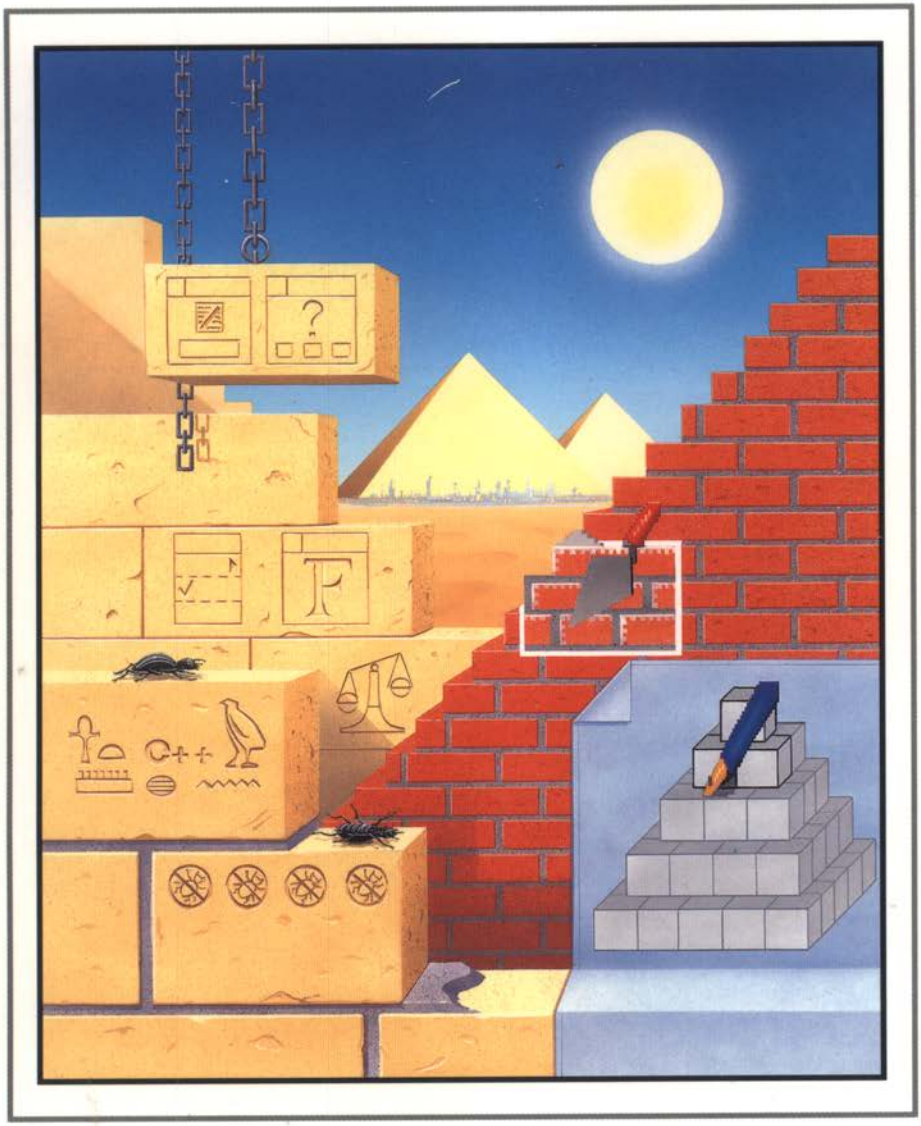
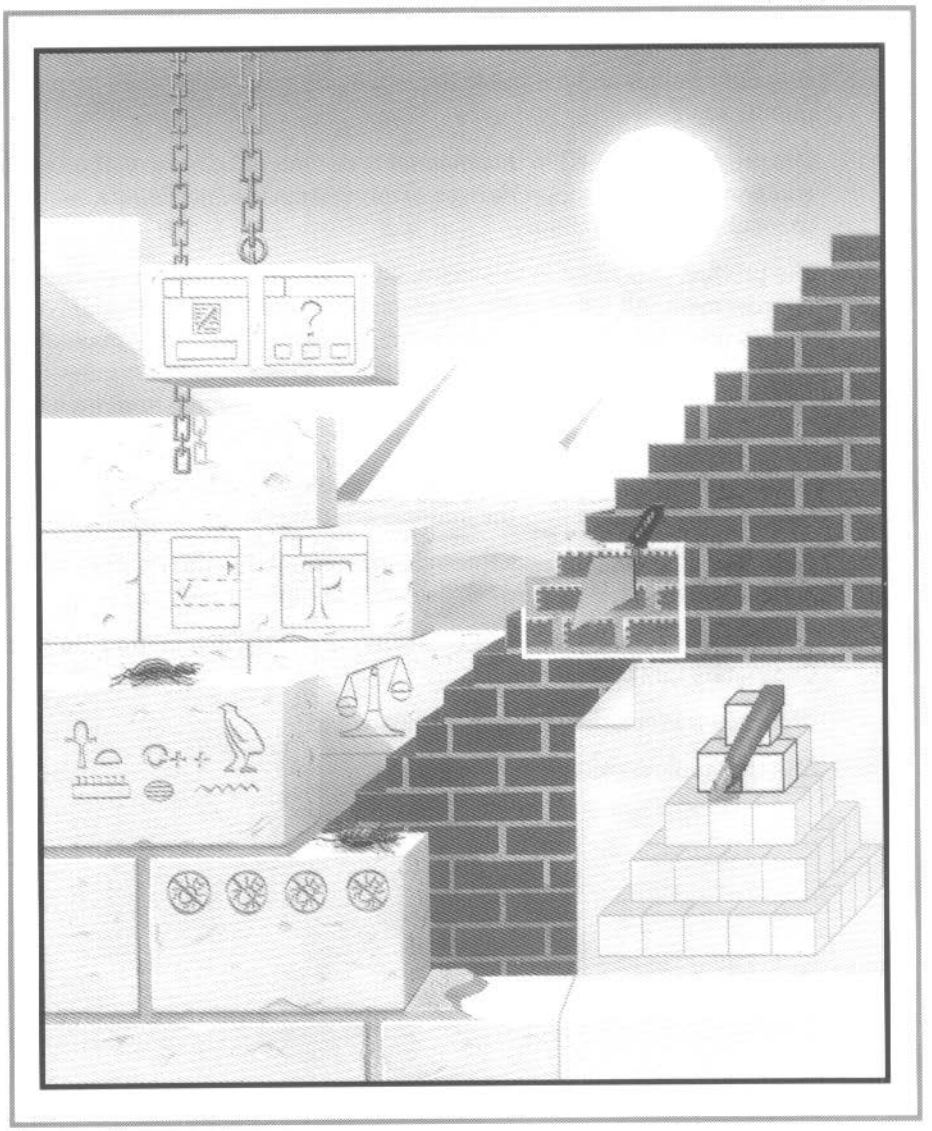
Acorn C/C++



Acorn

Acorn C/C++



Acorn

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Contents

1 Introduction

Acorn C/C++ is a development environment for producing RISC OS desktop applications and relocatable modules written in ANSI C and/or in C++. It consists of a number of programming tools which are RISC OS desktop applications. These tools interact in ways designed to help your productivity, forming an extendable environment integrated by the RISC OS desktop. Acorn C/C++ may be used with Acorn Assembler (a part of this product) to provide an environment for mixed C, C++ and assembler development.

Acorn C/C++ includes tools to:

- edit program source and other text files
- search and examine text files
- convert C source and header text between ANSI and UNIX dialects
- examine some binary files
- compile and link C programs
- compile and link C++ programs
- construct relocatable modules entirely from C or C++
- compile and construct programs under the control of makefiles, these being set up from a simple desktop interface
- squeeze finished program images to occupy less disk space
- construct linkable libraries
- debug RISC OS desktop applications interactively
- design RISC OS desktop interfaces and test their functionality
- use the Toolbox to interact with those interfaces.

Most of the tools in this product are also of general use for constructing applications in other programming languages, such as ARM Assembler. These non-language-specific tools are described in the accompanying *Desktop Tools* guide.

Installation of Acorn Desktop C

Installation of Acorn C/C++ is described in the chapter *Installing Acorn C/C++* on page 7 of the accompanying *Desktop Tools* guide.

The C compiler

The Acorn C compiler for RISC OS (the tool CC supplied as a part of this product) is a full implementation of C as defined by the 1989 ANSI language standard. To obtain this standard document, see the section *Useful references* on page 6. It is tested with the Plum-Hall C Validation Suite version 2.00, and passes all sections, except for failing to produce two required diagnostic messages, as described in the release note accompanying this user guide.

The C++ translator

The C++ translator for RISC OS (the tool C++ supplied as a part of this product) is a port of Release 3.0 of AT&T's CFront product.

This user guide

This guide is a reference manual for the C tools CC, C++, CMHG, ToANSI and ToPCC working as part of the development environment of Acorn C/C++. These are the only tools in this product which are not used for programming in other languages, and already described in the accompanying *Desktop Tools* guide. This manual also documents the C and C++ library support provided and other aspects that are particular to this C product:

- special features of this implementation of the C and C++ languages
- operating the Acorn C/C++ tools specific to the C and C++ languages
- developing programs for the RISC OS environment:
  - Portability issues, including the portable C compiler (pcc) facility
  - Desktop applications
  - Relocatable modules
  - Overlays
  - Calling other programs and languages from C.

This guide is not intended as an introduction to C or C++, and does not teach C or C++ programming; nor is it a reference manual for the ANSI C standard. Both these needs are addressed by publications listed in the section *Useful references* on page 6.

This guide is organised into parts:

Part 1 – Using the C tools

Part 2 – C language issues

Part 3 – C++ language issues

Part 4 – Developing software for RISC OS

Part 5 – Appendixes

Part 1 – Using the C tools

This part of the guide describes the operation of the programming tools specific to C. The first chapter describes the interaction of the C tools with the rest of the development environment; each of the remaining chapters is devoted to an individual tool. Examples in the text and on disc are used to illustrate several points.

The chapters are:

- *CC and* C++
- CMHG
- *To*ANSI
- *To*PCC

Part 2 – C language issues

This covers issues to do with the C programming language itself, in particular those parts of the ANSI standard that are necessarily machine- or operating system-specific.

The chapters are:

- *C implementation details*

  How Acorn C implements those aspects of the language which ANSI leaves to the discretion of the implementor; and how Acorn C behaves in those areas covered by Appendix A.6 of the draft standard (which lists those aspects which the standard requires each implementation to define).

- *The C library*

  This chapter works through the headers of the C library, (`assert.h` to `time.h`), outlining the contents of each one:
  - function prototypes
  - macro, type and structure definitions
  - constant declarations.
- *The ANSI library*

  This chapter details the ANSI library, a superset of the C library that provides additional features useful in debugging and profiling your software.
- *The Event library*

  This chapter details the Event library, which provides calls for you to more easily dispatch Toolbox and Wimp events within Toolbox based applications.
- *The Wimp library*

  This chapter documents the Wimp library, which provides a set of C veneers onto the Wimp (or Window Manager) SWI interface.
- *The Toolbox library*

  This chapter documents the Toolbox library, which provides a set of C veneers onto the Toolbox SWIs.
- *The Render library*

  This chapter documents the Render library, which provides a set of C veneers onto the DrawFile SWIs, used to render Draw files.

Part 3 – C++ language issues

This covers issues to do with the C++ programming language, such as details of its implementation and of the libraries supplied with it.

- *C++ implementation details*

  This chapter describes implementation specific behaviour of Acorn C++.
- *The Streams library*

  This chapter describes the C++ Streams library, giving a synopsis (including prototypes) and a description of each available interface.
- *The Complex Math library*

  This chapter describes the C++ Complex Math library, giving a synopsis (including prototypes) and a description of each available interface.

Part 4 – Developing software for RISC OS

This part of the Guide tells you how to write software in C for the RISC OS environment. Examples in the text and on disc are used to illustrate each type of program development. It also includes a chapter on portability to help with porting applications in C to and from RISC OS.

The chapters are:

- *Portability*

  The chapter covers:

  - portability considerations in general
  - the major differences between ANSI and 'K&R' C
  - using the pcc compatibility mode of the Acorn compiler
  - standard headers and libraries
  - environmental aspects of portability.

- *Assembly language interface*

  How to handle procedure entry and exit in assembly language, so that you can write programs which interface correctly with the code produced by the C compiler.

- *How to write relocatable modules in* C

  Relocatable modules – the building blocks of the RISC OS operating system – are needed for device drivers and similar low-level software.

- *Overlays*

  This chapter explains how to write an application using overlays, with a worked example as an illustration.

Part 5 – Appendixes

The appendixes are:

- *Changes to the* C *compiler*

  This is the fifth release of the C compiler product for Acorn computers running the RISC OS operating system. The appendix highlights all those features that are new since the previous release (Acorn Desktop C).

- C *errors and warnings*

  Messages produced by the compiler, of varying degrees of severity.

- C++ *errors and warnings*

  Messages produced by the translator, of varying degrees of severity.

Conventions used

Throughout this Guide, a fixed-width font is used for text that the user should type, with an italic version representing classes of item that would be replaced in the command by actual objects of the appropriate type. For example:

```
cc options filenames
```

This means that you type **cc** exactly as shown, and replace *options* and *filenames* by specific examples.

Where it is necessary to differentiate between text you type, and that output by the computer, your input is shown in **bold**, and the computer's response in a normal weight.

Useful references

C programming

- Harbison, S P and Steele, G L, (1984) A C *Reference* Manual, (second edition). Prentice-Hall, Englewood Cliffs, NJ, USA. ISBN 0-13-109802-0.

  This is a very thorough reference guide to C, including a useful amount of information on the ANSI C standard.

  Since the Acorn C compiler is an ANSI compiler, this book is particularly relevant, but you must get the second edition for coverage of the ANSI standard.

- Kernighan, B W and Ritchie, D M, (1988) *The* C *Programming Language* (second edition). Prentice-Hall, Englewood Cliffs, NJ, USA. ISBN 0-13-110362- 8.

  This is the original C 'bible', updated to cover the essentials of ANSI C too.

- Koenig, A, (1989) C *Traps and Pitfalls*, Addison-Wesley, Reading, Mass, USA. ISBN 0-201-17928-8.

  This book explains how to avoid the most common traps and pitfalls that ensnare even the most experienced C programmers. It provides informative reading at all levels.

C++ Programming

- Stroustrup, B, (1991) *The C++ Programming Language*, (second edition). Addison-Wesley, Reading, Mass, USA. ISBN 0-201-53992-6.

  The standard book describing the C++ language, including a complete copy of the Reference Manual.

- Ellis, A and Stroustrup, B, (1990) *The Annotated C++ Reference Manual*. Addison-Wesley, Reading, Mass, USA. ISBN 0-201-51459-1.

  The original Reference Manual, used as an ANSI base document, with additional annotations and commentary sections.

RISC OS

- The *User Guide* supplied with your computer, which describes how to use the RISC OS operating system and the applications Edit, Paint and Draw.
- The RISC OS 3 *Programmer's Reference Manual*.
- The RISC OS 3 *Style Guide*.

The ANSI C standard

The American National Standard for Information Systems – Programming Language C is available with the reference number ANSI X3.159-1989 for £45.00 from:

British Standards Institution
Foreign Sales Department
Linford Wood
Milton Keynes
MK14 6LE

Members of the BSI can order copies by telephone; non-members should send a cheque payable to BSI.

However, you should find the coverage of ANSI C in this manual and the books listed above adequate for all but the most demanding requirements.

The ANSI C++ standard

At the time of going to press, the ANSI standard for C++ was not yet published – but it is unlikely to deviate significantly from *The Annotated C++ Reference Manual* referred to above.

Part 1 – Using the C tools

2 CC and C++

CC is a desktop tool which provides an easy interface to the CC and Link programs that Acorn C/C++ installs in your computer's library. It constructs command lines and passes them to these programs. Likewise, **C++** is a desktop tool that constructs command lines for the CC, CFront and Link programs in the library.

Because these two desktop tools are so similar, and share the underlying CC and Link programs, we describe them in the same chapter. Most of the rest of this chapter covers the CC and C++ options, and gives some programming examples.

If you are new to RISC OS and the Acorn C/C++ product, read the whole of this chapter before starting to use Acorn C/C++. If you are an experienced C or C++ programmer, you will find this chapter essential for reference, and may choose to tackle the section *Worked examples* on page 47 first.

The underlying programs

The CC compiler is a full implementation of ANSI C as described in the chapter *Introduction* on page 1. It consists of a preprocessor and a code generator; it processes text files containing the source and headers of programs into linkable object files.

The Link program combines these object files to produce executable image files.

CFront is a C++ translator; it is a port of Release 3.0 of AT&T's CFront product. It converts C++ source code to C source code.

The characteristics of CC as a language implementation are defined in *Part 2 – C language issues* on page 67. Similar information for C++ is in *Part 3 – C++ language issues* on page 171.

How the tools use them

The command line that the CC tool produces first calls CC to preprocess and compile the source into object files; it then calls Link to link those object files.

