are two major differences between Turbo Pascal's constants and Turbo Modula-2's: (1) Turbo Modula-2 allows constant expressions in declarations. (2) There is no equivalent for Turbo Pascal's typed constants (which are actually pre-initialized variables).

Turbo Modula-2's constant expressions may be used anyplace Pascal allows only constants. Constant expressions consist of constants connected by the usual operators. Some examples of declarations follow (constant expressions are seen in lines 2, 5 and 8):

CONST

```
PiByTwo = 3.141592 / 2.0;
version = "1.6 last changes: Oct 84";
mask = {0..3,8};
Truth = NOT FALSE;
Size = 1000;
TYPE
a = ARRAY [0..Size-1] OF CHAR;
```

:

Turbo Pascal's typed constants can be simulated with normal Turbo Modula-2 variables and the initialization part of modules. The only difference is that the values are initialized at runtime instead of at load-time.

Type Declarations

Turbo Modula-2 has all of the types offered by Turbo Pascal, whether defined directly as standard identifiers or as library types. In addition, Turbo Modula-2 has procedure types. In defining types in Turbo Modula-2, a constant expression may be used anywhere a constant is used to define a type in Pascal.

Standard types in Turbo Modula-2 are CHAR, BOOLEAN, BITSET, IN-TEGER, CARDINAL, REAL, LONGINT, LONGREAL, and PROC. Of these, INTEGER, BOOLEAN, CHAR, and REAL are used exactly as they are in Turbo Pascal. We have already mentioned the addition numeric type, CARDINAL, 'LONGINT, and LONGREAL; the remaining types, BITSET and PROC, will be explained shortly. The user-defined types of both languages are similar, but have slight differences.

Subrange and enumeration types are the same for both languages except Turbo Modula-2 encloses in square brackets ([]) the values defining a subrange. For example:

TYPE bitnumber = [0..wordlength-1]; smallint = [0..255];

The presence of the types INTEGER and CARDINAL causes a slight ambiguity when defining a subrange. In the previous example, it's not known if the base type of the subrange is INTEGER or CARDINAL. This problem is resolved by the convention that the base type is assumed to be CARDINAL if the lower bound is not negative; otherwise, it is INTEGER. You may override this convention by explicitly specifying the base type as follows:

TYPE ismall = INTEGER[0..255];

Arrays

ŧ

As with subranges, the syntax of an array is slightly different in each language. When the bounds of an array are specified by a subrange, brackets are not needed; for example:

TYPE

```
color = (brown,purple,orange);
c = ARRAY color OF CHAR;
a = ARRAY [0..9],[0..9] OF REAL;
charkind = ARRAY OF CHAR (letter,digit,special,illegal);
```

Records

In Turbo Modula-2, records without variant parts are identical to those of Turbo Pascal. Turbo Modula-2 variant parts have a somewhat different syntax. If the name of the tag field is omitted, the colon and the type must still be written. The vertical bar serves to separate cases. Like Turbo Pascal, label ranges (for example, 0..5) and an optional ELSE part may be used. More than one variant part is allowed and it need not be written at the end of the record, as in Turbo Pascal. Variant parts in Turbo Modula-2 must have an END statement; for example:

```
complex = RECORD x, y : REAL END ;
sneaky = RECORD
          CASE : BOOLEAN OF
           FALSE : c : CARDINAL
                : p : POINTER TO CARDINAL
           TRUE
          END
         END;
demo = RECORD
        a, b : CARDINAL;
        x : REAL;
        CASE t1 : CARDINAL OF
         0..3,7 : f1,f2 : File
         4,6
                  : name : ARRAY [0..7] OF CHAR
        ELSE
                           : POINTER TO sneaky
                  link
```

END;

d, e : BOOLEAN ;
CASE c : color OF

```
red, blue: |
green : g : date |
END ;
last : BOOLEAN ;
END
```

Procedure Types

Procedure types are new to Turbo Pascal programmers. They can be used to define the interface of a procedure that is passed to some other procedure as a retaineter. This is useful for allowing one data access routine to perform many *L*erent functions on the data.

For example, you may pass a tree-traversal procedure a procedure parameter that prints the node, uses the node for a calculation, or performs some other function on the nodes of the tree. The point is that each of these operations have the same interface, which can be defined globally and exported.

The type PROC is a predefined procedure type with no parameters. Variables of this type may receive assignments from procedures declared as

PROCEDURE Foo; BEGIN (* Statements *) END Foo;

Procedure variables are defined with the reserved word **PROCEDURE**, followed by a formal type list. In contrast to normal parameter lists, the names of the parameters are not given. Types are separated by commas and may be preceded by a VAR to indicate variable parameters. Function procedures declare a result be (see the section, "Function Procedures").

Variables of a procedure type may assume as their values procedures whose formal parameter list is compatible with the formal type list of the procedure type. However, procedures local to another procedure and standard procedures may not be assigned to procedure variables. Note that arithmetic and file-handling procedures (for example, *Sin* and *Open*) are not standard procedures in Turbo Modula-2. They are library procedures and can be assigned to procedure variables of the correct type. For example:

```
MODULE ProcedureVars;
FROM Texts IMPORT TEXT;
TYPE
RealFunc = PROCEDURE (REAL): REAL;
TextDriver = PROCEDURE(VAR Text, CHAR);
VAR
MyExp: RealFunc;
MyWriteChar: TextDriver;
MyWriteChar: TextDriver;
MyClearScreen: PROC; (* Predefined parameterless procedure *)
```

```
PROCEDURE MyExponentiation(r:REAL): REAL;
```

BEGIN

```
(* Statements *)
```

```
END MyExponentiation.
```

PROCEDURE MyWriteCharacter(VAR t: TEXT; ch: CHAR); BEGIN

```
(* Statements *)
END MyWriteCharacter;
```

```
PROCEDURE MyClearTheScreen;
BEGIN
```

(* Statements *) END MyClearTheScreen;

```
PROCEDURE ExecuteP(p:PROC);
BEGIN p;
END ExecuteP;
```

```
BEGIN (* Assign procedures to the procedure variables *)
MyExp := MyExponentiation;
MyWriteChar := MyWriteCharacter;
MyClearScreen := MyClearTheScreen;
```

(* Execute procedure variables *)
MyClearScreen;
WRITE(MyExp(29.0));
MyWriteChar(output "A");
ExecuteP(MyClearScreen);
END ProcedureVars.

Variable Declarations

Turbo Modula-2's variable declarations are identical to those of Pascal: A list of variable identifiers are given (separated by commas), along with a colon and the variable's type. For example:

i, j, k : INTEGER;
printer : textwriter;

Like Turbo Pascal, Turbo Modula-2 offers a facility to specify the address of riable. This must be considered a low-level facility and must be used with care. The address is specified in brackets after the variable identifier. Unlike Turbo Pascal, Turbo Modula-2 restricts absolute variables from assuming dynamic values. Thus when a Turbo Pascal program uses a local variable "absoluted" with a parameter to the procedure, the Turbo Modula-2 equivalent would simply be pointer assignments that may require type coercion. Variables in Turbo Modula-2 are made absolute as shown here.

```
maskregister [OFFCDH]: BITSET;
```

Procedure Declarations

Procedures in both languages are declared in much the same way. Unlike Turbo Pascal but available in other Pascals, Turbo Modula-2's procedures and functions may be passed as parameters. The parameter must be declared as an already defined procedure type (shown in the previous section, "Variable Declarations").