The command line that the C++ tool produces first calls the CC preprocessor in a special C++ compatible mode; it then calls CFront to convert the resultant source files to C; it then calls CC to compile the C source into object files, again using a special C++ compatible mode; it finally calls Link to link those object files.

A note about Make

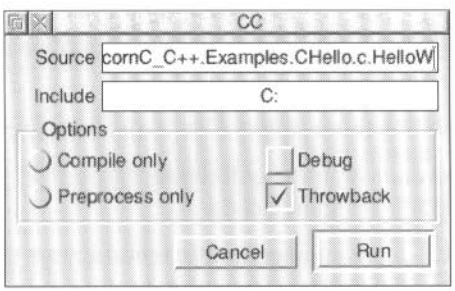
The Make tool (see the chapter *Make* on page 57 of the *Desktop Tools* guide) can also construct command lines for the underlying CC, CFront and Link programs. You'll find it a better tool for managing large projects. However, much of what is in this chapter is relevant, since Make both uses the same underlying programs, and sets options for those programs with the CC and C++ tools' user interfaces.

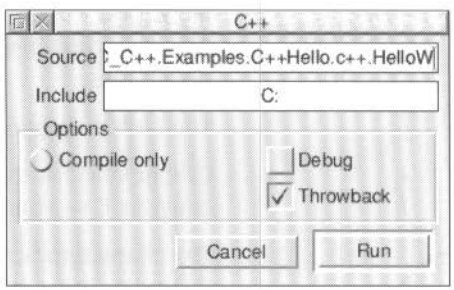
Getting started with CC and C++

To use the CC or C++ tool, first open the `AcornC_C++.Tools` directory display, then double click on !CC or !C++ as required. (You cannot start CC or C++ by double clicking on a file – the tools own no file type unlike, for example, Draw.)

The tool's icon appears on the icon bar:

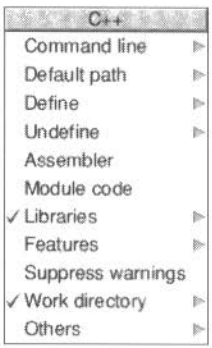
Clicking Select on this icon, or dragging a source file from a directory display to this icon, brings up the **SetUp** dialogue box. To see this work, open the directory display for `AcornC_C++.Examples`, and then drag either `CHello.c.HelloW` to the CC icon, or `C++Hello.c++.HelloW` to the C++ icon. The **SetUp** dialogue box appears:





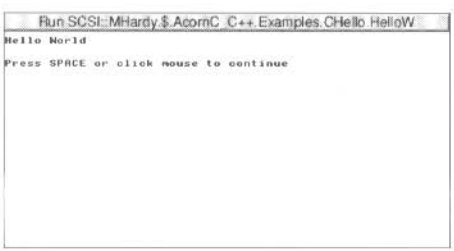
As you have dragged a source file to bring up this dialogue box, its name appears in the writable **Source** icon; otherwise this icon would have appeared containing the name of the last filename entered there, or be empty if there were none.

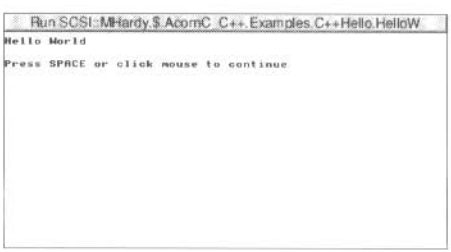
Clicking Menu on the SetUp dialogue box brings up the **SetUp** menu:



The SetUp dialogue box and menu specify the next compilation to be done. You start the next job by clicking Select on the **Run** button on the dialogue box (or on the **Command line** menu dialogue box). Clicking Select on the **Cancel** button removes the **SetUp** dialogue box and clears any changes you have just made to the options settings, leaving them back in the state they were in before you brought up the **SetUp** box. The options last until you adjust them again or reload the tool; or you can save the options for future use with an item from the main icon menu.

Ensure that the option settings are the defaults, as in the above pictures. Click on the **Run** button to compile either `HelloW` example with an integral link step. Save the executable image file produced in the directory above that holding the source, naming it `HelloW`, then double click Select on the file's icon to run it. The program runs, putting a `Hello world` message in the standard RISC OS command line window:





Libraries

C libraries

There are several libraries provided to support the C compiler:

- The stubs for the shared C library

  This provides all the standard facilities of the language, as defined by the ANSI standard document. Code using calls to the shared C library will be portable to other environments if an ANSI compiler and library are available for that environment. See the chapter *The C library* on page 91.

- The ANSI library

  The ANSI library is a stand-alone version of the shared C library that contains a few extra functions useful in debugging and profiling your code. You should use it for development only, using the shared C library in any final product. See the chapter *The ANSI library* on page 141.

- The Event library

  The purpose of the 'events' library is to allow the client to more easily dispatch Toolbox and Wimp events within Toolbox based applications. See the chapter *The Event library* on page 143.

- The Wimp library

  This is a low-level library that provides veneers to the Wimp_... SWI calls; you may use it to interface directly with the Window Manager module. See the chapter *The Wimp library* on page 153, and the RISC OS 3 *Programmer's Reference Manual*.

- The Toolbox library

  This library provides veneers onto the Toolbox SWIs; both the veneers and the SWIs are described in the accompanying *User Interface Toolbox* guide.

C++ libraries

The C++ compiler produces output which uses the ANSI C library (by linking with the stubs). A C++ program also needs to link with the C++ library which is held in `AcornC.C++.libraries.c++lib.o.c++lib`. This has support functions such as **new** and **delete**, and includes the streams and complex maths libraries.

File naming and placing conventions

This section explains the concept of a work directory, and describes the naming conventions used to identify the different classes of file you will come across when using Acorn C/C++.

Work directory

Both CC and C++ operate in a *work directory*. The work directory is where the tools place all output files that you don't explicitly place yourself by dragging from a **Save As** dialogue box. This includes object files to be linked by an integral link step, assembly language output and listing output. The work directory is also a place where some input source and header files are looked for – see the next sections for more details.

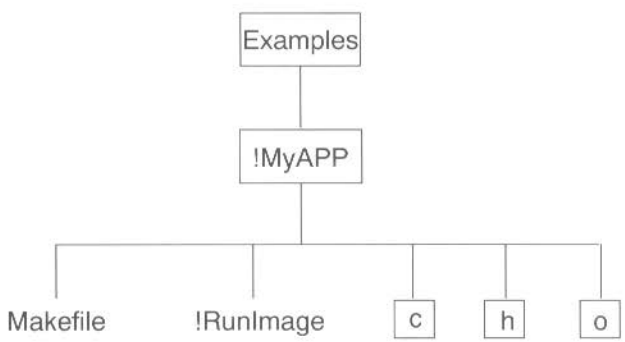
If you're using Make, the work directory is simply the directory containing the *makefile* controlling the job.

If you're using the CC or C++ tools, the work directory is formed from the directory containing the source file, modified by the relative path name specified by the **Work directory** option on the SetUp menu. The default **Work directory** SetUp menu value is ^.

For example, when compiling the example 'Hello world' C program with the default **Work directory** setting:

- The source is in the directory `AcornC_C++.Examples.CHello.c`
- The work directory is therefore `AcornC_C++.Examples.CHello.c.^`, i.e. `AcornC_C++.Examples.CHello`.

A typical directory arrangement is:



The resource files (such as !Run and Res) normally found in an application directory are not shown above. With directories arranged as above and default option settings, the work directories for both the Make and the CC/C++ tools are the same, namely `Examples.!MyApp`.

Filename conventions

The Acorn C/C++ system, in common with others, uses naming conventions to identify the classes of file involved in the compilation and linking process. Many systems use conventional suffixes for this. For example, the suffix `.c` denotes C source files on UNIX and MS-DOS systems. This convention clashes with Acorn's use of the full-stop character in pathnames. It is more natural under Acorn filing systems to use a prefix convention, e.g. `c.foo`, where `c` is the directory containing C source files, and `foo` is the filename.

However, portability is an increasingly important issue. CC recognises the standard file naming conventions and performs the appropriate transformations to construct valid RISC OS pathnames. The following sections summarise the conventions for referring to source, include, object and program files.

Rooted filenames

A filename is rooted if it is

- a RISC OS filename beginning with a '`$`' or an '`&`' – for example:
  `$.library.h.baricon &.h.myheader`
- a UNIX filename beginning with a '`/`' – for example:
  `/library/baricon.h`
- an MS-DOS filename beginning with a '`\`' – for example:
  `\library\baricon.h`

Rooted filenames are used by CC as absolute specifications of filenames, independent of work directories, search paths, etc. Rooted UNIX or MS-DOS filenames are converted into the Acorn syntax and prefix forms.

Source files

The CC and C++ tools specify the source files to be compiled on the command line they construct and pass to the underlying programs. Dragging a source file to the CC SetUp dialogue box specifies the file as an absolute rooted filename.

Make uses a makefile to specify the source files; their pathnames are normally given relative to the work directory. C source files will be looked for in the subdirectory `c` of the work directory. To aid portability, a file specified as `foo.c` in a makefile will be looked for in `@.c.foo`, where `@` means the work directory. C++ source files are similarly looked for in the subdirectory `c++`.

Include files

The way in which the compiler searches for included files is dealt with in detail in the section *Include file searching* on page 18. Here we describe the issues of naming header files and how to name them in `#include` lines in your C and C++ program source.

Include files are often headers for libraries, and are incorporated by issuing the `#include` directive – dealt with by the preprocessor – at the start of a source file. For instance, in the C `HelloW` example:

```
#include <stdio.h>
```

By convention, header files are placed in subdirectory `h`. This convention is followed here. You can use subdirectory `h` of the work directory for your own header files, which can be incorporated with a source line like:

```
#include "myfile.h"
```

Note that both the example filenames `stdio.h` and `myfile.h` are in suffix form rather than Acorn prefix form. This is because you can make use of Acorn C/C++'s filename processing to interpret these, leaving program lines which do not need altering to port them to machines expecting suffixes.

To facilitate the porting of code from UNIX and MS-DOS to RISC OS, UNIX-style and MS-DOS-style filenames are translated to equivalent RISC OS-style filenames.

For example:

`../include/defs.h`	is translated to	`^.include.h.defs`
`..\cls\hash.h`	is translated to	`^.cls.h.hash`
`includes.h`	is translated to	`h.includes`

but:

`system.defs`	is translated to	`system.defs`

In the same way, the lists of directory names given as arguments to the compiler's **Include** and **Default path** SetUp options (see below) are translated to RISC OS format before being used, in the rare event that this is necessary.

Object files

If you use the CC or C++ tool to compile a single file with the SetUp dialogue box option **Compile only** enabled, you use a standard **Save As** dialogue box to save the resultant object file.Otherwise the object files created by the compiler are instead stored in the `o` subdirectory of the work directory. Thus the result of compiling `c.sieve` will be found in `o.sieve`.

Program files

If you haven't enabled the **Compile only** option on the CC or C++ tool's SetUp menu, the tool compiles sources to object files, and then links them with the C library stubs to produce an executable program file. You may find it convenient to save this program file in the work directory itself – there is no conventional suffix for these.

Compilation list files

If you enable the **Listing** option on the CC tool's SetUp menu, then for each compiled source file the CC tool creates a compilation listing file in the `l` subdirectory of the work directory. Thus compiling `c.sieve` with **Listing** enabled will by default result in the list file `l.sieve` being created.

The C++ tool does not have a **Listing** option.

Assembly list files

If the CC or C++ tool's SetUp menu option **Assembler** is enabled, no object code is generated. Instead, an assembly listing of the code is created. If only one assembly listing file is produced, you save it from a standard **Save As** dialogue box. If more than one is produced these are placed in the subdirectory `s` of the work directory. Thus compiling `c.sieve` with **Assembler** enabled can result in the assembly language file `s.sieve` being created.

Filename validity

The compiler does not check whether the filenames you give are acceptable – whether they contain only valid characters and are of acceptable length – this is done by the filing system.

Include file searching

The process of converting text C or C++ source to linkable object files of binary code can be seen as a pipeline of several processes. The first stage is preprocessing the source. It is at this stage that the text of header files is brought in at the position of `#include` directives in the source text.

The preprocessor – which is used by both the CC and C++ tools – handles `#include` directives of two forms:

```
#include <filename>
```

or

```
#include "filename"
```

You will normally include four types of header file:

- headers for the ANSI parts of the C library
- headers for the non-ANSI parts of the C library
- headers for the other libraries supplied with Acorn C/C++
- headers for your own include files.

A special feature of the Acorn C/C++ system is that the standard ANSI headers are built into the compiler, and are used by default. By writing the filename in the angle bracket form, you indicate that the include file is a system file, and thus ensure that the compiler looks first in its built-in filing system. Of the common types of header above, only the headers for the ANSI parts of the C library should be referred to as system files in angle brackets. Writing the filename in the double quote form indicates that the include file is a user file.

The headers for the non-ANSI parts of the main C library – `kernel`, `pragmas`, `SWIs` and `varargs` – are not built in to the compiler; nor are the headers for the other libraries supplied with Acorn C/C++. However, by default the CC and C++ tools both set the **Include** icon on their SetUp dialogue box to `C:`. This makes the preprocessor use the value of the `C$Path` system variable to find the headers for all the libraries supplied in `AcornC_C++.Libraries`.

You can include headers for other libraries by adding the parent of the `h` directory holding them to the **Include** writable icon on the tool's **SetUp** dialogue box. The easiest way to do so is to drag the included directory's icon from a directory display to the writable field.

As mentioned before, you can use the subdirectory `h` of the work directory for the last common type of header file – your own header files, which you refer to as user files with directives such as:

```
#include "myfile.h"
```

This is all you need to know for basic use of CC with largely default options. The rest of this section provides a level of detail useful for reference or studying if you wish to use CC in a non-standard way.

Reference section

The way in which the preprocessor looks for included files depends on three factors:

- whether the filename is rooted
- whether the filename in the #include directive is between angle brackets <> or double quotes " "
- use of the **Include** and **Default path** SetUp options (including the special filename `:mem`).

If a filename is not rooted (as defined earlier) the preprocessor looks for it in a sequence of directories called the search path.

Search path

The order of directories in the search path is as follows:

1. The compiler's own in-memory filing system.
   This is only searched for `#include <filename>` directives when you have not enabled the SetUp menu's **Default path** option.
2. The *current place* (see the section *Nested includes* on page 20).
   This is only searched for `#include "filename"` directives.
3. Arguments to the **SetUp** dialogue box's **Include** option, if used.
   As noted above, this is set to `C:` by default, and so all the directories supplied in `AcornC_C++.Libraries` will be searched.
4. The system search path:
   - The path given as an argument to the **Default path** SetUp menu option (see below), if this is enabled; otherwise
   - The value of the system variable `C$Libroot`, if this is set; otherwise
   - `$.Clib`.

Nested includes

The *current place* is the directory containing the source file (C or C++ source, or `#include`d header) currently being processed by the compiler. Often, this will be the work directory.

When a file is found relative to an element of the search path, the name of the directory containing that file becomes the new current place. When the compiler has finished processing that file it restores the old current place. So at any given instant, there is a stack of current places corresponding to the stack of nested #includes.

For example, suppose the current place is `$.include` and the compiler is seeking the `#included` file `"sys.defs.h"` (or `"sys.h.defs"`, `"sys/defs.h"`, etc). Now suppose this is found as:

`$.include.sys.h.defs`

Then the new current place becomes `$.include.sys`, and files `#included` by `h.defs`, whose names are not rooted, will be sought relative to `$.include.sys`.

This is the search rule used by BSD UNIX systems. If you wish, you can disable the stacking of current places using the SetUp menu option **Features** with the argument `K`, to get the search rule described originally by Kernighan and Ritchie in *The C Programming Language*. Then all non-rooted user includes are sought relative to the directory containing the source file being compiled.

In all this, the penultimate `.c`, `.c++` and `.h` components of the path are omitted. These are logically part of the filename – a filename extension – not logically part of the directory structure. However, directory names other than `c`, `c++`, `h`, `o` and `s` are not so recognised (as filename extensions) and are used 'as is'. For example, the name `sys.new.defs` is exactly that: it is not translated to `sys.defs.new` and, if it is found, the new part of the name does become part of the new current path.

Use of :mem

You can use the SetUp menu option **Default path** to provide your own system search path, as mentioned in step 4 of the section *Search path* above. The preprocessor will then use the argument you give to the **Default path** option as the system search path. You will only require this feature if you use implementations of the C library other than those provided with the Acorn C system.

Use of the **Default path** option also prevents a `#include <filename>` directive being first searched for in the in-memory filing system (see step 1 of the section *Search path* above). It can be reinstated by using the pseudo-filename `:mem` as an argument to the **Default path** or **Include** options. If `:mem` is included in the search path in this way, its position in the path is as specified – not necessarily first – so you can take complete control over where the compiler looks for `#included` files.

Use of C$Libroot

`C$Libroot` is an environment variable that you can use to provide your own system search path, as shown in step 4 of the section *Search path* above. It is not needed for normal use of the compiler.