Open Array Parameters

(In array parameters allow arrays declared of different length to be passed to the same procedure. In Turbo Pascal, this can be done only with string parameters, and only when the V compiler option is turned on. In Turbo Modula-2, there is a provision for open arrays of any type and there is a mechanism to dynamically obtain the upper bound of open array parameters.

Within the procedure, the lowest array element always has an index of zero. The index of the highest array element can be obtained as HIGH(a), a being specified as ARRAY OF < some type >. For example:

```
PROCEDURE writevector(v : ARRAY OF REAL);
VAR
i : CARDINAL;
BEGIN
FOR i := 0 TO HIGH(v) DO WRITE(v[i]) END
END writevector;
```

Untyped Parameters

Turbo Pascal allows you to skip type-checking with untyped parameters by simply leaving off the type specification. This is useful for writing generic procedures. Of course, Turbo Modula-2 also allows this with an explicit declaration that uses the *SYSTEM* type WORD. Turbo Modula-2 goes one step further by allowing you to dynamically determine the size of the object passed with the standard procedures *SIZE* and *HIGH*. This is shown in the following example:

```
MODULE Untyped;
```

```
PROCEDURE foo(object: ARRAY OF WORD);
BEGIN
WRITELN(SIZE(object), HIGH(object));
END foo;
```

VAR

```
c: CARDINAL;
r: REAL;
BEGIN
foo(c);
foo(r);
END Untyped.
```

The first call to the procedure *foo* results in the output of 2 and 0. Thus, the procedure knows the object passed is 2 bytes and the highest index into the array of words is 0. During the second call, this procedure outputs a 4 and a 1, indicating the object is 4 bytes and occupies positions 0 and 1 of the word array.

Function Procedures

In Turbo Modula-2, FUNCTION is no longer a reserved word; function declarations differ from procedure declarations only by the indication of a result type. The following is an example of a function declaration that finds the length of a string:

```
PROCEDURE len(s: ARRAY OF CHAR): CARDINAL;
(* return length of string s *)
VAR
i : CARDINAL;
BEGIN i := 0;
WHILE (i <= HIGH(s)) & (s[i] # OC) DO i := i+1 END ;
RETURN i
ID len;</pre>
```

Expressions

Turbo Modula-2 expressions are very similar to those of Turbo Pascal. The usual operators, +, -, *, /, DIV, and MOD, are available for operands of type IN-TEGER, CARDINAL, and REAL, (DIV and MOD apply to INTEGER and CARDINAL, / applies to REAL). Of course, those operators applicable to IN-TEGER also work on LONGINT, and the same is true for REAL and LONGREAL.

There are, however, no implicit conversions. The following example would therefore be legal in Turbo Pascal but illegal in Turbo Modula-2, because REAL and CARDINAL are not compatible:

x := 1.0 + 1;

The logical operators AND (also written &), OR, and NOT (also written ~), are available. If the first operand of an AND evaluates to FALSE, the second is t evaluated. Similarly, the second operand of an OR is not evaluated if the first one is TRUE. This rule sometimes shortens programs by eliminating a Boolean flag and a GOTO statement. For example:

```
WHILE (I \neq 0) AND (s[I] > 0) DO
```

```
(* Something *)
END;
```

would have to be translated to the following Pascal statement if s is not defined for I equal to 0:

```
while I < > 0 do begin
   if s[I] <=0 then goto endwhile;
   (* Something *)
end ;
endwhile:</pre>
```

Set Operators

The major benefit of Turbo Modula-2 sets is the ability to treat bits in a word as elements in a set. This makes bit manipulation very easy and defines it directly in the language instead of as an extension as in Turbo Pascal.

The type BITSET is a special predefined set type. It is declared as

TYPE

BITSET = SET OF [0..wordlength-1];

where wordlength is the word length of the computer, which is 16 for Turbo Modula-2.

Since Turbo Modula-2 sets only take one word, the operations defined for sets can be viewed as equivalent to Turbo Pascal bitwise operations. Thus Turbo Modula-2 set operators can be viewed as abstract set operations or low-level bitwise operations as seen in Turbo Pascal equivalents.

Operation	Modula Symbol	Pascal Symbol
Union	+	OR
Difference	-	XOR and then AND
Intersection	*	AND
Symmetric Difference	/	XOR

In terms of set operations available in Turbo Pascal, only / is new. It is called symmetric set difference and is an exclusive OR. The resulting set contains all elements that are in either the first set operand or the second, but not in both. The following is an example using sets:

```
MODULE ExampleSet; TYPE
```

i

colors = (Red,White,Blue,Orange,Purple,Black,Yellow,Green,Cyan);
flagColors = SET OF colors;

CONST

```
frenchFlag = flagColors{Red,White};
VAR
 currentColors: flagColors;
BEGIN
 currentColors := flagColors{Red};
 currentColors := currentColors + flagColors{White};
 IF (currentColors=frenchFlag) THEN
  WRITELN('Viva la France !');
END;
END ExampleSet;
```

Familiar to Turbo Pascal programmers is Turbo Modula-2's alternate use for the preceding logical operators (AND, OR, XOR); in Turbo Pascal, these are also bitwise operators. As previously shown, Turbo Modula-2 has set operators that double as bitwise operators. The only bitwise operators defined in Turbo Pascal and not in Turbo Modula-2 are the shl and shr operators. However this is not a problem because Turbo Modula-2 translates multiplication and division by 2 into machine-language shifts in the appropriate direction. Thus, we have the following equivalents for the integer variable I:

Modula	Pascal	
I * 2	I shl 1	
I * 2 * 2	I shl 2	
I * 256	I shl 8	
I DIV 16	I shr 4	

Turbo Modula-2 and Turbo Pascal use the same relational operators. The only 'ifference is that Turbo Modula-2 provides an additional inequality operator, the pound sign (#), which has the same effect as < >. Both symbols are allowed in Turbo Modula-2.

Operands in expressions in Turbo Modula-2 are very similar to those found in Pascal. The familiar operations of indexing, field selection, dereferencing, and function invocation are available. One difference is seen in expressions that include parameterless function calls. Turbo Modula-2 requires the empty parameter list to be specified in function calls. This helps distinguish function identifiers from variable and constant identifiers.

The following are examples of expressions in Turbo Modula-2:

```
c + b*3
list IN options
sum + a[i,k]*a[k,j]
(ch >= "A") & (ch <= "Z")
s * {0..3}
Exp(Random( ))</pre>
```

Integer or cardinal expression Boolean expression Numeric expression using arrays Boolean expression with relations Set expression Real expression with nested function calls

Statements

Like Pascal, the most elementary statement in Turbo Modula-2 is the assignment statement. It is stricter in Turbo Modula-2 than in Turbo Pascal in that no implicit type conversions are made. This means you may not assign an integer expression to a real variable, as is allowed in Turbo Pascal. Of course, Turbo Modula-2 provides a mechanism to do this with explicit type-transfer functions; thus we have the following equalities (where x is a real and i is an integer):

Modula	Pascal		
<pre>x := FLOAT(i);</pre>	x := i;		
<pre>i := TRUNC(x * FLOAT(i));</pre>	i := trunc(x * i);		

Turbo Modula-2's structured statements have a more modern syntax that does away with Turbo Pascal's compound statement (begin ... end). Where Pascal requires the compound statement, Turbo Modula-2 allows a statement sequence to be terminated by an END statement.