If `C$Libroot` is set, and you have not used the **Default path** option, the preprocessor will use the variable's value as the system search path. By default, `C$Libroot` is not set.

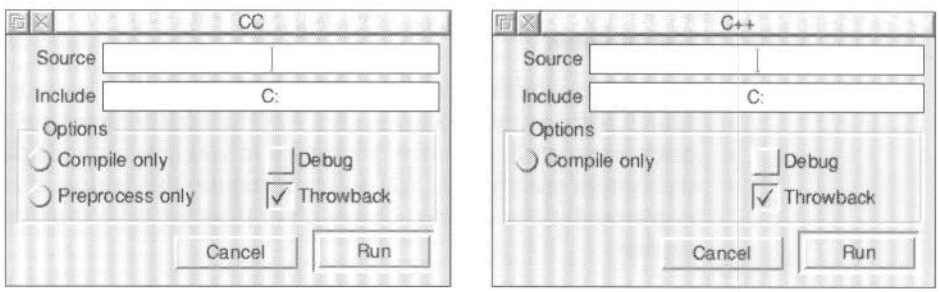
To set the value of `C$Libroot` to, for example, `"$.MyLib"`, at the command line type:

```
*Set C$Libroot $.MyLib
```

This variable is also used by the Acorn C/C++ system as the library search path, if set. With the example given, the compiler will now look for include files in `$.mylib.h`, and for libraries in `$.mylib.o`.

The SetUp dialogue box

Clicking Select on the tool's icon bar icon or dragging a source file from a directory display to this icon brings up the tool's SetUp dialogue box:



Source

This writable icon in the SetUp dialogue box contains the names of the source files to be compiled.

When the SetUp box is obtained by clicking on the tool's main icon, it comes up with this icon containing its previous setting. You can thus repeat your previous compilation by just clicking on the **Run** button.

If the SetUp box appears as a result of dragging a source file to the main icon, the writable **Source** icon appears containing the new source file name.

When the SetUp box appears the **Source** icon has input focus, and can be edited in the normal RISC OS fashion. If you select a further source file in a directory display and drag it to this writable icon, its name is added to a list of those already there.

If you drag pre-compiled or pre-assembled object files to the **Source** icon, they are included in the set of object files linked together in an integral link step after the source files themselves have been compiled to object files.

Include

This SetUp dialogue box icon adds specified directories to the list of places which are searched for `#include` files. The directories in the **Include** icon are searched in the order in which they are given. The path should end with the name of a directory, with no `.h`, which is added automatically.

The default setting of **Include** is to C:. This makes the preprocessor search for headers in the directories listed in the RISC OS environment variable `C$Path`, set by `AcornC_C++.!SetPaths`. The directories listed are those that hold all the libraries supplied with the product in `AcornC_C++.Libraries`

For more details of how to use `#include` lines and places searched for headers – both before and after those in this **Include** list – see the section *File naming and placing conventions* on page 15.

Compile only

This option switches off or on the linking of object files. When enabled, the link step is not performed, and the tools output object files. If you're only compiling one source file, you drag the object file produced from a **Save as** dialogue box. Otherwise, multiple files are saved in the `o` subdirectory of the work directory.

If not enabled, both CC and C++ instead perform an integral link step, linking any object files produced by compilation to any additional ones dragged to the **Source** icon, and library files, producing an executable program file. You control the saving of this from a **Save as** dialogue box.

Compile only is not enabled by default.

Preprocess only

This option is not available for the C++ tool.

If this option is enabled, only the preprocessor phase of the compiler is executed. The output from the preprocessor is sent to the standard output window. The standard non-interactive tool output window save facility is useful here to save this output to a file or SrcEdit window. By default, comments are stripped from the output, but see the SetUp menu option **Keep comments** on page 27.

Preprocess only is not enabled by default.

Debug

This option switches on or off production of debugging tables. When enabled, extra information is included in the resultant object files and image files which enables source level debugging of the linked image by the DDT debugger. If this option is disabled, any image file finally produced can only be debugged at machine level.

If you are only compiling the source to object files, you must remember to enable debugging in the Link tool when you link them. If you don't, you'll lose the debugging information produced by the CC and C++ tools.

Debug is not enabled by default.

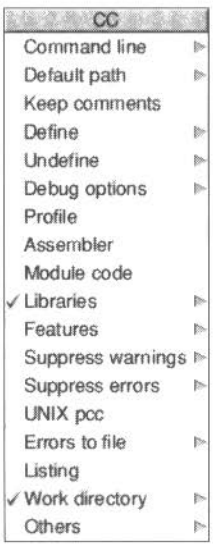
Throwback

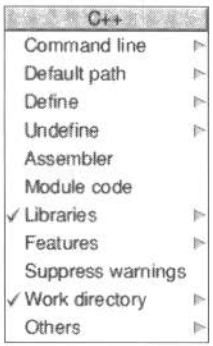
This option switches editor throwback on or off. When enabled, if the DDEUtils module and SrcEdit are loaded, any compilation errors cause the editor to display an error browser. Double clicking Select on an error line in this browser makes the editor display the source file containing the error, with the offending line highlighted. See the chapter *SrcEdit* on page 71 of the accompanying *Desktop Tools* guide for more details.

Throwback is on by default.

The SetUp menu

Clicking Menu on the SetUp dialogue box brings up the SetUp menu. The CC menu contains some options not available on the C++ menu, but the two menus are otherwise virtually identical:

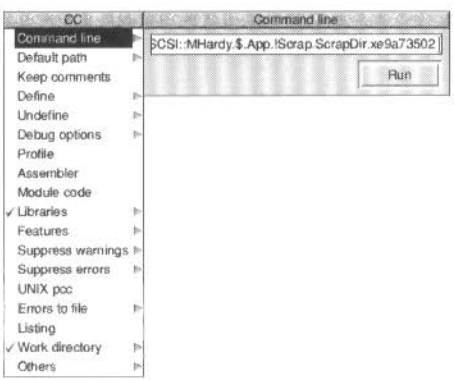


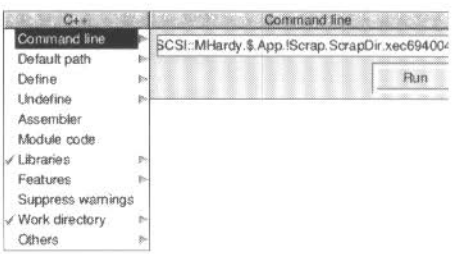


The options on this menu are described in the following subsections.

The command line

The **Command line** item at the top of the SetUp menu leads to a small dialogue box in which the command line equivalent of the current SetUp options is displayed:



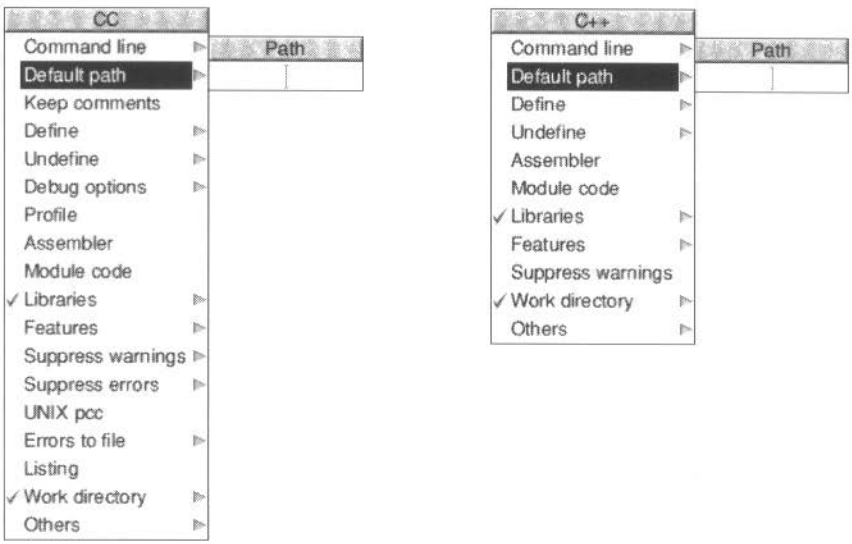


Clicking on the **Run** action button in this dialogue box starts compilation in the same way as that in the main SetUp box. Pressing Return in the writable icon in this box has the same effect. Before starting compilation from the command line box, you can edit the command line textually, although this is not normally useful.

Controlling the preprocessor

Default path

The **Default path** entry on the SetUp menu leads to a writable icon in which you specify a comma-separated list of directories to be searched for included files:



This overrides the system include path with the list of directories. You can specify the memory file system in the list by using the name `:mem` (in any case). An example is:

```
myhdrs,:mem,$.proj.public.hdrs
```

For more details of the system include path and searching for include files in general, see the section *File naming and placing conventions* on page 15.

Default path is not enabled by default.

Keep comments

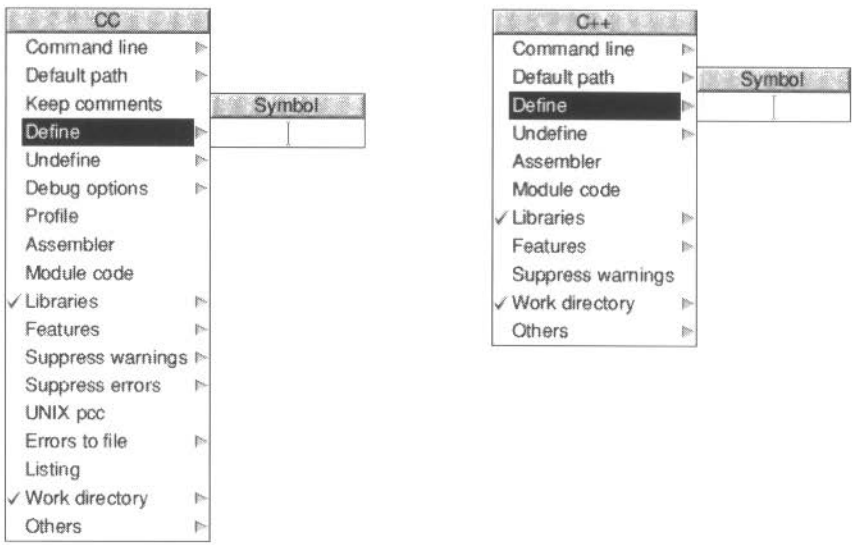
This option is not available for the C++ tool.

When enabled in conjunction with **Preprocess only**, this option retains comments in preprocessor output.

Keep comments is not enabled by default.

Define

The **Define** option on the SetUp menu leads to a writable icon in which you can predefine preprocessor macros:



You can enter two forms of macro predefinition:

```
sym=value
sym
```

These both define *sym* as a preprocessor macro for the compilation. The two forms are equivalent to the lines:

```
#define sym value
#define sym 1
```

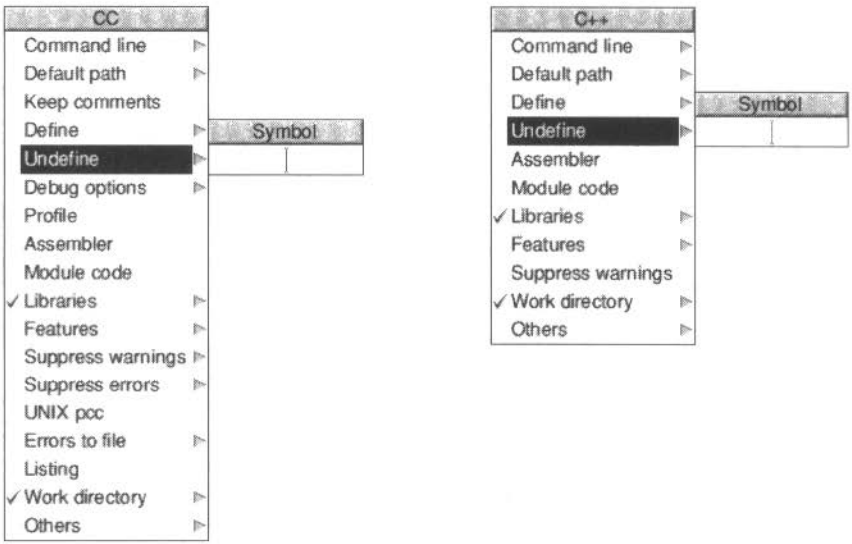
at the head of the source file.

You can enter multiple symbols as a space-separated list.

Define is not enabled by default.

Undefine

The **Undefine** option on the SetUp menu leads to a writable icon in which you can undefine preprocessor macros:



You enter the name of the macro concerned, eg:

sym

Use of this option is then equivalent to the line:

`#undef` *sym*

at the head of the source file.

You can enter multiple symbols as a space-separated list.

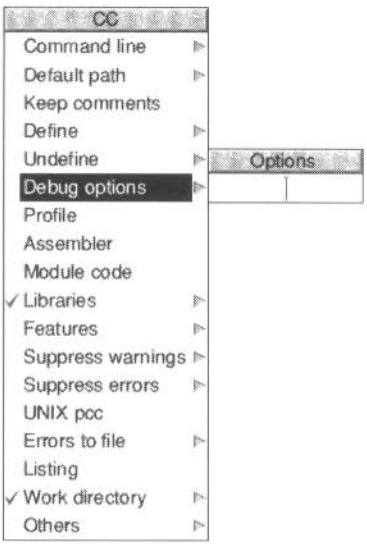
Undefine is not enabled by default.

Controlling code generation

Debug options

This option is not available for the C++ tool.

The **Debug options** option on the SetUp menu leads to a writable item in which you enter a set of modifier letters:



The modifier letters limit the debugging tables generated in response to enabling the **Debug** option on the SetUp dialogue box. The letters recognised are:

`f` generate information on functions and top-level variables (outside functions) only

`l` generate information only describing each line in the file

`v` Generate information only describing all variables

You can use these letters in any combination.

Debug options is not enabled by default.

Profile

This option is not available for the C++ tool.

Enabling this SetU menu option causes the compiler to generate code to count the number of times each function is executed. This is called profiling.

The counts can be printed by calling `_mapstore()` to print them to `stderr` or by calling `_fmapstore("filename")` to print them to a named file of your choice. You should do this just before the final statement of your program.

Profiling is not supported by the shared C library, so you must link programs to be profiled with ANSILib. If you wish, you can link with both Stubs and ANSILib, in which case only the code for `_mapstore()` and `_fmapstore()` will be included from ANSILib; your program will continue to use the shared C library, and will be much smaller than if linked with ANSILib alone.

The printed counts are lists of *`lineno: count`* pairs. The *`lineno`* value is the number of a line in your source code, and the *`count`* value is the number of times it was executed. Note that *`lineno`* is ambiguous: it may refer to a line in a `#include` file. However, this is rare and usually causes no confusion.

Provided you didn't compile your program with the **Features** option with `f` as an argument, blocks of counts will be interspersed with function names. In the simple cases, the output reduces to a list of line-pairs like:

```
function
lineno: count, where count is the number of times function was executed.
```

If you use the SetUp menu option **Others** to add the text `-px` to the command line, profiling of basic blocks within functions is performed in addition to profiling the functions. If you do this, the *`lineno`* values within each function relate to the start of each basic block. Sometimes, a statement (such as a `for` statement) may generate more than one basic block, so there can be two different counts for the same line.

Profiled programs run slowly. For example, when compiled with **Profile** enabled, Dhrystone 1.1 runs at about 5/8 speed; when compiled `-px` it runs at only about 3/8 speed.

There is no way, in this release of C, to relate execution counts to the proportion of time spent in each section of code. Nor is there any tool for annotating a source listing with profile counts. Future releases of C may address these issues.

Profile is not enabled by default.

Assembler

If this SetUp menu option is enabled, no object code is generated and, naturally, no attempt is make to link it. If only one assembly listing file is produced, you save it from a standard save dialogue box. If more than one is produced these are placed in the subdirectory **s** of the work directory.

Assembler is not enabled by default.

Module code

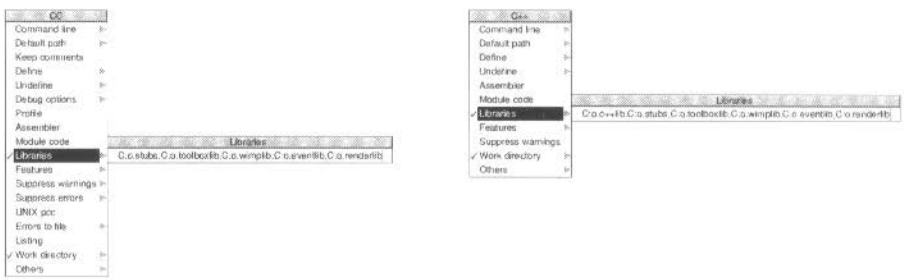
This SetUp menu option must be enabled when compiling code for linking into a RISC OS relocatable module, otherwise it should not be enabled. When enabled, code is produced which allows the module's static data to be separated from its code, hence be multiply instantiated.

Module code is not enabled by default.