Procedure Calls

The procedure call statement remains essentially unaltered in Turbo Modula- 2. If a procedure has no parameters, empty parentheses are allowed but not required, as in function procedures.

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Looping Statements Turbo Modula-2's WHILE and REPEAT statements are essentially the same as Turbo Pascal's.

Turbo Modula-2 has an EXIT statement, but it is used to terminate the LOOP statement. The LOOP statement is the same as a Turbo Pascal's repeat until

FALSE or while TRUE do begin end, except that instead of using a GOTO to exit the endless loop, Turbo Modula-2 uses the explicit EXIT statement. EXIT causes control to pass to the statement directly after the END that matches the LOOP statement.

The FOR statement has been slightly changed. A step value may now be given using a BY clause (default is +1 if the BY part is left out). The step value must be a constant expression. The Turbo Pascal downto symbol is no longer used. You now simply specify a step value of -1. For example:

```
FOR i := 0 TO size DO
                               (* Notice the explicit END *)
 flags[i] := TRUE
END;
FOR i := n-2 TO 2 BY -1 DO
                              (* Pascal's DOWNTO *)
 s[i] := (b[i] -
                              (* Any number of statements *)
a2[i]*s[i+1])/a1[i];
                               (* between DO and END *)
j := j + i
END;
```

CASE Statements

Turbo Modula-2's CASE statement has a different syntax than Pascal's. The vertical bar | is used to separate cases, thus eliminating the need for begin end in the statement part of the case statement. Like Turbo Pascal, Turbo Modula-2 allows ranges of values for CASE labels (like "A".."Z") and an optional ELSE part. For example:

CASE ch OF | "A"..."Z", "a"..."z" : chartype := letter 1 "0"..."9" : chartype := digit | " ",[™], "**#**", "&"..."/", ":"..">","[".."^","{"..."" : chartype := special WRITELN('illegal ELSE character'); chartype := illegal



END;

Note that the first and last vertical bars in this example are optional.

WITH Statements

The WITH statement has remained essentially unchanged. While in Turbo Pascal a list of record variables is allowed after WITH, Turbo Modula-2 makes you nest WITH statements to achieve the same effect. For example:

```
WITH p ^ DO (* in Pascal, only one WITH would have been used *)
WITH valu ^ DO
typ := reel; rval := nxrval;
END ;
link := head
END ;
```

RETURN Statements

There are two reserved words that take the place of Turbo Pascal's goto statement: the EXIT statement (already discussed) and the RETURN statement. The RETURN statement serves to terminate procedures the same way as the exit statement in Turbo Pascal. In addition, it is used to return function results instead of an assignment to the Pascal function identifier.

Standard Procedures in Turbo Modula-2

Several standard functions and procedures found in Turbo Pascal are no longer directly available in Turbo Modula-2: Some standard procedures have been added and some have been left to be implemented in library modules. Only the most important and commonly used standard procedures are still within the language.

Mathematical functions like Sqrt, Sin, Exp, and so on, are no longer standard functions. They must now be imported from the module MathLib (see Chapter 11). File-handling procedures must also be imported from the appropriate library modules (Files, Texts, or InOut).

The Turbo Pascal functions *pred* and *succ* can be replaced by the procedures *INC* and *DEC*. These procedures accept one argument of any scalar type and one count argument that determines the size of the increment or decrement. Thus, Turbo Pascal statements that look like the following:

```
i := i + 1;
color := pred(Green);
```

will look like this in Turbo Modula-2:

INC(i); DEC(color);

NEW and DISPOSE still exist and are translated by the compiler into calls to procedures ALLOCATE and DEALLOCATE, which must be imported from the module STORAGE but may also be redefined within the user program. In contrast to Pascal, a FLOAT function exists in Turbo Modula-2. You may be surprised to find that there is no ROUND or EVEN function; instead, use Entier(Value + 0.5) for negative numbers and TRUNC(Value + 0.5) for positive numbers.

Tables A-1 through A-3 show which identifiers remain defined within the language. If you don't find what you're looking for here, try Chapter 12, "Turbo Modula-2 Reference Directory." Table A-1. Standard Modula-2 Functions

ABS(x)

Returns absolute	value of	x; resul	t type is	the same	e as argu-
ment type.					

- CAP(c) Returns argument and result type are of type CHAR, the capital letter corresponding to c.
- CHR(x) Returns the character with ordinal number x.
- FLOAT(x) Converts value x of type CARDINAL to type **REAL**.
- HIGH(a) Returns high index bound of array a.

MAX(T) Returns the largest element of the argument type.
 T is CARDINAL, INTEGER, BOOLEAN, CHAR, REAL, LONGREAL, LONGINT, any enumeration or scalar type.

MIN(T) Returns the smallest element of type T.

ODD(x) Returns TRUE is x is odd; otherwise it returns FALSE.

ORD(x)

Returns the ordinal value of x, where x is of type BOOLEAN, CHAR, INTEGER, CARDINAL, or every enumeration type.

SIZE(T)	Returns the storage requirements of type T in bytes.	
SIZE(x)	Returns the storage requirements of variable x in bytes.	
TRUNC(x)	Returns CARDINAL result; x of type REAL truncated to integral part.	
VAL(T,x)	Returns the value of type T , which has ordinal number x . T is BOOLEAN, CHAR, INTEGER, CARDINAL or every enumeration type.	
Table A-2. Addi	tional Functions Offered by Turbo Modula-2	
LONG(x)	Converts its argument to LONGINT	
INT(x)	Converts its argument to INTEGER	
CARD(x)	Converts its argument to CARDINAL	
FLOAT(x)	Converts its argument to REAL	
DOUBLE(x)	Converts its argument to LONGREAL	
Note: These functions only work on numeric types.		
Table A-3. Standard Procedures in Turbo Module-2		
DEC(x)	x := x - 1	
DEC(x,n)	x := x - n	

EXCL(s,i) $s := s - \{i\}$

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HALT Terminates program execution

INC(x)x := x + l

INC(x,n) x := x + n

INCL(s,i) $s := s + \{i\}$

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Note that type identifiers may be used like function identifiers denoting socalled type-transfer functions. (This is considered a low-level facility and is discussed in Chapter 8.)

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APPENDIX B Installation Procedures

The installation program INSTM2 has two functions. Its primary function is to allow you to configure the Turbo Modula-2 system to your hardware and to configure the Turbo Modula-2 editor to your own taste. Thus, you may tell the system what type of terminal you have and which disk drives you wish it to search for ceded files. You may also change the editing commands to more familiar ones.

Note: The installation must be performed if you want Turbo Modula-2 to work the way it is described in this manual.

The second function of INSTM2 is to allow programs compiled on your setup to be re-installed on different terminals. This allows you to distribute .COM files (executable files) to your customers without knowing what type of terminal they have. All you need to do is include INSTM2 files along with your executable program.

In this chapter we will describe how to use INSTM2 to install Turbo Modula-2, and then discuss programs in general.

Installing M2

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By this point we assume you have made a backup copy of the Turbo Modula-2 distribution disk, as well as a working disk. (If not, these procedures are describ-1 in Chapter 1, »Getting Started.«)

Place your working disk in the logged drive. It should contain all the installation

files and the M2.COM file, listed as follows:

INSTM2.COM INSTM2.OVR INSTM2.DTA M2.COM Type INSTM2 to start the installation program. After the prompt, press **1** and the following menu will appear:

Modula-M2 system installation menu. Choose installation item from the following:

[S]creen installation[C]ommand installation[M]iscellaneous[Q]uit

Enter S, C, M, or Q:

There are four possible choices at this menu: Screen installation, Command installation, Miscellaneous, and Quit. To select a choice, enter one of the highlighted letters shown in square brackets. Any legal selection except Q will bring up a new menu: Quit will return you to the operating system (unless it is being run from the M2 shell).

Screen installation allows proper functioning of Turbo Modula-2's WordStarlike editor and the various screen manipulation functions in the module *Terminal*.

Command installation is performed if you wish to alter the WordStar-style editing commands. We recommend that you become familiar with the capabilities of the editor before you change any of the editing keys. Generally, you only need to go through the Command installation if your keyboard is missing the necessary keys or if you want your Turbo Modula-2 editor to be compatible with a non-WordStar-like editor. Miscellaneous installation is used in two instances. First, if your keyboard does not have certain display characters used in standard Modula-2, this command will allow you to substitute an alternate character or sequence of characters for those missing from your keyboard. Second, this command allows you to tell Turbo Modula-2 where it should look for files when it is compiling and linking.

Screen Installation

When you press **s** to perform Screen installation, the following menu will appear:

Installation Procedure.

- 1) ADDS 20/25/30
- 2) ADDS 40/60
- 3) ADDS Viewpoint-1A
- . 4) ADM-3A
 - 5) DEC Rainbow, 8 bit
 - 6) Ampex D80
 - 7) ANSI
 - 8) Morrow MDT-20
 - 9) Hazeltine 1500
- 10) Hazeltine Esprit
- 11) Kaypro with hilite
-) Kaypro, no hilite
- 13) Lear-Siegler ADM-20
- 14) Lear-Siegler ADM-31
- 15) Liberty
- 16) Osborne 1

- 17) Otrona Attache
- 18) Qume
- 19) RC-855 (ITT)
- 20) Soroc 120/Apple CP/M
- 21) Soroc new models
- 22) SSM-UB3
- 23) Tandberg TDV 2215
- 24) Teleray series 10
- 25) Teletex 3000
- 26) Televideo 912/920/92
- 27) Texas Instruments
- 28) Visual 200
- 29) Wyse WY-100/200/300
- 30) Zenith
- 31) None of the above
- 32) Delete a definition

Which terminal? (Enter no. or ^Q to exit):

Select the terminal type you will be using while running Turbo Modula-2 by entering the appropriate number for your terminal at the prompt. Several things are dependent on the terminal you are using. Of course, the editor needs to know about the terminal, but your programs must also know the capabilities of the terminal they are running on. This information is available from the standard module *Terminal*.

Before installation is actually performed, you are asked the question:

Do you want to modify this definition before installation? (Y/N)?

This allows you to modify one or more of the values being installed (described the next section). If you do not want to modify the terminal definition, type N to complete the installation and be returned to the Main Installation Menu.

Manual Installation

If your terminal is *not* on the menu, however, you must define the required values yourself (refer to your terminal manual for these values). An alternative method exists if you also own a copy of Turbo Pascal and have installed it for your configuration.

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Using the Turbo Pascal TINST.DTA File

Many people with unusual terminals have Turbo Pascal because (like Turb Modula-2) it runs on almost anything with a Z80 in it. These people have alread gone through a painstaking installation procedure that required searching obscu manuals for cryptic codes. If you are one of these people, relax; you can use you existing TINST.DTA file simply by renaming it to INSTM2.DTA. (Note that the DTA file only contains data for screen commands not keyboard commands.)

Use the renamed file as if it were the one on the distribution disk. When the terminal menu comes up you will see your terminal listed with any others in the TINST.DTA file.

Entering Terminal Codes

Enter the number corresponding to »None of the above« and answer the questio one by one as they appear on the screen.

The following section describes each installable command in detail. If your terminal does not support a command, press \square at the prompt. If *Delete lin Insert line*, or *Erase to end of line* are not installed, they can be emulated in t editor. However, these emulation functions are not available in the module *Terminal* only provides a method to check if the functions z available so that your programs can emulate them if necessary. Commands m be entered by pressing the appropriate keys or by entering the decimal or he adecimal ASCII value of the command. If a command requires the two characte ['ESCAPE'] and ['='], you may

- \Box First press the [Esc] key, then the [=], and the entry will be echoed with ε propriate labels.
- □ Or you can enter the decimal or hexadecimal values separated by spac (Hexadecimal values must be preceded by a dollar sign (\$); for example,

61, \$1B 61, or \$1B \$3B, which are all equivalent.) These two methods can be mixed since once you have entered a specific character (except a dol sign), the rest of the command must be defined in that mode, and vice ver If you need to delete an entry, you may enter a hyphen as the first charac on the line; the text *Nothing* is echoed. This is only effective on comman that expect more than a single number of a Yes/No answer.

Terminal Properties

The following is an explanation of each question asked by the terminal installation program.

Terminal type:

Enter the name of the terminal you are about to install. When you complete INSTM2, the values will be stored and the terminal name will appear on the initial list of terminals. If you later need to re-install Turbo Modula-2 to this terminal, you can do so by choosing the terminal from the list.

Send an initialization string to the terminal?

If you want to initialize your terminal when Turbo Modula-2 starts (for example, to download commands to programmable function keys), press \boxed{Y} to answer this question; otherwise, press \boxed{A} .

Send a reset string to the terminal?

Define a string to be sent to the terminal when Turbo Modula-2 terminates. The description of the preceding initialization command also applies here.

CURSOR LEAD-IN command:

Cursor Lead-in is a special sequence of characters that tells your terminal that the following characters comprise an address on the screen on which the cursor should be placed. When you define this command, you are asked the following supplemental questions:

CURSOR POSITIONING COMMAND to send between line and column:

Some terminals need a command between the two numbers defining the row and column cursor address.

CURSOR POSITIONING COMMAND to send after line and column: Some terminals need a command *after* the two numbers defining the row and column cursor address.

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Column first?

Most terminals require the address in the format: first ROW, then COLUMN. If this is the case on your terminal, press \boxed{N} . If your terminal requires COLUMN first, then ROW, press \boxed{Y} .

OFFSET to add to LINE

Enter the number to add to the LINE (ROW) address.

OFFSET to add to COLUMN

Enter the number to add to the COLUMN address.

Binary address?

Most terminals need the cursor address sent in binary form. If this is true for yo terminal, press [Y]. If your terminal expects the cursor address as ASC digits, press N . You are then asked the supplemental question

2 or 3 ASCII digits?

Enter the number of digits in the cursor address for your terminal.

CLEAR SCREEN command:

Enter the command that will clear the entire contents of your screen, be foreground and background, if applicable.

Does CLEAR SCREEN also HOME cursor?

This is normally the case; if it is not so on your terminal, press N and (fine the cursor HOME command.

DELETE LINE command:

Enter the command that deletes the entire line at the cursor position.

INSERT LINE command:

Enter the command that inserts a line at the cursor position.

ERASE TO END OF LINE command:

Enter the command that erases the line at the cursor position, starting from cursor position through to the end of the line.

START OF 'LOW VIDEO' command:

If your terminal supports different video intensities, then define the command t initiates dim video.

START OF 'NORMAL VIDEO' command:

Define the command that sets the screen to show characters in 'normal vid Some terminals have one command that toggles the video mode; thus this c may be the same as the last one.

Number of rows (lines) on your screen: Enter the number of horizontal lines on your screen.

Number of columns on your screen:

Enter the number of vertical column positions on your screen.