Controlling the linker

Libraries

The **Libraries** option on the SetUp menu leads to a writable icon in which you specify a comma-separated list of filenames of libraries to be used in an integral link step:



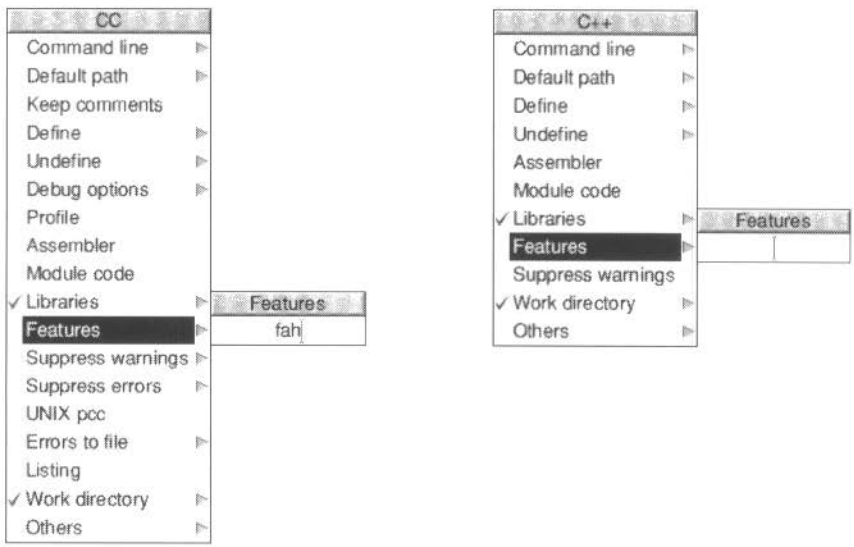
The libraries specified with this option are used instead of the standard one (`AcornC_C++.Libraries.clib.o.Stubs`), not in addition to it.

Libraries is not enabled by default.

Using the Features menu option

Features

The **Features** option on the SetUp menu leads to a small writable icon in which you can specify additional compiler features with single modifier letters:



This entry controls a variety of compiler features, including certain checks on your code more rigorous than usual. At least one of the following modifier letters must be entered if **Features** are enabled:

a Check for certain types of data flow anomalies. The compiler performs data flow analysis as part of code generation. The checks enabled by this option can sometimes indicate when an automatic variable has been used before it has been assigned a value.

c Enable the Limited pcc option. This allows characters after `#else` and `#endif` preprocessor directives (treated as comments), and explicit casts of integers to function as pointers (forbidden by ANSI). These features are often required in order to use pcc-style include files in ANSI mode.

e Check that external names used within the file are still unique when reduced to six case-insensitive characters. Some linkers only provide six significant characters in their symbol tables. This can cause problems with clashes if a system uses two names such as `getExpr1` and `getExpr2`, which are only unique in the eighth character. The check can only be made

within one compilation unit (source file) so cannot catch all such problems. Acorn C and C++ allow external names of up to 256 characters, so this is a portability aid.

`f` Do not embed function names in the code area. The compiler does this to make the output produced by the stack backtrace function (which is the default signal handler) and `_mapstore()` more readable. Removing the names from the compiler makes the code slightly smaller (typically 5%) at the expense of less meaningful backtraces and `_mapstore()` outputs.

`h` Check that all external objects are declared in some included header file, and that all static objects are used within the compilation unit in which they are defined. These checks support good modular programming practices.

`i` In the listing file (see the **Listing** option) include the lines from any files included with directives of the form:

```
#include "file"
```

`j` As above, but for files included by lines of the form:

```
#include <file>
```

`k` Use K&R search rules for nested `#include` directives (the 'current place' is defined by the original source file and is not stacked; see the section *File naming and placing conventions* on page 15 for details).

`m` Give a warning for preprocessor symbols that are defined but not used during the compilation.

`n` Embed function names in the code area (see `f` feature). This improves the readability of the output produced by the stack backtrace run time support function and the `_mapstore()` function (see *Profile* on page 30). However, it does increase the size of the code area slightly (around 5%). In general it is not useful to specify the `f` feature with **Profile** (i.e. `-p`).

`p` Report on explicit casts of integers into pointers, eg:

```
char *cp = (char *) anInteger;
```

Implicit casts are reported anyway, unless suppressed by the **Suppress warnings** option.

`u` By default, the source text as 'seen' by the compiler after preprocessing (expansion) is listed. If this feature is specified then the unexpanded source text, as written by the user, is listed. Consider the line

```
p = NULL;
```

By default, this will be listed as `p=(0);`. With the `u` feature specified, it will be listed as `p=NULL;`.

v Report on all unused declarations, including those from standard headers.

w Allow string literals to be writable, as expected by some UNIX code, by allocating them in the program's data area rather than the notionally read-only code area.

When writing high-quality production software, you are encouraged to use at least the `fah` **Features** options in the later stages of program development (the extra diagnostics produced can be annoying in the earlier stages).

Features is not enabled by default.

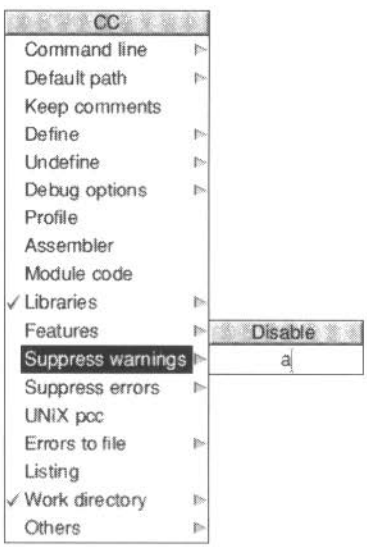
Handling warnings and errors

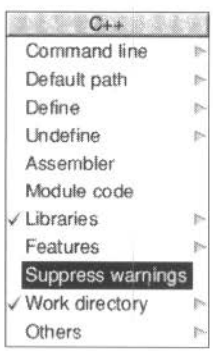
Suppress warnings

The **Suppress warnings** option on the SetUp menu prevents warnings from appearing.

For the C++ tool, all warnings are suppressed.

For the CC tool, this menu option leads to a writable icon in which you can enter a set of modifier letters:





The modifier letters specify various kinds of warning message to be suppressed by CC. Usually the compiler is very free with its warnings, as this tends to indicate potential portability or other problems. However, too many such messages can be a nuisance in the early stages of porting a program from old-style C, so you can disable them.

The modifier letters for CC are:

a Give no **`Use of = in a condition context`** warning. This is given when the compiler encounters statements such as **`if (a=b) {...`** where it is quite possible that == was intended.

d Give no **`Deprecated declaration foo() – give arg types`** warning. Use of old-style function declarations is deprecated in ANSI C, and in a future version of the standard this feature may be removed. However, it is useful sometimes to suppress this warning when porting old code.

f Give no **`Inventing "extern int foo()"`** message. This may be useful when compiling old-style C as if it were ANSI C.

n Give no **`Implicit narrowing cast`** warning. This warning is issued when the compiler detects an assignment of an expression to an object of narrower width (eg long to int, float to int). This can cause problems with loss of precision for certain values.

p Give no **`non-ANSI #include <...>`** warning. ANSI require that **`#include <...>`** should only be used for ANSI headers, but it can be useful to disable this warning when compiling code which does not conform to this aspect of the standard.

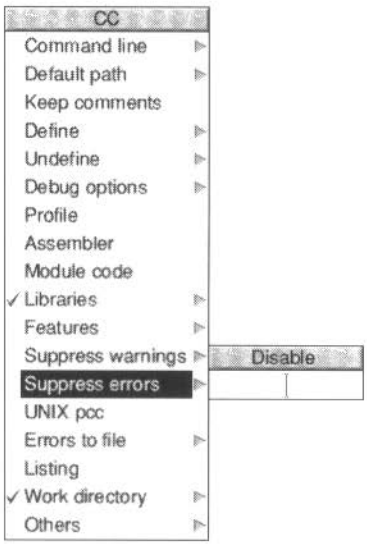
v Give no **`Implicit return in non-void contex`**t warning. This is most often caused by a return from a function which was assumed to return int (because no other type was specified) but is in fact being used as a void function.

If you enter a space in the writable icon, then Select or Return, all warning messages from CC are suppressed.

Suppress errors

This option is not available for the C++ tool.

The **Suppress errors** option on the SetUp menu leads to a writable icon in which you can enter a set of modifier letters:



These modifier letters can be used to force CC to accept C source which would normally produce errors. If any of these options are needed, it means that the C source in question does not conform to the ANSI C standard (CC normally generates precisely the diagnostics required by ANSI).

The modifier letters are:

`c` Suppresses all implicit cast errors, e.g. 'implicit cast of non-0 int to pointer'.

`f` Suppresses errors for unclean casts such as short to pointer.

`i` Suppresses syntax checking for `#if`.

`p` Suppresses the error which occurs if there are extraneous characters at the end of a preprocessor line.

`z` Suppresses the error if a zero-length array is used.

UNIX pcc

This option is not available for the C++ tool.

Enabling this SetUp menu option switches to compiling 'portable C compiler' C rather than ANSI C. This is based on the original Kernighan and Ritchie (K&R) definition of C, and is the dialect used on UNIX systems such as Acorn's RISC iX product. This option changes the syntax that is acceptable to the compiler, but the default header and library files are still used. See the section on this option in the chapter *Portability* on page 259 for more details.

UNIX pcc is not enabled by default.

Errors to file

This option is not available for the C++ tool.

Errors to file allows you to specify a file to which error messages are output for later inspection:

Listings

Listing

This option is not available for the C++ tool.

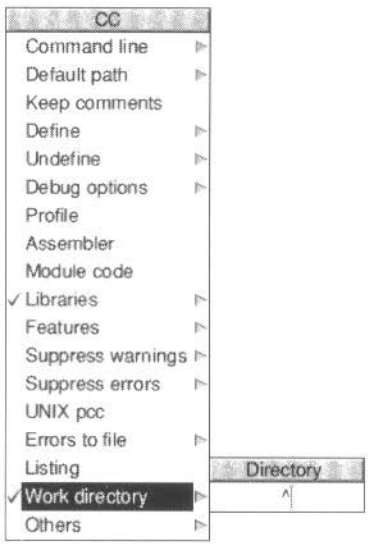
Enabling this SetUp menu option causes a listing file to be created. This consists of lines of source interleaved with error and warning messages. You can get finer control over the contents of this file using the **Features** option (see page 32).

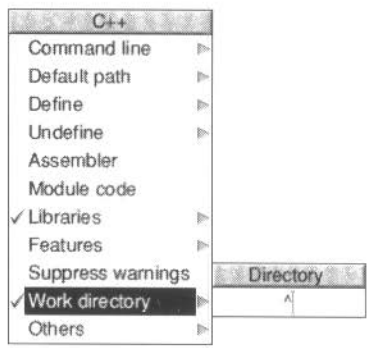
Listing is not enabled by default.

Choosing your work directory

Work directory

The **Work directory** entry on the SetUp menu leads to a writable icon in which you specify the work directory:





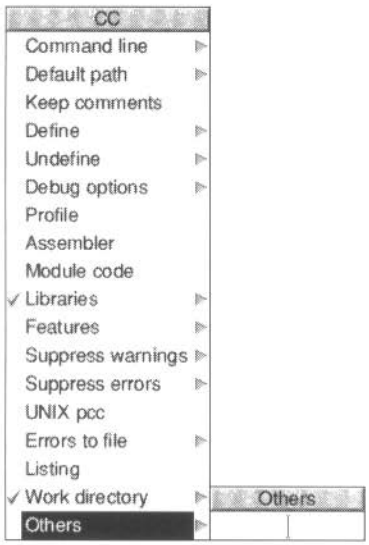
The effect of this option is described in the section *File naming and placing conventions* on page 15.

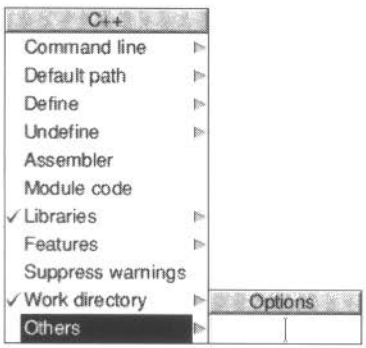
The default **Work directory** setting is ^.

Specifying other command line options

Others

The **Others** option on the SetUp menu leads to a writable icon in which you can add an arbitrary extra section of text to the command line to be passed to the relevant underlying program:



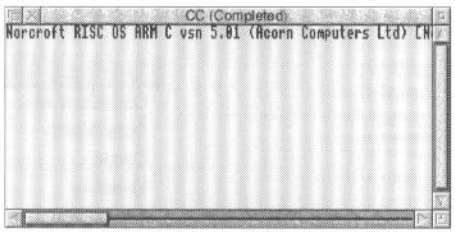


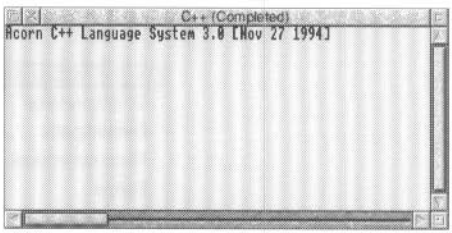
This facility is useful if you wish to use any feature which is not supported by any of the other entries on the SetUp dialogue box and menu. This may be because the feature is used very little, or because it may not be supported in the future.

For a full description of command line options, see *Command lines* on page 42.

Output messages

The CC and C++ tools output text messages as they proceed. These include preprocessed source (see **Preprocess only**), warning and error messages. By default any such text is directed into a scrollable output window:

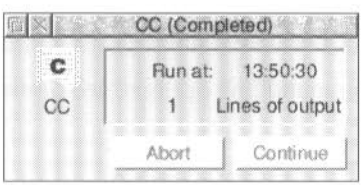


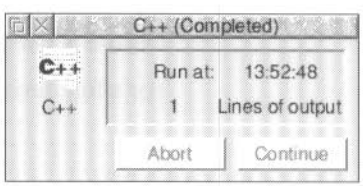


This window is read-only; you can scroll up and down to view progress, but you cannot edit the text without first saving it. Clicking Select on the scrollable part of this window has no effect, to indicate this.

The contents of the window illustrated above are typical of those you see from a successful compilation – the title line of the compiler with version number, followed by no error messages.

Clicking Adjust on the close icon of the output window switches to the output summary dialogue box. This presents a reminder of the tool running (CC or C++), the status of the task (Running, Paused, Completed or Aborted), the time when the task was started and the number of lines of output that have been generated (ie those that are displayed by the output window):





Clicking Adjust on the close icon of the summary box returns to the output window.

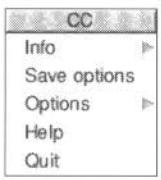
Both the above output displays follow the standard pattern of those of all the non-interactive Desktop tools. The common features of the non-interactive Desktop tools are covered in more detail in the chapter *General features* on page 101 of the accompanying *Desktop Tools* guide. Both tools' output displays and the menus brought up by clicking Menu on them offer the standard features allowing you to abort, pause, or continue execution (if the execution hasn't completed); and to save output text to a file, or repeat execution.

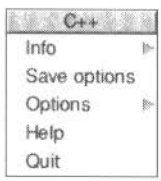
Error messages appear in the output viewer, with copies in the editor error browser when throwback is working. The appendixes C *errors and warnings* on page 303 and C++ *errors and warnings* on page 339 contain more details for interpreting error messages.

Preprocessed source appearing in the output window is often very large for compilation of complex source files. The scrolling of the output window is useful to view it, and to investigate it with the full facilities of the source editor, you can save the output text straight into the editor by dragging the output file icon to the SrcEdit main icon on the icon bar (providing `Wimp$Scrap` is properly set on your machine).

The icon bar menu

Clicking Menu on either the CC or the C++ icon on the icon bar gives the following menu:





Save options saves all the tool's current options, including those set both from the SetUp dialogue box and from the **Options** item on this menu. When you restart the tool it is initialised with these options rather than the defaults.

The **Options** item on the main menu allows you to enable **Auto run**, **Auto save** or start the output display as either a text window (default) or summary box. When **Auto run** is enabled, dragging a source file to the tool's icon starts a compilation immediately with the current options, rather than displaying the SetUp box first. When **Auto save** is enabled, output object files are saved to suitable places automatically without producing a save dialogue box for you to drag the file from. Both **Auto run** and **Auto save** are off by default.

For a description of each option in the tool's menu see the chapter *General features* on page 101 of the accompanying *Desktop Tools* user guide.

Command lines

For normal use you do not need to understand the syntax of the underlying CC and C++ programs' command lines, as they are generated automatically for you from the **SetUp** dialogue box and menu settings.

The syntax of the command lines is:

```
cc «options» filenames
c++ «options» filenames
```

By default, the C compiler and C++ translator look for source files, and create object, assembler and listing files, beneath the current work directory.

Many aspects of the programs' operation can be controlled via command-line options. All options are prefixed by a minus sign. There are two classes of option: keywords and flags:

- Keywords are recognised in upper case or lower case.
- A flag is a single letter, sometimes followed by an argument. Whenever this is the case, the C compiler allows white space to be inserted between the flag letter and the argument. However, this is not always true of other C compilers, so in the following subsections we only list the form that would be acceptable to a UNIX C compiler. Similarly, we only use the case of the letter that would be accepted by a UNIX C compiler.

  By using the conventions common to many C compilers, you can build portable *makefiles* that you can easily move between different environments.

The options are listed below. Where an option merely gives a page reference to a desktop equivalent, you should see that page for full details. Should you need to use any of the more esoteric options that have no direct desktop equivalent, remember that you can always add them to the SetUp menu's **Others** option (see *Specifying other command line options* on page 39).

Where an option is shaded, we recommend that you don't use it with C++. You may use all options with CC, save for the *Translator options* on page 45, which are used by CFront and hence irrelevant to CC.

Keyword options

Command line option	Description
`-help`	Outputs a summary of the command line options.
`-pcc`	Equivalent to **UNIX pcc** in SetUp menu; see page 37.

Command line option	Description
`-fussy` or `-strict`	Be extra strict about enforcing conformance to the ANSI standard or to pcc conventions (e.g. prohibit the `volatile` qualifier in `-pcc` mode).
`-list`	Equivalent to **Errors to file** in SetUp menu; see page 37.
`-via` *file*	Reads in extra command line arguments from the given *filename*.
`-errors` *file*	Equivalent to **Listing** in SetUp menu; see page 38.
`-littleend` or `-li`	Compile code suitable for a little-endian ARM.
`-bigend` or `-be`	Compile code suitable for a big-endian ARM.
`-apcs «3»`*qualifiers*	Specify which variant of the ARM Procedure Call Standard is to be used by the compiler. At least one qualifier must be present, and there must be no space between qualifiers. The following qualifiers are permitted:
`/26«bit»`	26 bit APCS variant.
`/32«bit»`	32 bit APCS variant.
`/reent«rant»`	Reentrant APCS variant.
`/nonreent«rant»`	Non reentrant APCS variant.
`/swst«ackcheck»`	Software stack checking APCS variant.
`/noswst«ackcheck»`	No software stack checking APCS variant.
`/fp`	Use a dedicated frame-pointer register.
`/nofp`	Do not use a frame-pointer.
`/fpe2`	Floating point emulator 2 compatibility.
`/fpe3`	Floating point emulator 3 compatibility.
`/fpr«egargs»`	Floating point arguments passed in floating point registers.
`/nofpr«egargs»`	Floating point arguments are not passed in floating point registers.
`-depend` *dependfile*	Saves include file dependency lists, which are suitable for use with 'make' utilities.
`-throwback`	Equivalent to **Throwback** option icon in SetUp dialogue box; see page 24.
`-desktop` *directory*	Equivalent to **Work directory** in SetUp menu; see page 38.

Command line option	Description
`-C++`	Assume C++ code is being processed. This option is only used by the C++ program, when invoking the compiler to pre-process C++ source before translation, and when compiling the generated C. When preprocessing under the -E option, comment handling is changed to correctly deal with C++'s '`//`' comments (which are terminated by the end of the source line), and `#pragma` lines are passed through to the preprocessor output. During the C compilation stage, use of this flag disables certain warnings (most notably 'no side-effect in void context', and messages about unused variables), otherwise produced by some rather odd code constructs in the generated C. It also arranges that in any warning or error reports, the original (type-qualified) C++ source names are printed rather than the modified names CFront generates in order to implement overloading.

Preprocessor options

Command line option	Description
`-I`*`directory`*	Equivalent to **Include** option icon in SetUp dialogue box; see page 23.
`-j`*`directories`*	Equivalent to **Default path** in SetUp menu; see page 26.
`-E`	Equivalent to **Preprocess only** option icon in SetUp dialogue box; see page 24.
`-C`	Equivalent to **Keep comments** in SetUp menu; see page 27.
`-M`	If this flag is specified, only the preprocessor phase of the compiler is executed (as with `cc -E`) but the only output produced is a list, on the standard output stream, of *makefile* dependency lines suitable for use by a make utility. This can be redirected to a file using standard UNIX/MS-DOS notation. For example: `cc -M xxx.c >> Makefile.`

Command line option	Description
`-Dsymbol«=value»`	Equivalent to **Define** in SetUp menu; see page 27.
`-Usymbol`	Equivalent to **Undefine** in SetUp menu; see page 28.

Translator options

These options affect the operation of CFront.

Command line option	Description
`+v`	Print commands as CFront executes them
`+w`	Equivalent to **Suppress warnings** in C++'s SetUp menu; see page 34. (**Suppress warnings** also uses CC's `-W` option.)
`+p`	Pedantic – compile strict C++
`+g`	Equivalent to **Debug** option icon in C++'s SetUp dialogue box; see page 24. (**Debug** also uses CC's `-g` option.)
`-F`	Send CFront output to `stdout`; do not compile it

Code generation options

If you are using C++, we recommend you only use the following from the code generation options below: `-o`, `-g`, `-S` and `-zM`.

Command line option	Description
`-o file`	The argument to the -o flag gives the name of the file which will hold the final output of the compilation step. In conjunction with -c, it gives the name of the object file; in conjunction with -S, it gives the name of the assembly language file. Otherwise, it names the final output of the link step.
`-g«options»`	Equivalent to **Debug** option icon in SetUp dialogue box and **Debug options** in SetUp menu; see pages 24 and 29.
`-p«options»`	Equivalent to **Profile** in SetUp menu; see page 30.
`-S`	Equivalent to **Assembler** in SetUp menu; see page 31.
`-zM`	Equivalent to **Module code** in SetUp menu; see page 31.

Linker options

Command line option	Description
`-c`	Equivalent to **Compile only** option icon in SetUp dialogue box; see page 23.
`-llibraries`	Equivalent to **Libraries** in SetUp menu; see page 31.

Warning and error message options

If you are using C++, we recommend you only use the following from the warning and error message options below: `-W`.

Command line option	Description
`-Woptions`	Equivalent to **Suppress warnings** in SetUp menu; see page 34.
`-eoptions`	Equivalent to **Suppress errors** in SetUp menu; see page 36.

Additional feature options

If you are using C++, we recommend you only use the following from the additional feature options below: `-zr` and `-f`.

Command line option	Description
`-zpAlphaNum`	This flag can be used to emulate `#pragma` directives. The letter and digit which follow it are the same characters that would follow the '-' of a #pragma directive. See *#pragma directives* on page 86 for details.
`-zrnumber`	This flag allows the size of (most) LDMs and (all) STMs to be controlled between the limits of 3 and 16 registers transferred. This can be used to help control interrupt latency where this is critical.
`-ffeatures`	Equivalent to **Features** in SetUp menu; see page 32.

Worked examples

Several examples of C and C++ programs on the discs of Acorn C/C++ are worked through in this guide and in the *Desktop Tools* guide. A collection of examples are listed here illustrating various points and styles of working.

The following example programs are in the directory **AcornC_C++.Examples**, each in a subdirectory with the name of the example. For each program, we give a 'recipe' for how to compile, link and run the program. Filenames are given relative to the subdirectory containing each example unless otherwise stated. It is assumed that you have read the preceding parts of this chapter. For more details of the tool Make, see the chapter *Make* on page 57 of the accompanying *Desktop Tools* user guide. When you enter any command lines given below, you must first ensure that the currently-selected directory is the subdirectory containing the example being tried.

There are some further less trivial examples that we omit here. These show you how to implement more esoteric features, mainly involving interworking C and/or C++ with assembler. They are described elsewhere in the Acorn C/C++ manual set, together with necessary supporting technical information.

CHello

Purpose:	The standard most trivial C program. Try it as an exercise.
Source:	**c.HelloW**
Compile using:	default CC SetUp options
Run by:	double clicking on **HelloW**
Clean up by:	deleting **HelloW** and **o.HelloW**

C++Hello

Purpose:	The standard most trivial C++ program. Try it as an exercise.
Source:	**c++.HelloW**
Compile using:	default C++ SetUp options
Run by:	double clicking on **HelloW**
Clean up by:	deleting **HelloW** and **o.HelloW**

Sieve

Purpose:	The Sieve of Eratosthenes is often presented as a standard benchmark, though it is not very meaningful in this context.
Source:	`c.Sieve`
Compile using:	default CC SetUp options
Run by:	double clicking on `Sieve`
Clean up by:	deleting `Sieve` and `o.Sieve`

Dhrystone 2.1

Purpose:	Dhrystone 2.1 is the standard integer benchmark. Its results require careful interpretation (it often overstates the real performance of machines). Try as a first exercise in using the Make utility (!Make).

Sources:	`h.dhry`
	`c.dhry_1`
	`c.dhry_2`

Makefile:	`Makefile`
Build by:	double clicking on `Makefile`, with default Make options
Run by:	double clicking on `Dhrystone` Reply with any number in the range 20000 to 250000 to the prompt for number of iterations. Try a big number such as 200000 and time the execution with a stopwatch or sweep second hand to confirm the claimed performance. Note how performance depends on screen mode.
Rebuild by:	double clicking on `Makefile` again (try altering some of the options in `Makefile` with Make between rebuilds: eg compile in UNIX pcc mode or link with ANSILib instead of Stubs).
Clean up by:	deleting `Dhrystone`, `o.dhry_1` and `o.dhry2`.

CModule

Purpose:	To illustrate how to implement a module in C. You can also use it as another exercise in using Make. For more details on constructing relocatable modules in C see the chapter *How to write relocatable modules in* C on page 279.

Sources: `c.CModule CModuleHdr`

Build using: CC of `c.CModule` with options **Compile only** and **Module code** enabled, saving output object file as `o.CModule`. CMHG of `cmhg.CModuleHdr` to `o.CModuleHdr`. Link of `o.CModule`, `o.CModuleHdr` and `AcornC_C++.Libraries.CLib.o.Stubs` with **Module** enabled to the output file `CModule`.

or by: double clicking on `Makefile`, with default Make options.

Run from: the command line using `CModule`

Test from: the command line using:

```
help tm1
help tm2
tm1 hello
tm2 1 2 3 4 5
tm1 1 2 3
tm2 hello
```

(try other combinations too)

```
*BASIC
> SYS &88000 : REM should give an error
> SYS &88001 : REM should give divide by 0 error
> SYS &88002 : REM no error, just a message
> SYS &88003 : REM no error, just a message
> SYS &88004 : REM same as &88000...
```

(now repeat some of these after issuing some invalid * commands...)

```
>*foo
> SYS &88002
```

etc.

```
>QUIT
```

Clean up by: from the command line typing: `RMKill TestCModule` deleting `CModule`, `o.CModule` and `o.CModuleHdr` or running Make on `Makefile` with target clean selected.

Desktop application examples

The desktop applications !Hyper, !MinApp and !TBoxCalc and the various versions of SaveAs are all too complex to be described here in great detail.

They are best built by double clicking on their Makefiles. They can be run by double clicking on their application icons.

3 CMHG

CMHG (the C *Module Header Generator*) is a desktop tool which provides an easy interface to the CMHG program that Acorn C/C++ installs in your computer's library. The CMHG tool constructs command lines and passes them to the CMHG program. By using CMHG you can write a RISC OS relocatable module entirely in C without having to use ARM assembly language.

Every relocatable module has at its start (ie the part that loads into memory at its lowest address) a header table pointing to various items of data and program. Most of the items pointed to are optional, the pointers being zero if not needed. When writing a relocatable module in assembly language you lay this table out yourself, but when writing in C, you use CMHG to generate this for you. In addition to generating a module header, CMHG also inserts small standard routines to, for example, initialise the C language library support and make service call handling efficient.

To construct a relocatable module you write a number of routines in C with standard prototypes, some of these routines to be called with the processor in supervisor (SVC) mode. These are accompanied by a text description file written in a special syntax which CMHG understands. For details of this language and the specifications of the C routines, see the chapter *How to write relocatable modules in* C on page 279. For more details of relocatable module headers, see the chapter entitled *Modules* in the RISC OS 3 *Programmer's Reference Manual*. For some hints about memory usage from relocatable module code, see the RISC OS 3 *Programmer's Reference Manual*.

The rest of this chapter explains the (simple) controls of the CMHG tool. CMHG is one of the non-interactive desktop tools, its desktop user interface being provided by the FrontEnd module. It shares many common features with the other non-interactive tools. These common features are described in the chapter *General features* on page 101 of the accompanying *Desktop Tools* guide.

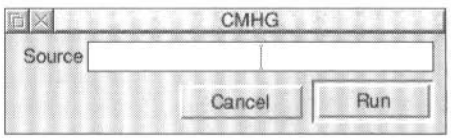
A note about Make

The Make tool (see the chapter *Make* on page 57 of the *Desktop Tools* guide) can also construct command lines for the underlying CMHG program. You'll find it a better tool for managing large projects. However, much of what is in this chapter is relevant, since Make sets options for the CMHG program with the CMHG tool's user interface.

Starting CMHG

To start the CMHG tool, first open the `AcornC_C++.Tools` directory display, then double click on !CMHG. Its icon appears on the icon bar:

Clicking Select on this icon, or dragging a CMHG description file from a directory display to this icon, brings up the **SetUp** dialogue box, from which you control the running of CMHG:

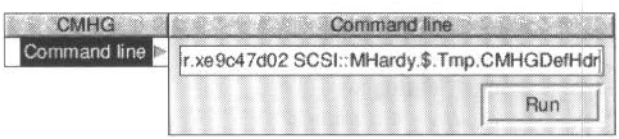


CMHG has hardly any options for its use, so its interface is simpler than most of the other Acorn C/C++ tools.

The **Source** writable icon is for the name of the description file to be processed. If you displayed the **SetUp** dialogue box by clicking on the CMHG icon bar icon, you will want to fill this in by dragging a CMHG description file from a directory display to this icon before running CMHG.

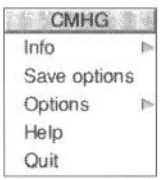
Clicking Menu on the SetUp dialogue box brings up the CMHG **SetUp** menu, which owing to the simplicity of CMHG only has a single **Command line** item:

You can get CMHG to generate a header file from the description file, which contains `#define`s of constants for the commands declared in the description file. To do so, you need to append the name of the header file to the text in the **Command line** writable icon:



The icon bar menu

Clicking Menu on the CMHG application icon on the icon bar gives access to the following options:



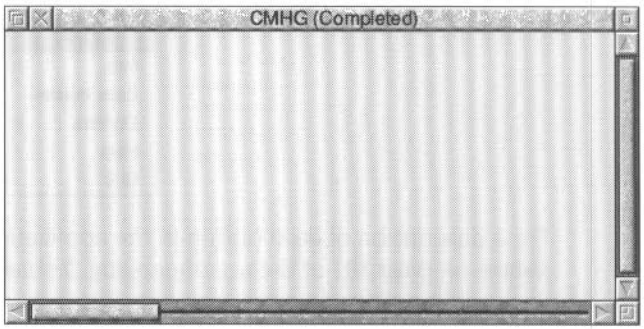
For a description of each option in the application menu see the chapter *General features* on page 101 of the accompanying *Desktop Tools* guide.

Example output

The following is an example CMHG description file, similar to that used within Acorn to construct the FrontEnd module, which is itself a relocatable module written in C:

```
; Purpose: module header for the generalised front end module ;

module-is-runnable:                                    ; module start code

initialisation-code:    FrontEnd_init

service-call-handler:   FrontEnd_services  0x11        ; service-memory

title-string:           FrontEnd

help-string:            FrontEnd  1.00

command-keyword-table:  FrontEnd_commands
                        FrontEnd_Start(min-args: 4, max-args: 5,
                                help-text: "Help text\n"),
                        FrontEnd_Setup(min-args: 8, max-args: 8,
                                help-text: "Help text\n")

swi-chunk-base-number:  0x081400
```

Running CMHG displays any error messages in the standard text output window for non-interactive tools. If all goes well, as it should do if you try CMHG with the above description file, this window is empty:



The output file produced is an object file. You link this with the object files compiled from your C code to produce your relocatable module.

Command line interface

For normal use you do not need to understand the syntax of the underlying CMHG program's command line, as it is generated automatically for you from the **SetUp** dialogue box and menu settings.

The syntax of the CMHG command line is:

`cmhg` *`descfile «objfile «defsfile»»`*

`descfile`	Filename of the CMHG description file.
`objfile`	Filename of the output object file to link with your objects to form a relocatable module.
`defs-file`	Filename of the output definitions header file, giving constants for the commands in the description file.

4 ToANSI

ToANSI is a desktop tool which provides an easy interface to the ToANSI program that Acorn C/C++ installs in your computer's library. The ToANSI tool constructs command lines and passes them to the ToANSI program. ToANSI helps convert program source written in the PCC style of C to program source in the ANSI style of C. PCC is the UNIX Portable C Compiler, and closely follows K&R C, as defined by B Kernighan and D Ritchie in their book *The C Programming Language*.