Delay after CURSOR ADDRESS (0-255 ms): Delay after CLEAR, DELETE, and INSERT (0-255 ms): Delay after ERASE TO END OF LINE and HIGHLIGHT On/Off (0-255 ms): Enter the delay in milliseconds required after the functions specified. RETURN means 0 (no delay).

Is this definition correct?

If you have made any errors in the definitions, press [N] to be returned to the terminal selection menu. The installation data you have just entered will be included in the installation data file and appear on the terminal selection menu, but installation will not be performed.

When you press \boxed{Y} in response to this question, installation is completed, the installation data is written to M2.COM, and you are returned to the main menu. Installation data is also saved in the installation data file and the new terminal will appear on the terminal selection list when you run INSTM2 in the future.

Installation of Editing Commands

The built-in editor performs a number of commands. Each function may be activated by either of two commands: a primary command and a secondary command. Primary commands are undefined, but can be easily defined to fit your taste or your keyboard. The secondary commands are installed by Borland and comply with the standard set by WordStar. From the installation main menu, press **c** for Command installation. The first command will appear like the following:

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CURSOR MOVEMENTS:

Nothing -> Character left 1:

This means that no primary commands have been installed to move the cursor one character left. If you want to install a primary command (in addition to the secondary WordStar-like Control-S, which is not shown here), you may enter the desired command after the -> prompt in either of two ways:

1. Simply press the key you want to use. It can be a function key; for example, a left-arrow key or any other key or sequence of keys that you choose (the maximum is 2).

The installation program responds with a mnemonic of each character it receives. If you have a left-arrow key that transmits an Escape character followed by a lower case a, and you press this key in the situation given previously, your screen will look like the following:

CURSOR MOVEMENTS:

- 1: Character left Nothing -> <ESC> a
- 2. Instead of pressing the key you want to use, you may enter the ASCII value(s) of the character(s) in the command. The values of multiple characters are entered and separated by spaces. Hexadecimal values are prefixed by a dollar sign (\$1B).

This may be useful to install commands not presently available on your keyboard; for example, if you want to install the values of a new terminal while still using the old one.

In both cases, terminate your input by pressing \square . Note that the two methods cannot be mixed within one command. If you have started defining a command sequence by pressing keys, you must define all characters in that command by pressing keys and vice versa.

You may enter a minus (-) sign to remove a command from the list or a B to back through the list one item at a time.

The editor accepts a total of 45 commands, all of which may be installed to your

specifications. If you make an error in the installation, such as defining the same command for two different purposes, a self-explanatory error message is issued. You must correct the error before terminating the installation. If a primary command conflicts with one of the WordStar- compatible secondary commands, it will render the secondary command inaccessible.

Table B-1 lists the secondary commands, and allows you to enter any primary commands you have installed.

Note: Items 2 and 28 let you define alternative commands to Character Left and Delete Left Character commands. Normally, the Back Spacec key is the alternative to **s**, while there is no defined alternative to **bel**. You may install primary commands to suit your keyboard; for example, to use the Back ce as an alternative to Del if the Back Space key is more conveniently located. Of course, the two alternative commands must be unambiguous like all other commands.

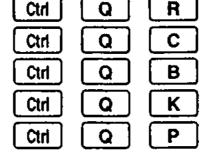
Table B-1 Turbo Modula-2 Secondary Commands

Cursor Movements

- 1: Character left
- 2: Alternative
- 3: Character right
- 4: Word left
- 5: Word right
- 6: Line up
- 7: Line down
- 8: Scroll up
- 9: Scroll down
- 10: Page up
- 11: Page down
- '2: To left on line
- 13: To right on line
 - 14: To top of page
 - 15: To bottom of page

	S H	
Ctrl Ctrl	F	
Ctrl Ctrl	X	
Ctrl Ctrl	Z	
Ctrl	C	S
Ctrl Ctrl		
		X
I CHA I		

16: To top of file To end of file 17: 18: To beginning of block 19: To end of block 20: To last cursor position



APPENDIX C Summary of Compiler Directives

This appendix contains a list of available compiler directives and a brief description of each. For a detailed explanation of compiler directives, refer to Chapter 10, »System Operations.«

There are two ways to set the current compiler options. The first is with the global switches in the Options submenu in the Turbo Modula-2 shell. These global switches have an effect over an entire program text. However, the second method, embedded switches, overrides the first method. Embedded switches appear directly in the program text within comments. In the following list of compiler options, the switch settings on the left are embedded and the ones on the right are globa! (as they appear in the options menu).

List Source Option

Embedded Global

\$L+	List(ON)	Generates a listing
\$L-	List(OFF)	Generates none

Overflow Check Option (INTEGER and CARDINAL)

Embedded Global

\$ O+	Overflow(ON)	Checks for overflows
\$ 0-	Overflow(OFF)	Does not check for overflow

Test Range Option

Embedded Global

\$T+ Test(ON) \$T-Test(OFF)

Checks array indices and subrange variables Does not check them

The Upper=Lower Case Sensitivity Option

Embedded Global

\$U+	Upper=lower(ON)	Does not distinguish between uppercase and lowercase
\$U-	Upper=lower(OFF)	Distinguishes between type case
Extension	Option	
Embedded	Global	
\$X+ \$X-	eXtensions(ON) eXtensions(OFF)	Allows Turbo Modula-2 extensions Flags extension as nonstandard
Native Co	de Option	
Embedded	Global	
N/A N/A	Native(ON) Native(OFF)	Generates native code for the Z80 Generates M-code

Note: Embedded native code switches have no effect.

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APPENDIX D Error Diagnosis

This section lists most messages that Turbo Modula-2 issues for execution errors. Usually, an error message is caused by a faulty program; however, some messages can also result from illegal input to an otherwise correctly executing program.

Format of a Runtime Error Message

While a program is executing, the Turbo Modula-2 system checks for a number of runtime error conditions. The various error sources are listed in the next two sections.

An error message can be issued by the runtime system, as well as by some support module or application program. The process is the same in every case: The executing program is stopped and a message of the following form is given:

```
(Name of Error) in module (Name of Module)
(possibly a further explaining message)
Press "C" for calling chain >
```

For example, in module *BadStuff* the value of an expression computes to 11 where the maximum allowed is 10. The following message is then given:

```
BoundsError in module BADSTUFF
O to 10 is legal range, but 11 was evaluated
Press "C" for calling chain >
```

In another example, an attempt was made to read data from file IN.DAT when the end of that file had already been reached. This error is not detected by the interpreter, but rather by the module *Files*.

EndError in module FILES While processing file B:IN.DAT Press "C" for calling chain > In Turbo Modula-2, an error constitutes an *exception*. Exceptions can be issued by the Turbo Modula-2 interpreter and by any Modula-2 program unit. They can be trapped in an application program with an exception handler. The raising and handling of an exception is explained further in Chapter 9, "Turbo Modula-2 Extensions."

Errors Detected by the Interpreter

Errors detected by the interpreter are often caused by faulty program logic, and with some of these errors there is no reasonable way to continue a program. Therefore, only part of the following errors can be caught explicitly (by name) in an exception handler. These exceptions are the ones exported by the pseudomodule *SYSTEM*: OVERFLOW, REALOVERFLOW, and OUTOFMEMORY. The remainder can only be caught with the ELSE clause of the EXCEPTION statement: BoundsError, DivisionByZero, StringTooLong, FunctionReturnsNoResult, EndOfCoroutine, CaseSelectError, PointerError, and IllegalInstruction.