ToANSI enables you to write (with care) programs that can be automatically converted between the PCC and ANSI dialects of C, hence assisting you in constructing easily portable programs. The associated tool ToPCC makes approximately the reverse translations to ToANSI. For more details of portability issues, see the chapter *Portability* on page 259. The changes that ToANSI makes to C source are listed in the section *ToANSI C translation* below.

ToANSI is one of the non-interactive desktop tools, its desktop user interface being provided by the FrontEnd module. It shares many common features with the other non-interactive tools. These common features are described in the chapter *General features* on page 101 of the accompanying *Desktop Tools* guide.

ToANSI C translation

ToANSI makes the following transformations to C source code or header text:

- Function declarations with embedded comments are rewritten without the comment tokens. This reverses the action of ToPCC with regard to function declarations, rewriting

  ```
  type foo(/* args */);
  ```

  as

  ```
  type foo(args);
  ```

  This transformation is one which requires care in the use of ToANSI, as it can result in invalid C being uncommented.

- Function definitions of the form

  ```
  type foo(a1, a2)
  type a1;
  type a2;
  {...}
  ```

  are rewritten as

  ```
  type foo(type a1, type a2)
  ```

- A `va_alist` in the function definition is translated to

  ```
  ...
  ```

- `type foo()` is rewritten as `type foo(void)`.
- `VoidStar` (what ToPCC replaces `void *` with) is left untouched, as if it is correctly `typedef`'d to something suitable, thereafter its use is correct in both PCC and ANSI C.
- ToPCC rewrites `unsigned` and `unsigned long` constants using the typecasts `(unsigned)` and `(unsigned long)`. ToANSI does not reverse this change, as this is not required for correct ANSI C.

Note that ToANSI performs only simple textual translations and is not able to reliably diagnose C syntax errors, which may produce surprising results, so it is best to use ToANSI only on code you already know compiles.

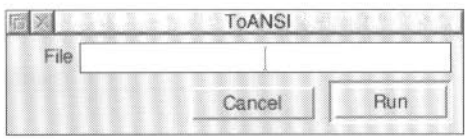
A note about Make

Since porting programs is usually a one-off process involving some experimentation, only direct use of ToANSI makes sense. You cannot use ToANSI from Make.

Starting ToANSI

To start the ToANSI tool, first open the `AcornC_C++.Tools` directory display, then double click on !ToANSI. Its icon appears on the icon bar:

Clicking Select on this icon, or dragging a source file from a directory display to this icon, brings up the **SetUp** dialogue box, from which you control the running of ToANSI:



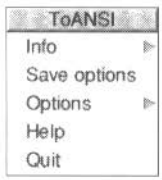
ToANSI has hardly any options for its use, so its interface is simpler than most of the other Acorn C/C++ tools.

The **File** writable icon is for the name of the description file to be processed. If you displayed the **SetUp** dialogue box by clicking on the ToANSI icon bar icon, you will want to fill this in by dragging a source file from a directory display to this icon before running ToANSI.

Clicking Menu on the SetUp dialogue box brings up the ToANSI **SetUp** menu, which owing to the simplicity of ToANSI only has a single **Command line** item:

The icon bar menu

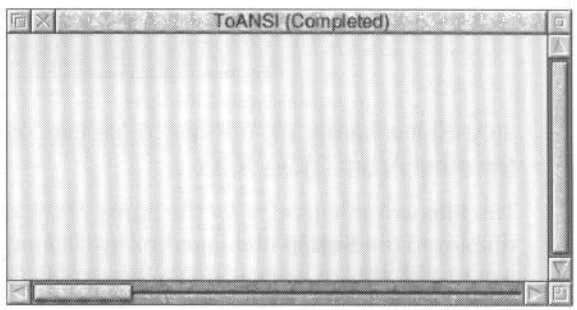
Clicking Menu on the ToANSI application icon on the icon bar gives access to the following options:



For a description of each option in the application menu see the chapter *General features* on page 101 of the accompanying *Desktop Tools* guide.

Example output

Running ToANSI displays any error messages in the standard text output window for non-interactive tools. If all goes well this window is empty:



As an example of using the tool ToANSI, open an empty SrcEdit text window and type the following example C source lines in it:

```
int foo(a, b)
float a;
double b;
{}
```

Check that your **Wimp$Scrap** environment variable is set to a sensible file name, then save your new text file straight onto the ToANSI icon bar icon. Run ToANSI, then save the output text file straight onto the SrcEdit icon bar icon. The translated file looks like:

```
int foo(float a, double b)
{}
```

Command line interface

For normal use you do not need to understand the syntax of the underlying ToANSI program's command line, as it is generated automatically for you from the **SetUp** dialogue box and menu settings.

The syntax of the ToANSI command line is:

```
toansi «options» «infile «outfile»»
```

options	Options: the **-d** option describes ToANSI, and the **-help** option gives the command line syntax and options.
infile	Filename of the input C source or header text file, which defaults to **stdin**.
outfile	Filename of the output C source or header text file, which defaults to **stdout**.

5 ToPCC

ToPCC is a desktop tool which provides an easy interface to the ToPCC program that Acorn C/C++ installs in your computer's library. The ToPCC tool constructs command lines and passes them to the ToPCC program. ToPCC helps convert program source written in the ANSI style of C to program source in the PCC style of C. PCC is the UNIX Portable C Compiler, and closely follows K&R C, as defined by B Kernighan and D Ritchie in their book *The C Programming Language*.

ToPCC enables you to write (with care) programs that can be automatically converted between the ANSI and PCC dialects of C, hence assisting you in constructing easily portable programs. The associated tool ToANSI makes approximately the reverse translations to ToPCC. For more details of portability issues, see the chapter *Portability* on page 259. The changes that ToPCC makes to C source are listed in the section *ToPCC C translation* below.

ToPCC is one of the non-interactive DDE tools, its desktop user interface being provided by the FrontEnd module. It shares many common features with the other non-interactive tools. These common features are described in the chapter *General features* on page 101 of the accompanying *Desktop Tools* guide.

ToPCC C translation

ToPCC makes the following transformations to C source code or header text:

- Function declarations of the form

  ```
  type foo(args);
  ```

  are rewritten as

  ```
  type foo(/* args */);
  ```

  Any comment tokens `/*` or `*/` in `args` are removed.

- Function definitions of the form

  ```
  type foo(type a1, type a2) {...}
  ```

  are rewritten as

  ```
  type foo(a1, a2)
  type a1;
  type a2;
  ```

- A `...` in the function `definition is interpreted as int va_alist. Full translation of variadic functions is not performed.`

- `type foo(void)`

  is rewritten as

  ```
  type foo()
  ```

- `Type void *` is converted to `VoidStar` which can be `typedef`'d to something suitable (eg `char *`).

- Unsigned and unsigned long constants are rewritten using the typecasts (unsigned) and (unsigned long).

  For example, `300ul` becomes `(unsigned long)300L`.

Note that ToPCC performs only simple textual translations and is not able to reliably diagnose C syntax errors, which may produce surprising results, so it is best to use ToPCC only on code you already know compiles.

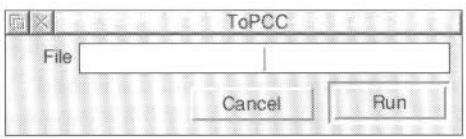
A note about Make

Since porting programs is usually a one-off process involving some experimentation, only direct use of ToPCC makes sense. You cannot use ToPCC from Make.

Starting ToPCC

To start the ToPCC tool, first open the `AcornC_C++.Tools` directory display, then double click on !ToPCC. Its icon appears on the icon bar:

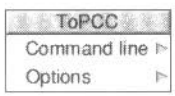
Clicking Select on this icon, or dragging a source file from a directory display to this icon, brings up the **SetUp** dialogue box, from which you control the running of ToPCC:



ToPCC has hardly any options for its use, so its interface is simpler than most of the other Acorn C/C++ tools.

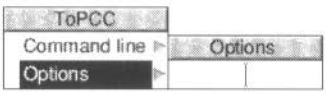
The **File** writable icon is for the name of the description file to be processed. If you displayed the **SetUp** dialogue box by clicking on the ToPCC icon bar icon, you will want to fill this in by dragging a source file from a directory display to this icon before running ToPCC.

Clicking Menu on the SetUp dialogue box brings up the ToPCC **SetUp** menu:



Command line shows you the command line that will be passed to the underlying ToPCC program; you can then alter it if necessary.

Options leads to a writable field in which you can specify one or more single letter options:

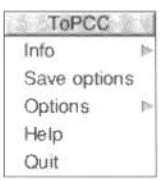


These options are:

- `c` Don't remove the keyword `const`
- `e` Don't remove `#error ...` directives
- `l` Don't remove `#line ...` directives
- `p` Don't remove `#pragma ...` directives
- `s` Don't remove keyword `signed`
- `t` Don't remove the second argument to `va_start()`
- `v` Don't remove the keyword `volatile`

The icon bar menu

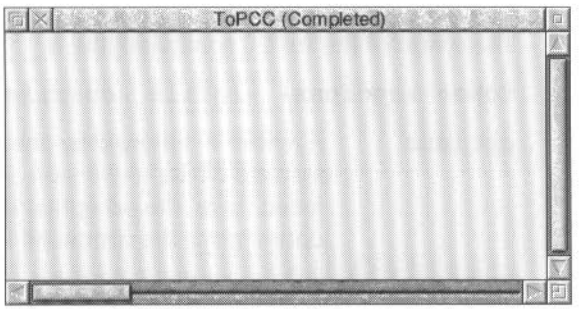
Clicking Menu on the ToPCC application icon on the icon bar gives access to the following options:



For a description of each option in the application menu see the chapter *General features* on page 101 of the accompanying *Desktop Tools* guide.

Example output

Running ToPCC displays any error messages in the standard text output window for non-interactive tools. If all goes well this window is empty:



As an example of using the tool ToPCC, open an empty SrcEdit text window and type the following example C source line in it:

```
int foo(float a);
```

Check that your **Wimp$Scrap** environment variable is set to a sensible file name, then save your new text file straight onto the ToPCC icon bar icon. Run ToPCC, then save the output text file straight onto the SrcEdit icon bar icon. The translated file looks like:

```
int foo(/* float a */);
```

Command line interface

For normal use you do not need to understand the syntax of the ToPCC command line, as it is generated automatically for you from the SetUp dialogue box setting before it is used.

The syntax of the ToPCC command line is:

`topcc «options» «infile «outfile»»`

options	A minus '**-**' followed by one or more letters controlling individual features of the conversion; see page 64. As well as the options listed there, the **-d** option describes ToPCC, and the **-help** option gives the command line syntax and options.
infile	Filename of the input C source or header text file, which defaults to **stdin**.
outfile	Filename of the output C source or header text file, which defaults to **stdout**.

Part 2 – C language issues

6 C implementation details

This chapter is split into parts, each of which details certain aspects of Acorn C's implementation of the ANSI C standard.

- The first part – *Implementation details* on page 70 – gives details of those aspects of the compiler which the ANSI standard identifies as implementation-defined, and some other points of interest to programmers. They are grouped by subject; the section *Implementation limits* on page 76 lists the points required to be documented as set out in appendix A.6 of the standard.
- The second part – *Standard implementation definition* on page 77 – discusses aspects of the compiler which are not defined by the ANSI standard, but are implementation-defined and must be documented.

  Appendix A.6 of the standard X3.159-1989 collects together information about portability issues; section A.6.3 lists those points which are implementation defined, and directs that each implementation shall document its behaviour in each of the areas listed. This part corresponds to appendix A.6.3, answering the points listed in the appendix, under the same headings and in the same order.
- The third part – *Extra features* on page 86 – describes some machine-specific features of the Acorn C compiler: `#pragma` directives, and special declaration keywords for functions and variables.

Implementation details

Identifiers

Identifiers can be of any length. They are truncated by the compiler to 256 characters, all of which are significant (the standard requires a minimum of 31).

The source character set expected by the compiler is 7 bit ASCII, except that within comments, string literals, and character constants, the full ISO 8859-1 8 bit character set is recognised. At run time, the C library processes the full ISO 8859-1 8 bit character set, except that the default locale is the C locale (see the section *Standard implementation definition* on page 77). The **ctype** functions therefore all return 0 when applied to codes in the range 160–255. By calling **setlocale(LC_CTYPE,"ISO8859-1")** you can cause the **ctype** functions such as **isupper( )** and **islower( )** to behave as expected over the full 8 bit Latin alphabet, rather than just over the 7 bit ASCII subset.

Upper and lower case characters are distinct in all identifiers, both internal and external.

In **-pcc** and **-fc** modes an identifier may also contain a dollar character.

Data elements

The sizes of data elements are as follows:

Type	Size in bits	
char	8	
short	16	
int	32	
long	32	
float	32	
double	64	
long double	64	(subject to future change)
all pointers	32	

Integers are represented in two's complement form.

Data items of type **char** are **unsigned** by default, though they may be explicitly declared as **signed char** or **unsigned char**. (In **-pcc** mode there is no **signed** keyword, so **char**s are signed by default and may be declared unsigned if required.) Single-character constants are thus always positive.

Floating point quantities are stored in the IEEE format. In double and long double quantities, the word containing the sign, the exponent and the most significant part of the mantissa is stored at the lower machine address.

Limits: `limits.h` and `float.h`

The standard defines two header files, `limits.h` and `float.h`, which contain constant declarations describing the ranges of values which can be represented by the arithmetic types. The standard also defines minimum values for many of these constants.

The following table sets out the values in these two headers on the ARM, and a brief description of their significance. See the standard for a full definition of their meanings.

Number of bits in smallest object that is not a bit field (ie a byte):

CHAR_BIT 8

Maximum number of bytes in a multibyte character, for any supported locale:

MB_LEN_MAX 1

Numeric ranges of integer types:

The middle column gives the numerical value of each range's endpoint, while the right hand column gives the bit patterns (in hexadecimal) that would be interpreted as this value in C. When entering constants you must be careful about the size and signed-ness of the quantity. Furthermore, constants are interpreted differently in decimal and hexadecimal/octal. See the ANSI standard or any of the recommended textbooks on the C programming language for more details.

Range	End-point	Hex representation
CHAR_MAX	255	0xff
CHAR_MIN	0	0x00
SCHAR_MAX	127	0x7f
SCHAR_MIN	-128	0x80
UCHAR_MAX	255	0xff
SHRT_MAX	32767	0x7fff
SHRT_MIN	-32768	0x8000
USHRT_MAX	65535	0xffff
INT_MAX	2147483647	0x7fffffff
INT_MIN	-2147483648	0x80000000
UINT_MAX	4294967295	0xffffffff
LONG_MAX	2147483647	0x7fffffff
LONG_MIN	-2147483648	0x80000000
ULONG_MAX	4294967295	0xffffffff

Characteristics of floating point:

FLT_RADIX	2
FLT_ROUNDS	1

The base (radix) of the ARM floating point number representation is 2, and floating point addition rounds to nearest.

Ranges of floating types:

FLT_MAX	3.40282347e+38F
FLT_MIN	1.17549435e-38F
DBL_MAX	1.79769313486231571e+308
DBL_MIN	2.22507385850720138e-308
LDBL_MAX	1.79769313486231571e+308
LDBL_MIN	2.22507385850720138e-308

Ranges of base two exponents:

FLT_MAX_EXP	128
FLT_MIN_EXP	(-125)
DBL_MAX_EXP	1024
DBL_MIN_EXP	(-1021)
LDBL_MAX_EXP	1024
LDBL_MIN_EXP	(-1021)

Ranges of base ten exponents:

FLT_MAX_10_EXP	38
FLT_MIN_10_EXP	(-37)
DBL_MAX_10_EXP	308
DBL_MIN_10_EX	(-307)
LDBL_MAX_10_EXP	308
LDBL_MIN_10_EXP	(-307)

Decimal digits of precision:

FLT_DIG	6
DBL_DIG	15
LDBL_DIG	15

Digits (base two) in mantissa:

`FLT_MANT_DIG`	24
`DBL_MANT_DIG`	53
`LDBL_MANT_DIG`	53

Smallest positive values such that (1.0 + x! = 1.0):

`FLT_EPSILON`	1.19209290e-7F
`DBL_EPSILON`	2.2204460492503131e-16
`LDBL_EPSILON`	2.2204460492503131e-16L

Structured data types

The standard leaves details of the layout of the components of structured data types to each implementation. The following points apply to the Acorn C compiler:

- Structures are aligned on word boundaries.
- Structures are arranged with the first-named component at the lowest address.
- A component with a **`char`** type is packed into the next available byte.
- A component with a **`short`** type is aligned to the next even-addressed byte.
- All other arithmetic type components are word-aligned, as are pointers and **`int`**s containing bitfields.
- The only valid type for bitfields are (signed) **`int`** and **`unsigned int`**. (In **`-pcc`** mode, **`char`**, **`unsigned char`**, **`short`**, **`unsigned short`**, **`long`** and **`unsigned long`** are also accepted.)
- A bitfield of type **`int`** is treated as unsigned by default (signed by default in **`-pcc`** mode).
- A bitfield must be wholly contained within the 32 bits of an **`int`**.
- Bitfields are allocated within words so that the first field specified occupies the lowest addressed bits of the word. (When configured *little-endian*, lowest addressed means least significant; when configured big-endian, lowest addressed means most significant.