BoundsError. The value of an arithmetic expression lies outside of its admissable bounds. This can happen when

- □ A value is assigned to a variable of some subrange type, some user- defined scalar type, or one of the types CHAR, BOOLEAN, CARDINAL, or IN-TEGER. The value lies outside of the bounds defined by the type used.
- □ A function procedure returns a value exceeding the bounds defined by the type of the function.
- □ An array index lies outside of the admissable bounds.

A check for this error can be suppressed by the compiler option (* T-*). This leads to somewhat shorter object modules and slightly faster execution times. As

a rule, however, the efficiency gains do not make up for the resulting safety loss; therefore, bounds-checking is turned on by default.

Additional messages: (number) to (number) is legal range, but (number) evaluated. Indicates the maximum or minimum value allowed, as well as the computed value. This can occur if a negative INTEGER value is assigned to a CAR-DINAL, or if a CARDINAL above 32767 (the maximum INTEGER value) is

assigned to an INTEGER. The system does not know whether the left-hand side of the assignment is of type INTEGER or CARDINAL; therefore, both possibilities are displayed. For example:

65535 is assigned to an INTEGER

or

-1 is assigned to a CARDINAL

(Note that the same internal bit value denotes 65535 when interpreted as a CAR-NAL and -1 when regarded as an INTEGER.

DivisionByZero. An attempt has been made to divide by 0.

Additional message: None

Overflow. The result of some computation involving CARDINALs, INTEGERs, or LONGINTs that became too large or too small to be represented in the computer's memory. If the truncated value does not fit into the range of the destination type, an OVERFLOW can also result from a truncation function such as *INT*, *CARD*, *LONG*, or *TRUNC*. The ranges of the three types in question are CAR-DINAL, 0 to 65535; INTEGER, -32768 to 32767; and LONGINT, -2147483648 to 2147483647.

For operations involving INTEGER and CARDINAL arithmetic and CAR-DINAL multiplication, overflow checking can be suppressed by turning the compiler option \$0 off.

Additional message: None

RealOverflow. A real value has been computed that exceeds the admissable range for REALs (-10^{38} to 10^{38}).

StringTooLong. A string expression has been assigned to an array with elements of type CHAR. The string is too long to be held in its full length in the array. The string is not truncated to fit; instead, StringTooLarge is raised.

Additional message: None

FunctionReturnsNoResult. A function procedure reaches its end before executing a RETURN statement.

Additional message: None

EndOfCoroutine. A coroutine reaches its end before being left by a TRANSFER or IOTRANSFER statement.

Additional message: None

OUTOFMEMORY. The program has run out of main memory.

Additional message: Stack = (number), Heap = (number). Storage is occupied from two sides: Stack and Heap mark the boundaries of the upper and lower occupied part of memory, respectively. The out-of-memory condition arises when Stack and Heap meet.

CaseSelectError. A CASE statement without an ELSE clause has executed where no case alternatives apply.

Additional message: None.

PointerError. Dereferencing of some pointer with the value *NIL* has been attempted. For example, given the declaration VAR cp: POINTER TO RECORD x,y: REAL END; and the program fragment cp:=*NIL*; IF $cp \land .x > 0.0$ THEN ..., the exception PointerError is raised upon execution of the last statement.

Additional message: None

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IllegalInstruction. The interpreter finds a code byte that does not represent a legal command. This is a rare but severe error. It can occur if some parts of code have been overwritten by the executing program; for example, if the user erroneously addresses computations.

Additional message: (1) Absolute PC = (number), and (2) prints the value of the instruction counter.

Errors Detected by Support Modules

This section concentrates on exceptions that result from presenting illegal input or exceeding the computer's limits. All exceptions signaling a programming error are discussed in their respective modules description in Chapter 11, "The Standard Library."

The modules in the Turbo Modula-2 Library recognize some error conditions. An error issued by a library module can be caught in an exception handler, provided the exception is imported from the library module.

Exceptions Issued by Module Files

UseError. This usually occurs if writing to a write-protected disk has been attempted. This exception is most often caused by a disk swap. You can solve the situation by resetting the disk before trying again.

Additional message: Drive (Drive-Code) is read-only.

DiskFull. Writing to disk is impossible, presumably because the disk or disk directory is full.

Additional message: While processing file, (Name): indicates the name of the file involved in the write operation.

EndError. An attempt has been made to read data after the end of a file has been reached. This usually constitutes a programming error.

Additional message: While processing file (Name): indicates the name of the file involved in the read operation.

DeviceError. The disk cannot be read correctly. This is equivalent to the dreaded BDOS ERROR/BAD-SECTOR message of CP/M.

Exceptions Issued by Module Loader

LoadError. An error has occurred during the loading of a program. The cause of the error is given in an additional message.

Additional messages: (1) File not found : (File Name); (2) Read Error : (File Name); (3) Out of memory; (4) Version Conflict : (File Name).

The first three messages are self-explanatory. The fourth, version conflict, results when the version of an object module does not coincide with the version required by an importing module. (For a more detailed discussion, refer to the section about *Loader* in Chapter 11.)

The Calling Chain

If a program exhibits a runtime error, the Turbo Modula-2 system offers a powerful diagnosis. Turbo Modula-2 helps to localize the error and gives some clues about the state of the program at the time of the error's occurrence. This information is contained in the calling chain, which displays all active procedures at the point where they were called. The chain is displayed on the screen if you press [C] after the following prompt:

Press "C" for calling chain >

This appears next to the actual error message. If you do not want a calling chain, simply press \Box or any letter except C. This will return you to the main menu.

The calling chain consists of one or several lines of the following form:

(Name of Module) (Name of Procedure) (Offset Number) (Program Counter)

The first line states the module, the procedure, the offset number, and the program counter where the error occurred. Note that only the first six characters of the module and procedure are displayed. The left column specifies the module enclosing the procedure in which the error occurred. The second column shows

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the procedure where the error occurred. The offset number corresponds to the numbers produced in the compiler listing. It specifies the offset (in bytes) of the error point from the beginning of the enclosing procedure or module, whose name is listed in the second column. The program counter is used in the Options menu to find where the error occurred in the source file.

The second line of the calling chain specifies the point where the procedure in the first line was called. The same specification holds for the lines that follow.

The chain finishes when the main program is reached. At that point, the name of the main program is in both the module and the procedure column. The calling chain also terminates if a procedure representing a coroutine is reached. Since coroutines are not called by any other part of the program, they are considered the same as main programs.

If you trace the calling chain from bottom to top, you will experience the same quence of situations that your program went through before the point of the runie error.

A calling chain, caused by some hypothetical program, is shown in the following example:

```
BoundsError in module BADSTUFF
0 to 10 is legal range, but 11 was evaluated
Press "C" for calling chain > C
```

Module	Procedure	offset	PC
BADSTUFF	SNEAKY	17	101
BADSTUFF	SUB	113	123
TEST	Q	55	154
TEST	TEST	20	164
>			

We can follow the events by starting at the bottom with the main program *Test*. *Test* executes until it reaches the offset of 20 in the main program, then it calls the procedure Q. The call to procedure Q occurs when the program counter is ual to 164.

Looking at the next line we see that procedure Q exists in the module *Test*. This procedure then executes until it reaches an offset of 55 from its beginning. At this point the program counter is 154, which is pointing at a call to the procedure *Sub*.

The next line shows that we have called the procedure Sub in module BadStuff. The procedure Sub executes until it calls Sneaky. When Sneaky is called, the program counter is 123. The top line of the calling chain shows that the error occurred in the procedure *Sneaky* in module *BadStuff*. The offset of the error in *Sneaky* is 17. The program counter where the error occurred is 101. We know from the error message that there was some type of bounds error; so we can look at that line for assignment or indexing problems.

Finding RunTime Errors

To find where this error occurred in the source code without having to guess with offsets into the procedures or look at a listing, you can use the program counter and the Find RunTime Error option found in the Options menu.

At the main menu, press o to enter the Options menu. Then press **F** for Find RunTime Error. You should know the program counter and the name o the module in which the error occurred. First you are prompted with the name of the main module that was running. If this is not the module where the error occurred, then backspace over it and enter the correct name. If it is the correct module name, then just press **J**.

Next you are prompted to enter the PC. At this point you should enter the number you obtained from the calling chain in the program counter column When the compiler has compiled to this point, you will be thrown into the editor with the cursor at the corresponding runtime error position. This utility is helpfu for finding errors quickly and reducing program development time.

Compiler Error Messages

Error messages sent by the compiler can be synthesized or fixed. The »fixed messages are read from a file named ERRMSGS.TXT, which may or may not be online during compilation. If it is not, only the error number, not the corresponding message, can be displayed. Table D-1 provides all of the messages contained in ERRMSGS.TXT.

Some messages will not be found in this list. For example:

":=" expected, but "=" found

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is not in the list because it is synthesized from parts of the faulty program together with predefined pieces of text. Other messages are contained only partial ly by ERRMSGS.TXT; the rest are supplied from the faulty program. Items supplied by the compiler appear in parentheses.

Table D-1 Messages in ERRMSGS.TXT

Error in Identifier

- 0 (Identifier) is undeclared.
- 1 (Identifier) is declared twice.
- 2 (Identifier) is not field of this record.
- 3 (Identifier) is not exported by this module.
- 4 (Identifier) already exists outside of module.
- 5 Unresolved FORWARD reference: (Identifier).
- 6 Unresolved export: (Identifier).
- 7 (Identifier) is not readable.
- 8 (Identifier) is not printable.
- 9 (Identifier) expected.
- 10 (File name) not found.
- 11 CODE must be imported from SYSTEM.
- 12 Two different versions of (Module name).SYM imported.
- 13 No standard procedure allowed here.
- 14 Procedure must be declared at outer-most level.
- 15 (Identifier) is exported twice.

Error in Syntax

- 20 Illegal key word at start of statement.
- 21 Illegal start of statement.
- 22 Identifier, literal, or »(« expected.
- 23 (Not used).
- 24 Loop counter may not be external or parameter.
- 25 Expression must have constant value.
- 26 No enclosing LOOP for EXIT.

- 27 No RETURN from module allowed.
- 28 String literal spans over several lines.
- 29 Past end of file.
- 30 Badly formed number.
- 31 Illegal symbol.
- 32 End of file expected.
- 33 String literal expected.

34 CODE must follow procedure heading; it is not allowed here.

General Errors

- 41 Set elements may only range from 0 to 15.
- 42 (Not used).
- 43 Modules with unqualified export list may not be exported.
- 44 Module does not export in QUALIFIED mode.
- 45 Length of actual string does not match.
- 46 Second value must be greater.
- 47 Case label occurs twice.
- 50 String assignments not allowed in standard Modula-2.
- 51 String comparisons not allowed in standard Modula-2.
- 52 Not allowed in standard Modula-2.
- 53 Procedure ALLOCATE not found.
- 54 Procedure DEALLOCATE not found.
- 55 Illegal definition of procedure ALLOCATE.
- 56 Illegal definition of procedure DEALLOCATE.

Error in Type

- 60 Function procedure required.
- 61 No function procedure allowed here.
- 62 Actual parameter is byte-packed, but Formal VAR parameter assigns a word.
- 63 No such variant exists.
- 64 Element types of actual and formal arrays differ.
- 65 Types of actual and formal parameters differ.
- 66 Sizes of type and argument differ.
- 67 Declarations of procedure variable and procedure differ.
- 68 Two different declarations of same procedure.

Error in Constant

うちょうかん しょうちょう いちょうかん しょうちょう しょうしょう しょうしょう

- 70 Integer required, but large cardinal value computed.
- 71 Cardinal required, but negative value computed.
- 72 Value lies outside of subrange bounds.
- 73 Number too large.
- 74 Real number too large.
- 75 Overflow in constant expression.

Error/Compiler Limit Exceeded

- 80 Case label must not be greater than 32767.
- 81 Too many local variables.
- 82 Too many procedures, strings, and exceptions.
- 84 Too many imported modules.
- 85 Insufficient space for import/export: name-table overflow.
- 86 Insufficient space for import/export: type-table overflow.
- 87 Insufficient space for import/export: identifier-table overflow.
- 88 Insufficient space for import/export.
- 90 Expression too complex or too many parameters.
- 91 Boolean expression too long.
- 92 Too many nested function calls.

Error Implementation Restriction

- 95 Byte-sized array elements cannot be substituted for VAR parameters.
- 96 Byte-sized array elements cannot be used as arguments of INC or DEC.

Warning

- 50 String assignments not allowed in standard Modula-2.
- 51 String comparisons not allowed in standard Modula-2.
- 52 & not allowed in standard Modula-2.

APPENDIX E **BNF Syntax for Turbo Modula-2**

The syntax of the Turbo Modula-2 language is presented here using the formalism known as Backus-Naur Form (BNF). The following symbols are meta symbols belonging to the BNF formalism; they are not symbols of the language.

<term></term>	Names of language constructs are surrounded by $" < "$ and $" > "$.
{ X }*	Represents zero or more repetitions of X.
[X] ·	Means X is optional.
Х	Means X is mandatory.
XIY	Indicates that X and Y are alternatives and that
	either X or Y must be used.
"X". or 'X'	Means X is written exactly as shown.
(X)	Means X must be chosen.

All other symbols are part of the language (reserved words of Turbo Modula-2 are in **boldface** type). For easy reference, the syntactic constructs are listed alphabetically.

```
<ActualParameters> ::= "(" [<ExpList> ] ")"
<AddOperator> ::= "+" | "-" | "OR"
<ArrayType> ::= "ARRAY" <SimpleType> {"," <SimpleType>}*
" OF "
<type>
```

<assignment> ::= <designator> ":=" <expression>

<block> ::= { <declaration> }* ["BEGIN" <StatementSequence>] [<ExceptionHandler>] "END"

<case> ::= [<CaseLabelList> ":" <StatementSequence>]