Pointers

The following remarks apply to pointer types:

- Adjacent bytes have addresses which differ by one.
- The macro `NULL` expands to the value 0.
- Casting between integers and pointers results in no change of representation.
- The compiler warns of casts between pointers to functions and pointers to data (but not in `-pcc` mode).

Pointer subtraction

When two pointers are subtracted, the difference is obtained as if by the expression:

```
((int)a - (int)b) / (int)sizeof(type pointed to)
```

If the pointers point to objects whose size is no greater than four bytes, word alignment of data ensures that the division will be exact in all cases. For longer types, such as doubles and structures, the division may not be exact unless both pointers are to elements of the same array. Moreover the quotient may be rounded up or down at different times, leading to potential inconsistencies.

Arithmetic operations

The compiler performs all of the 'usual arithmetic conversions' set out in the standard.

The following points apply to operations on the integral types:

- All signed integer arithmetic uses a two's complement representation.
- Bitwise operations on signed integral types follow the rules which arise naturally from two's complement representation.
- Right shifts on signed quantities are arithmetic.
- Any quantity which specifies the amount of a shift is treated as an unsigned 8 bit value.
- Any value to be shifted is treated as a 32 bit value.
- Left shifts of more than 31 give a result of zero.
- Right shifts of more than 31 give a result of zero from a shift of an unsigned or positive signed value; they yield –1 from a shift of a negative signed value.
- The remainder on integer division has the same sign as the divisor.

- If a value of integral type is truncated to a shorter signed integral type, the result is obtained by masking the original value to the length of the destination, and then sign extending.
- Conversions between integral types never causes an exception to be raised.
- Integer overflow does not cause an exception to be raised.
- Integer division by zero causes an exception to be raised.

The following points apply to operations on floating types:

- When a `double` or `long double` is converted to a `float`, rounding is to the nearest representable value.
- Conversions from floating to integral types cause exceptions to be raised only if the value cannot be represented in a `long int` (or `unsigned long int` in the case of conversion to an `unsigned int`).
- Floating point underflow is not detected; any operation which underflows returns zero.
- Floating point overflow causes an exception to be raised.
- Floating point divide by zero causes an exception to be raised.

Expression evaluation

The compiler performs the 'usual arithmetic conversions' (promotions) set out in the standard before evaluating any expression.

- The compiler may re-order expressions involving only associative and commutative operators of equal precedence, even in the presence of parentheses (e.g. a + (b – c) may be evaluated as (a + b) – c).
- Between sequence points, the compiler may evaluate expressions in any order, regardless of parentheses. Thus the side effects of expressions between sequence points may occur in any order.
- Similarly, the compiler may evaluate function arguments in any order.
- Any detail of order of evaluation not prescribed by the standard may vary between releases of the Acorn C compiler.

Implementation limits

The standard sets out certain minimum translation limits which a conforming compiler must cope with; you should be aware of these if you are porting applications to other compilers. A summary is given here. The 'mem' limit indicates that no limit is imposed other than that of available memory.

Description	Requirement	Acorn C
Nesting levels of compound statements and iteration/selection control structures	15	mem
Nesting levels of conditional compilation	8	mem
Declarators modifying a basic type	31	mem
Expressions nested by parentheses	32	mem
Significant characters		
in internal identifiers and macro names	31	256
in external identifiers	6	256
External identifiers in one source file	511	mem
Identifiers with block scope in one block	127	mem
Macro identifiers in one source file	1024	mem
Parameters in one function definition/call	31	mem
Parameters in one macro definition/invocation	31	mem
Characters in one logical source line	509	no limit
Characters in a string literal	509	mem
Bytes in a single object	32767	mem
Nesting levels for #included files	8	mem
Case labels in a `switch` statement	257	mem
Members in a single `struct` or `union`, enumeration constants in a single `enum`	127	mem
Nesting of struct/union in a single declaration	15	mem

Standard implementation definition

Translation (A.6.3.1)

Diagnostic messages produced by the compiler are of the form

`"source-file", line #: severity: explanation`

where *`severity`* is one of

- *warning*: not a diagnostic in the ANSI sense, but an attempt by the compiler to be helpful to you.
- *error*: a violation of the ANSI specification from which the compiler was able to recover by guessing your intentions.
- *serious error*: a violation of the ANSI specification from which no recovery was possible because the compiler could not reliably guess what you intended.
- *fatal* (for example, 'not enough memory'): not really a diagnostic, but an indication that the compiler's limits have been exceeded or that the compiler has detected a fault in itself.

Environment (A.6.3.2)

The mapping of a command line from the ARM-based environment into arguments to **`main()`** is implementation-specific. The shared C library supports the following:

- The arguments given to **`main()`** are the words of the *command line* (not including I/O redirections, covered below), delimited by white space, except where the white space is contained in double quotes. A white space character is any character of which **`isspace`** is true. (Note that the RISC OS Command Line Interpreter filters out some of these).

  A double quote or backslash character (\) inside double quotes must be preceded by a backslash character. An I/O redirection will not be recognised inside double quotes.

The shared C library supports a pair of *interactive devices*, both called **`:tt`**, that handle the keyboard and the VDU screen:

- No buffering is done on any stream connected to **`:tt`** unless I/O redirection has taken place. If I/O redirection other than to **`:tt`** has taken place, full file buffering is used except where both **`stdout`** and **`stderr`** have been redirected to the same file, in which case line buffering is used.

Using the shared C library, the standard input, output and error streams, **stdin**, **stdout**, and **stderr** can be redirected at runtime in the ways shown below. For example, if **mycopy** is a compiled and linked program which simply copies the standard input to the standard output, the following line:

```
*mycopy < infile > outfile 2> errfile
```

runs the program, redirecting **stdin** to the file **infile**, **stdout** to the file **outfile** and **stderr** to the file **errfile**.

The following shows the allowed redirections:

`0< filename`	read **stdin** from *filename*
`< filename`	read **stdin** from *filename*
`1> filename`	write **stdout** to *filename*
`> filename`	write **stdout** to *filename*
`2> filename`	write **stderr** to *filename*
`2>&1`	write **stderr** to wherever **stdout** is currently going
`>& filename`	write both **stdout** and **stderr** to *filename*
`>> filename`	append **stdout** to *filename*
`>>& filename`	append both **stdout** and **stderr** to *filename*
`1>&2`	write **stdout** to wherever **stderr** is currently going

Identifiers (A.6.3.3)

256 characters are significant in identifiers without external linkage. (Allowed characters are letters, digits, and underscores.)

256 characters are significant in identifiers with external linkage. (Allowed characters are letters, digits, and underscores.)

Case distinctions are significant in identifiers with external linkage.

In **-pcc** and **-fc** modes, the character '$' is also valid in identifiers.

Characters (A.6.3.4)

The characters in the source character set are ISO 8859-1 (Latin-1 Alphabet), a superset of the ASCII character set. The printable characters are those in the range 32 to 126 and 160 to 255. Any printable character may appear in a string or character constant, and in a comment.

The compiler has no support for multibyte character sets.

The ARM C library supports the ISO 8859-1 (Latin-1) character set, so the following points hold:

- The execution character set is identical to the source character set.
- There are four `char`s/bytes in an `int`. If the ARM processor is configured to operate with a *little-endian* memory system (as in RISC OS), the bytes are ordered from least significant at the lowest address to most significant at the highest address. If the ARM is configured to operate with a *big-endian* memory system, the bytes are ordered from least significant at the highest address to most significant at the lowest address.
- A character constant containing more than one character has the type `int`. Up to four characters of the constant are represented in the integer value. The first character contained in the constant occupies the lowest-addressed byte of the integer value; up to three following characters are placed at ascending addresses. Unused bytes are filled with the `NULL` (or `/0`) character.
- There are eight bits in a character in the execution character set.
- All integer character constants that contain a single character or character escape sequence are represented in the source and execution character set.
- Characters of the source character set in string literals and character constants map identically into the execution character set.
- No locale is used to convert multibyte characters into the corresponding wide characters (codes) for a wide character constant.
- A plain `char` is treated as unsigned (but as signed in `-pcc` mode).
- Escape codes are:

Escape sequence	Char value	Description
`\a`	7	Attention (bell)
`\b`	8	Backspace
`\f`	12	Form feed
`\n`	10	Newline
`\r`	13	Carriage return
`\t`	9	Tab
`\v`	11	Vertical tab
`\x`*nn*	0x*nn*	ASCII code in hexadecimal
`\`*nnn*	0*nnn*	ASCII code in octal

Integers (A.6.3.5)

The representations and sets of values of the integral types are set out in the section *Data elements* on page 70. Note also that:

- The result of converting an integer to a shorter signed integer, if the value cannot be represented, is as if the bits in the original value which cannot be represented in the final value are masked out, and the resulting integer sign-extended. The same applies when you convert an unsigned integer to a signed integer of equal length.
- Bitwise operations on signed integers yield the expected result given two's complement representation. No sign extension takes place.
- The sign of the remainder on integer division is the same as defined for the function `div()`.
- Right shift operations on signed integral types are arithmetic.

Floating point (A.6.3.6)

The representations and ranges of values of the floating point types have been given in the section *Data elements* on page 70. Note also that:

- When a floating point number is converted to a shorter floating point one, it is rounded to the nearest representable number.
- The properties of floating point arithmetic accord with IEEE 754.

Arrays and pointers (A.6.3.7)

The ANSI standard specifies three areas in which the behaviour of arrays and pointers must be documented. The points to note are:

- The type `size_t` is defined as `unsigned int`.
- Casting pointers to integers and vice versa involves no change of representation. Thus any integer obtained by casting from a pointer will be positive.
- The type `ptrdiff_t` is defined as `(signed) int`.

Registers (A.6.3.8)

In the Acorn C compiler, you can declare any number of objects to have the storage class **register**. Depending on which variant of the ARM Procedure Call Standard is in use, there are between five and seven registers available. (There are six available in the default APCS variant, as used by RISC OS.) Declaring more than this number of objects with register storage class must result in at least one of them not being held in a register. It is advisable to declare no more than four. The valid types are:

- any integer type
- any pointer type
- any integer-like structure (any one word struct or union in which all addressable fields have the same address, or any one word structure containing only bitfields).

Note that other variables, not declared with the **register** storage class, may be held in registers for extended periods; and that **register** variables may be held in memory for some periods.

Note also that there is a **#pragma** which assigns a file-scope variable to a specified register everywhere within a compilation unit.

Structures, unions, enumerations and bitfields (A.6.3.9)

The Acorn C compiler handles structures in the following way:

- When a member of a union is accessed using a member of a different type, the resulting value can be predicted from the representation of the original type. No error is given.
- Structures are aligned on word boundaries. Characters are aligned in bytes, shorts on even numbered byte boundaries and all other types, except bitfields, are aligned on word boundaries. Bitfields are subfields of **int**s, themselves aligned on word boundaries.
- A 'plain' bitfield (declared as **int**) is treated as **unsigned int** (**signed int** in **-pcc** mode).
- A bitfield which does not fit into the space remaining in the current **int** is placed in the next **int**.
- The order of allocation of bitfields within **int**s is such that the first field specified occupies the lowest addressed bits of the word.
- Bitfields do not straddle storage unit (**int**) boundaries.
- The integer type chosen to represent the values of an enumeration type is **int** (**signed int**).

Qualifiers (A.6.3.10)

An object that has `volatile`-qualified type is *accessed* if any word or byte of it is read or written. For `volatile`-qualified objects, reads and writes occur as directly implied by the source code, in the order implied by the source code.

The effect of accessing a `volatile`-qualified `short` is undefined.

Declarators (A.6.3.11)

The number of declarators that may modify an arithmetic, structure or union type is limited only by available memory.

Statements (A.6.3.12)

The number of `case` values in a `switch` statement is limited only by memory.

Preprocessing directives (A.6.3.13)

A single-character constant in a preprocessor directive cannot have a negative value.

The standard header files are contained within the compiler itself. The mechanism for translating the standard suffix notation to an Acorn filename is described in the chapter CC *and* C++ on page 11.

Quoted names for includable source files are supported. The rules for directory searching are given in the chapter CC *and* C++ on page 11.

The recognized `#pragma` directives and their meaning are described in the section *#pragma directives* on page 86.

The date and time of translation are always available, so __DATE__ and __TIME__ always give respectively the date and time.

Library functions (A.6.3.14)

The C library has or supports the following features:

- The macro `NULL` expands to the integer constant 0.
- If a program redefines a reserved external identifier, then an error may occur when the program is linked with the standard libraries. If it is not linked with standard libraries, then no error will be detected.

- The **assert()** function prints the following message:
  *** assertion failed: *expression*, file *filename*, line, *line-number*
  and then calls the function **abort()**.
- The functions **isalnum()**, **isalpha()**, **iscntrl()**, **islower()**, **isprint()**, **isupper()** and **ispunct()** usually test only for characters whose values are in the range 0 to 127 (inclusive). Characters with values greater than 127 return a result of 0 for all of these functions, except **iscntrl()** which returns non-zero for 0 to 31, and 128 to 255.

After the call **setlocale(LC_CTYPE,"ISO8859-1")** the following statements also apply to character codes and affect the results returned by the *ctype* functions:

- codes 128 to 159 are control characters
- codes 192 to 223 except 215 are upper case
- codes 224 to 255 except 247 are lower case
- codes 160 to 191, 215 and 247 are punctuation

The mathematical functions return the following values on domain errors:

Function	Condition	Returned value
log(x)	x <= 0	-HUGE_VAL
log10(x)	x <= 0	-HUGE_VAL
sqrt(x)	x < 0	-HUGE_VAL
atan2(x,y)	x = y = 0	-HUGE_VAL
asin(x)	abs(x) > 1	-HUGE_VAL
acos(x)	abs(x) > 1	-HUGE_VAL

Where **-HUGE_VAL** is written above, a number is returned which is defined in the header **h.math**. Consult the **errno** variable for the error number.

The mathematical functions set **errno** to **ERANGE** on underflow range errors.

A domain error occurs if the second argument of **fmod** is zero, and **-HUGE_VAL** returned.

The set of signals for the generic **signal()** function is as follows:

SIGABRT	Abort
SIGFPE	Arithmetic exception
SIGILL	Illegal instruction
SIGINT	Attention request from user
SIGSEGV	Bad memory access
SIGTERM	Termination request
SIGSTAK	Stack overflow

The default handling of all recognised signals is to print a diagnostic message and call **exit**. This default behaviour applies at program start-up.

When a signal occurs, if **func** points to a function, the equivalent of `signal(sig, SIG_DFL);` is first executed.

If the **SIGILL** signal is received by a handler specified to the signal function, the default handling is reset.

The C library also has the following characteristics relating to I/O:

- The last line of a text stream does not require a terminating newline character.
- Space characters written out to a text stream immediately before a newline character do appear when read back in.
- No null characters are appended to a binary output stream.
- The file position indicator of an append mode stream is initially placed at the end of the file.
- A write to a text stream does not cause the associated file to be truncated beyond that point.
- The characteristics of file buffering are as intended by section 4.9.3 of the standard.
- A zero-length file (on which no characters have been written by an output stream) does exist.
- The validity of filenames is defined by the host computer's filing system.
- The same file can be opened many times for reading, but only once for writing or updating. A file cannot however be open for reading on one stream and for writing or updating on another.

Note also the following points about library functions:

`remove()`	Cannot remove an open file.
`rename()`	The effect of calling the `rename()` function when the new name already exists is dependent on the host filing system. Not all renames are valid: examples of invalid renames include `("net:file1","net:$.file2")` and `("net:file1","adfs:file2")`.
`fprintf()`	Prints `%p` arguments in hexadecimal format (lower case) as if a precision of 8 had been specified. If the variant form (`%#p`) is selected, the number is preceded by the character `@`.
`fscanf()`	Treats `%p` arguments identically to `%x` arguments. Always treats the character – in a `%[` argument as a literal character.
`ftell()` and `fgetpos()`	Set **errno** to the value of EDOM on failure.

`perror()` Generates the following messages:

Error:	Message:
0	No error (`errno` = 0)
EDOM	EDOM – function argument out of range
ERANGE	ERANGE – function result not representable
ESIGNUM	ESIGNUM – illegal signal number to signal() or raise()
others	Error code **number** has no associated message

`calloc()`, `malloc()` and `realloc()` If the size of the area requested is zero, `NULL` is returned under RISC OS 3.10, and non-`NULL` is returned under RISC OS 3.50..

`abort()` Closes all open files, and deletes all temporary files.

`exit()` The status returned by `exit` is the same value that was passed to it. For a definition of `EXIT_SUCCESS` and `EXIT_FAILURE` refer to the header file `stdlib.h`.