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```
<CaseLabelList> ::= <CaseLabels> {"," <CaseLabels>}*
<CaseLabels> ::= <ConstExpression> [ ".. " <ConstExpression> ]
<CaseStatement> :: = "CASE" <expression> "OF" <case>
                     { "!" [ <case> ] }
                     [ "ELSE" <StatementSequence> ]
                        " END "
.<character> ::= <letter> | <digit> | " " | "!" | "!" | "#" |
                   п$п | п%п | п&п | пти | п(п | п)п | п×п | п+п |
                   n, n \mid n-n \mid n, n \mid n/n \mid n; n \mid n; n \mid n < n \mid n=n
                   u > u | u 3 u | u @ u | u [ u | u / u | u ] u | u v u | u <sup>-</sup> u |
                   п л | п { п | п | п } п | п~ п
<CompilationUnit> ::= <DefinitionModule> | ["IMPLEMENTATION"]
                         <ProgramModule>
<ConstantDeclaration> ::= <ident> "=" <ConstExpression>
<ConstExpression> ::= <expression>
<declaration> ::= "CONST" { <ConstantDeclaration> ";" }* }
                     "TYPE" { < TypeDeclaration >
                                                        "; " }米 |
                                                        n; n }* |
                             { <VariableDeclaration>
                     "VAR "
                                                        n; n |
                     <ExceptionDeclaration>
                                                        n ; n |
                     <ProcedureDeclaration>
                     <ModuleDeclaration>
                                                        n ; n
                    "CONST" { < ConstantDeclaration> ";" }* |
<definition> ::=
                             { <ident> ["="<type>] ";" }* |
                     "TYPE "
                             { <VariableDeclaration> ";" }* |
                     "VAR "
                                                        n ; n |
                     <ExceptionDeclaraton>
```

<ProcedureHeading>

```
<designator> ::= qualident { "." <ident>!
"["ExpList"]"| " ^ "}*
<digit> ::= <octalDigit> | "8" | "9"
<element> ::= <expression> [ ".." <expression> ]
<enumeration> ::= "(" <IdentList> ")"
<exception> ::= [ <IdentList> ":" <StatementSequence> ]
 <export> ::= "EXPORT" [ "QUALIFIED" ] <IdentList> ";"
<expression> ::= <SimpleExpression> { <relation>
<SimpleExpression> }*
<ExceptionDeclaration>::="EXCEPTION"<ident> {"," <ident>}*
<ExceptionHandler> ::= "EXCEPTION" < exception> { "|"
                       <exception> ]*
                       [ "ELSE" < StatementSequence > ]
<ExpList> ::= <expression> { ", " <expression> }*
<factor> ::=<number> | <string> | <set> | <designator>
[<ActualParamters>] |
              "(" < expression > ")" | "NOT" < factor >
<FieldList> ::=[ <IdentList> ":" <type> |
                "CASE" [<ident>] ":" <qualident>
                "OF" <variant> {"|" <variant>}*
                [ "ELSE" < FieldListSequence > ] "END" ]
```

<ForStatement> ::= "FOR" <ident> ":=" <expression> "TO" <expression> ["BY" <ConstExpression>] "DO" <StatementSequence> "END"

```
<FormalParamenters> ::= "(" [ <FPSection>
                         { "; " < FPSection > ]*] ") "
                         [ ":" <qualident> ]
<FormalType> ::= [ "ARRAY OF" <qualident> ]
<FormalTypeList> ::="(" [ ["VAR"] <FormalType>
                    {"," [VAR"] <FormalType>}* ] ")" [ ":"
                    <qualident> ]
<FPSection> ::= [ "VAR" ] <IdentList> ":" <FormalType>
<hexDigit> ::= <digit> ! "A" | "B" | "C" | "D" | "E" | "F"
<ident> ::= letter {letter | <digit>}*
<IdentList> ::= <ident> {"," <ident>}*
<IfStatement> ::="IF" <expression> "THEN"
                 <StatementSequence>
                 {"ELSIF" <expression> "THEN"
                 <StatementSequence> ]*
                 ["ELSE < StatementSequence> ]
                  "END"
<import> ::= [ "FROM" <ident> ] "IMPORT" <IdentList> ";"
<InlineCode> ::= "CODE" "(" <string> ")" "END"
<integer> ::=<digit> {<digit>}* |
             {<octalDigit>}* ( "B" | "C" ) |
              <digit> {<hexDigit>}*
```

<letter> ::="A" | "B" | "C" | "D" | "E" | "F" | "G" | "H" |
 "I" | "J" | "K" | "L" | "M" | "N" | "O" | "P" |
 "Q" | "R" | "S" | "T" | "U" | "V" | "W" | "X" |
 "Y" | "Z" | "a" | "D" | "c" | "d" | "e" | "f" |
 "g" | "h" | "i" | "j" | "k" | "l | "m" | "n" |
 "n" | "p" | "q" | "r" | "s" | "t" | "u" | "v" |
 "w" | "x" | "y" | "z"

```
<LoopStatement> ::= "LOOP" <StatementSequence> "END"
<ModuleDeclaration> ::= "MODULE" <ident> [ <priority> ] ";"
                       { <import> } [ <export> ] <block>
                       <ident>
< MulOperator > ::= "*" | "/" | "DIV" | "MOD" | "AND"
<number> ::= <integer> | <real>
<octalDigit> ::= "0" | "1" | "2" | "3" | "4" | "5" | "6" | "7"
<PointerType> ::= "POINTER TO" <type>
<priority> ::= "[" <ConstExpression> "]"
<ProcedureCall> ::= <designator> [ <ActualParameters> ]
<ProcedureDeclaration> ::= <ProcedureHeading> ";"
                         ( <block> | <InlineCode> )
                         <ident>
<ProcedureHeading> ::= "PROCEDURE" <ident>
[ < FormalParameters> ]
<ProcedureType> ::= "PROCEDURE" [FormalTypeList]
<ProgramModule> ::= "MODULE" <ident> [ <priority> ] ";"
                   { <import> }* <block> <ident> "."
<qualident> ::= <ident> {"." <ident>}*
<RaiseStatement> ::= "RAISE" [ <ident> [ "," <expression> ] ]
```

<real> ::= <digit> {<digit>}* "." {<digit>}* [ScaleFactor]

<RecordType> ::= "RECORD" <FieldListSequence> "END"

<relation> ::= "=" | ">" | "<" | ">=" | "<=" | "#" | "<>" | "IN"

```
<RepeatStatement> ::= "REPEAT <StatementSequence> "UNTIL"
 <expression>
 <ScaleFactor> ::= ( "E" | "D" ) [ "+" | "-" ] <digit>
{<digit>}*
 <set> ::= [ <qualident> ] "{" [ <element> { ","
 <element> }* ] "}"
 <SetType> ::= "SET OF" <SimpleType>
 <SimpleExpression> ::= [ "+" | "-" ] <term> { <AddOperator>
 < term > \}*
 <SimpleType> ::= <qualident> | <enumeration> |
 <SubrangeType>
 <statement>::=[ assignment | ProcedureCall | IfStatement |
                CaseStatement | WhileStatement | RepeatStatement |
                LoopStatement | ForStatement | WithStatement |
                RaiseStatement | "EXIT" | "RETURN" [expression] ]
 <StatementSequence> ::= <statement> { ";" <statement> }*
 <string> ::= "'" {<character>}* "'" | '"' {<character>}* '"'
 <SubrangeType> ::=[ <qualident> ] "[" <ConstExpression> ".."
                    <ConstExpression> "]"
 <term> ::= <factor> { <MulOperator> <factor> }*
 <type> ::=<SimpleType> | <ArrayType> | <RecordType> |
            <SetType> | <PointerType> | <ProcedureType>
```

<TypeDeclaration> ::= <ident> "=" <type>

```
<VariableDeclaration>::= <ident>["[" <ConstExpression>"]"]
{ "," <ident> ["[" <ConstExpression>
"]"] }*
":" <type>
<variant> ::= [ <CaseLabelList> ":" <FieldListSequence> ]
<WhileStatement> ::= "WHILE" <expression> "DO"
<StatementSequence>
"END"
<WithStatement> ::= "WITH" <designator> "DO"
<StatementSequence>
"END"
```

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