`getenv()` Returns the value of the named RISC OS Environmental variable, or `NULL` if the variable had no value. For example:

```
root = getenv ("C$libroot");
if (root == NULL) root = "$.arm.clib";
```

`system()` Used either to `CHAIN` to another application or built-in command or to `CALL` one as a sub-program. When a program is chained, all trace of the original program is removed from memory and the chained program invoked. If a program is called (which is the default if no `CHAIN:` or `CALL:` precedes the program name – a change from Release 2), the calling program and data are moved in memory to somewhere safe and the callee loaded and started up. The return value from the `system()` call is `-2` (indicating a failure to invoke the program) or the value of `Sys$ReturnCode` set by the called program (0 indicates success).

`strerror()` The error messages given by this function are identical to those given by the `perror()` function.

`clock()` Returns the time taken by the program since its invocation, as indicated by the host's operating system.

Extra features

This section describes the following machine-specific features of the Acorn C compiler:

- `#pragma` directives
- special declaration keywords for functions and variables.

#pragma directives

Pragmas recognised by the compiler come in two forms:

`#pragma -letter«digit»`

and

`#pragma «no»feature-name`

A short-form pragma given without a digit resets that pragma to its default state; otherwise to the state specified.

For example:

```
#pragma -s1
#pragma nocheck_stack

#pragma -p2
#pragma profile_statements
```

The set of pragmas recognised by the compiler, together with their default settings, varies from release to release of the compiler. The current list of recognised pragmas is:

Pragma name	Short form	Short 'No' form	Command line option
`warn_implicit_fn_decls`	`a1 *`	`a0`	`-Wf`
`check_memory_accesses`	`c1`	`c0 *`	`-zpc0|1`
`warn_deprecated`	`d1 *`	`d0`	`-Wd`
`continue_after_hash_error`	`e1`	`e0 *`	
(FP *register variable*)	`f1-f4`	`f0 *`	
`include_only_once`	`i1`	`i0 *`	
`optimise_crossjump`	`j1 *`	`j0`	`-zpj0|1`
`optimise_multiple_loads`	`m1 *`	`m0`	`-zpm0|1`
`profile`	`p1`	`p0 *`	`-p`
`profile_statements`	`p2`	`p0 *`	`-px`
(*integer register variable*)	`r1-r7`	`r0 *`	

Pragma name	Short form	Short 'No' form	Command line option
check_stack	s0 *	s1	-zps0|1
force_top_level	t1	t0 *	
check_printf_formats	v1	v0 *	
check_scanf_formats	v2	v0 *	
side_effects	y0 *	y1	
optimise_cse	z1 *	z0	-zpz0|1

In each case, the default setting is starred.

You can also globally set pragmas by options set in the command line passed to the **cc** program (see the section *Command lines* on page 42); the preferred option to use is shown above. Where no option is shown for a pragma, it is because that pragma may only sensibly be used locally, and should be enabled/disabled around the particular program statements it is to affect.

Pragmas controlling the preprocessor

The pragma **continue_after_hash_error** in effect implements a **#warning** ... preprocessor directive. Pragma **include_only_once** asserts that the containing **#include** file is to be included only once, and that if its name recurs in a subsequent **#include** directive then the directive is to be ignored.

The pragma **force_top_level** asserts that the containing **#include** file should only be included at the top level of a file. A syntax error will result if the file is included, say, within the body of a function.

Pragmas controlling printf/scanf argument checking

The pragmas **check_printf_formats** and **check_scanf_formats** control whether the actual arguments to **printf** and **scanf**, respectively, are type-checked against the format designators in a literal format string.

Of course, calls using non-literal format strings cannot be checked. By default, all calls involving literal format strings are checked.

Pragmas controlling optimisation

The pragmas **optimise_crossjump**, **optimise_multiple_loads** and **optimise_cse** give fine control over where these optimisations are applied. For example, it is sometimes advantageous to disable cross-jumping (the *common tail* optimisation) in the critical loop of an interpreter; and it may be helpful in a timing loop to disable common subexpression elimination and the opportunistic optimisation of multiple load instructions to load multiples. Note that the correct

use of the `volatile` qualifier should remove most of the more obvious needs for this degree of control (and `volatile` is also available in the Acorn C compiler's `-pcc` mode unless `-strict` is specified).

By default, functions are assumed to be impure, so function invocations are not candidates for common subexpression elimination. Pragma `noside_effects` asserts that the following function declarations (until the next `#pragma side_effects`) describe pure functions, invocations of which can be common subexpressions. See also the section *__pure* on page 90.

Pragmas controlling code generation

Stack limit checking

The pragma `nocheck_stack` disables the generation of code at function entry which checks for stack limit violation. In reality there is little advantage to turning off this check: it typically costs only two instructions and two machine cycles per function call. The one circumstance in which `nocheck_stack` must be used is in writing a signal handler for the `SIGSTAK` event. When this occurs, stack overflow has already been detected, so checking for it again in the handler would result in a fatal circular recursion.

Memory access checking

The pragma check_memory_accesses instructs the compiler to precede each access to memory by a call to the appropriate one of:

`__rt_rd`*n*`chk` where *n* is 1, 2, or 4, for byte, short, or long reads (respectively)
`__rt_wr`*n*`chk` where *n* is 1, 2, or 4, for byte, short, or long writes (respectively).

Global (program-wide) register variables

The pragmas `f0-f4` and `r0-r7` have no long form counterparts. Each introduces or terminates a list of `extern`, file-scope variable declarations. Each such declaration declares a name for the **same** register variable. For example:

```
#pragma r1              /* 1st global register */
extern int *sp;
#pragma r2              /* 2ndglobal register */
extern int *fp, *ap;    /* Synonyms */
#pragma r0              /* End of global declaration */
#pragma f1              /* 1st global FP register */
extern double pi;
#pragma f0              /* End of global declaration */
```

Any type that can be allocated to a register (see the section *Registers* (A.6.3.8) on page 81) can be allocated to a global register. Similarly, any floating point type can be allocated to a floating point register variable.

Global register r1 is the same as register v1 in the ARM Procedure Call Standard (APCS); similarly, r2 equates to v2, and so on. Depending on the APCS variant, between five and seven integer registers (v1-v7, machine registers R4-R10) and four floating point registers (F4-F7) are available as register variables. (There are six integer registers available in the default APCS variant, as used by RISC OS.) In practice it is probably unwise to use more than three global integer register variables and 2 global floating point register variables.

Provided the same declarations are made in each compilation unit, a global register variable may exist program-wide.

Otherwise, because a global register variable maps to a callee-saved register, its value will be saved and restored across a call to a function in a compilation unit which does not use it as a global register variable, such as a library function.

A corollary of the safety of direct calls out of a global-register-using compilation unit, is that calls back into it are dangerous. In particular, a global-register-using function called from a compilation unit which uses that register as a compiler allocated register, will probably read the wrong values from its supposed global register variables.

Currently, there is no link-time check that direct calls are sensible. And even if there were, indirect calls via function arguments pose a hazard which is harder to detect. This facility must be used with care. Preferably, the declaration of global register variable should be made in each compilation unit of the program. See also the section *__global_reg(n)* on page 90.

Special function declaration keywords

Several special function declaration options are available to tell the Acorn C compiler to treat that function in a special way. None of these are portable to other machines.

__value_in_regs

This allows the compiler to return a structure in registers rather than returning a pointer to the structure. For example:

```
typedef struct int64_structt {
        unsigned int lo;
        unsigned int hi;
} int 64;

__value_in_regs extern int64 mul64(unsigned a, unsigned b);
```

See the appendix ARM *procedure call standard* on page 247 of the *Desktop Tools* guide for details of the default way in which structures are passed and returned.

__pure

By default, functions are assumed to be *impure* (i.e. they have side effects), so function invocations are not candidates for common subexpression elimination. `__pure` has the same effect as pragma `noside_effects`, and asserts that the function declared is a *pure* function, invocations of which can be common subexpressions.

Special variable declaration keywords

__global_reg(*n*)

Allocates the declared variable to a global integer register variable, in the same way as `#pragma rn`. The variable must have an integral or pointer type. See also the section *Global (program-wide) register variables* on page 88.

__global_freg(*n*)

Allocates the declared variable to a global floating point register variable, in the same way as `#pragma fn`. The variable must have type float or double. See also the section *Global (program-wide) register variables* on page 88.

Note that the global register, whether specified by keyword or pragmas, must be declared in all declarations of the same variable. Thus:

```
int x;
__global_reg(1) x;
```

is an error.

7 The C library

The shared C library is a relocatable module in the RISC OS ROM. Applications which are resident in memory at the same time can share it. It provides all the standard facilities of the language, as defined by the ANSI standard document. Code using calls to the shared C library will be portable to other environments if an ANSI compiler and library are available for that environment.

C and C++ programs are linked with a small piece of code and data called **Stubs**, which itself interfaces with the shared C library. The stubs contain your program's copy of the library's data, and an *entry vector* which allows your program to locate library routines in the C library module. **Stubs** is found in the directory **AcornC_C++.Libraries.clib.o**.

Use of the shared C library:

- economises on RAM space when multiple C applications are running
- saves space on disc, benefiting users with single floppy disc drives
- makes programs load faster
- costs practically nothing at run time.
  (For example, the Dhrystone benchmark runs just as quickly using the shared C library as when linked stand-alone with ANSILib.)

Without the shared C library, it would not be possible to pack so much into Acorn C/C++.

assert.h

The **assert** macro puts diagnostics into programs. When it is executed, if its argument expression is false, it writes information about the call that failed (including the text of the argument, the name of the source file, and the source line number, the last two of these being, respectively, the values of the preprocessing macros **__FILE__** and **__LINE__**) on the standard error stream. It then calls the **abort** function. If its argument expression is true, the **assert** macro returns no value.

If **NDEBUG** is #defined prior to inclusion of **assert.h**, calls to **assert** expand to null statements. This provides a simple way to turn off the generation of diagnostics selectively.

Note that **assert.h** may be included more than once in a program with different settings of **NDEBUG**.

ctype.h

`ctype.h` declares several functions useful for testing and mapping characters. In all cases the argument is an int, the value of which is representable as an unsigned char or equal to the value of the macro EOF. If the argument has any other value, the behaviour is undefined.

`int isalnum(int c)`	Returns true if c is alphabetic or numeric
`int isalph(int c)`	Returns true if c is alphabetic
`int iscntrl(int c)`	Returns true if **c** is a control character (in the ASCII locale)
`int isdigit(int c)`	Returns true if c is a decimal digit
`int isgraph(int c)`	Returns true if **c** is any printable character other than space
`int islower(int c)`	Returns true if **c** is a lower-case letter
`int isprint(int c)`	Returns true if **c** is a printable character (in the ASCII locale this means 0x20 (space) → 0x7E (tilde) inclusive).
`int ispunct(int c)`	Returns true if **c** is a printable character other than a space or alphanumeric character
`int isspace(int c)`	Returns true if c is a white space character viz: space, newline, return, linefeed, tab or vertical tab
`int isupper(int c)`	Returns true if c is an upper-case letter
`int isxdigit(int c)`	Returns true if c is a hexadecimal digit, ie in 0...9, a...f, or A...F
`int tolower(int c)`	Forces c to lower case if it is an upper-case letter, otherwise returns the original value
`int toupper(int c)`	Forces c to upper case if it is a lower-case letter, otherwise returns the original value

errno.h

This file contains the definition of the macro **errno**, which is of type **volatile int**. It contains three macro constants defining the error conditions listed below.

EDOM

If a domain error occurs (an input argument is outside the domain over which the mathematical function is defined) the integer expression **errno** acquires the value of the macro **EDOM** and **HUGE_VAL** is returned. **EDOM** may be used by non-mathematical functions.

ERANGE

A range error occurs if the result of a function cannot be represented as a double value. If the result overflows (the magnitude of the result is so large that it cannot be represented in an object of the specified type), the function returns the value of the macro **HUGE_VAL**, with the same sign as the correct value of the function; the integer expression **errno** acquires the value of the macro **ERANGE**. If the result underflows (the magnitude of the result is so small that it cannot be represented in an object of the specified type), the function returns zero; the integer expression **errno** acquires the value of the macro **ERANGE**. **ERANGE** may be used by non-mathematical functions.

ESIGNUM

If an unrecognised signal is caught by the default signal handler, **errno** is set to **ESIGNUM**.

float.h

This file contains a set of macro constants which define the limits of computation on floating point numbers. These are discussed in the chapter C *implementation details* on page 69.

limits.h

This set of macro constants determines the upper and lower value limits for integral objects of various types, as follows:

Object type	Minimum value	Maximum value
Byte (number of bits)	0	8
Signed char	-128	127
Unsigned char	0	255
Char	0	255
Multibyte character (number of bytes)	0	1
Short int	-0x8000	0x7fff
Unsigned short int	0	65535
Int	(~0x7fffffff)	0x7fffffff
Unsigned int	0	0xffffffff
Long int	(~0x7fffffff)	0x7fffffff
Unsigned long int	0	0xffffffff

See also the chapter C *implementation details* on page 69.

locale.h

This file handles national characteristics, such as the different orderings month-day-year (USA) and day-month-year (UK).

```
char *setlocale(int category, const char *locale)
```

Selects the appropriate part of the program's locale as specified by the **category** and **locale** arguments. The **setlocale** function may be used to change or query the program's entire current locale or portions thereof. Locale information is divided into the following types:

LC_COLLATE	string collation
LC_CTYPE	character type
LC_MONETARY	monetary formatting
LC_NUMERIC	numeric string formatting
LC_TIME	time formatting
LC_ALL	entire locale

The locale string specifies which locale set of information is to be used. For example,

setlocale

```
setlocale(LC_MONETARY,"uk")
```

would insert monetary information into the **lconv** structure. To query the current locale information, set the **locale** string to null and read the string returned.

lconv

```
struct lconv *localeconv(void)
```

Sets the components of an object with type struct **lconv** with values appropriate for the formatting of numeric quantities (monetary and otherwise) according to the rules of the current locale. The members of the structure with type **char *** are strings, any of which (except **decimal_point**) can point to "", to indicate that the value is not available in the current locale or is of zero length. The members with type **char** are non-negative numbers, any of which can be **CHAR_MAX** to indicate that the value is not available in the current locale. The members included are described above.

`localeconv` returns a pointer to the filled in object. The structure pointed to by the return value will not be modified by the program, but may be overwritten by a subsequent call to the `localeconv` function. In addition, calls to the `setlocale` function with categories `LC_ALL`, `LC_MONETARY`, or `LC_NUMERIC` may overwrite the contents of the structure.

math.h

This file contains the prototypes for 22 mathematical functions. All return the type `double`.

Function	Returns
`double acos(double x)`	arc cosine of `x`. A domain error occurs for arguments not in the range –1 to 1
`double asin(double x)`	arc sine of `x`. A domain error occurs for arguments not in the range –1 to 1
`double atan(double x)`	arc tangent of `x`
`double atan2(double x, double y)`	arc tangent of `y/x`
`double cos(double x)`	cosine of `x` (measured in radians)
`double sin(double x)`	sine of `x` (measured in radians)
`double tan(double x)`	tangent of `x` (measured in radians)
`double cosh(double x)`	hyperbolic cosine of `x`
`double sinh(double x)`	hyperbolic sine of `x`
`double tanh(double x)`	hyperbolic tangent of `x`
`double exp(double x)`	exponential function of `x`
`double frexp(double x, int *exp)`	the value `x`, such that `x` is a double with magnitude in the interval 0.5 to 1.0 or zero, and value equals `x` times 2 raised to the power `*exp`
`double ldexp(double x, int exp)`	`x` times 2 raised to the power of `exp`
`double log(double x)`	natural logarithm of `x`
`double log10(double x)`	log to the base 10 of `x`
`double modf(double x, double *iptr)`	signed fractional part of `x`. Stores integer part of `x` in object pointed to by `iptr`.
`double pow(double x, double y)`	`x` raised to the power of `y`
`double sqrt(double x)`	positive square root of `x`
`double ceil(double x)`	smallest integer not less than `x` (ie rounding up)
`double fabs(double x)`	absolute value of `x`
`double floor(double x)`	largest integer not greater than `x` (ie rounding down)
`double fmod(double x, double y)`	floating-point remainder of `x/y`

setjmp.h

This file declares two functions, and one type, for bypassing the normal function call and return discipline (useful for dealing with unusual conditions encountered in a low-level function of a program). It also defines the **jmp_buf** structure type required by these routines.

setjmp

```
int setjmp(jmp_buf env)
```

The calling environment is saved in **env**, for later use by the **longjmp** function. If the return is from a direct invocation, the **setjmp** function returns the value zero. If the return is from a call to the **longjmp** function, the **setjmp** function returns a non-zero value.

longjmp

```
void longjmp(jmp_buf env, int val)
```

The environment saved in **env** by the most recent call to **setjmp** is restored. If there has been no such call, or if the function containing the call to **setjmp** has terminated execution (eg with a return statement) in the interim, the behaviour is undefined. All accessible objects have values as at the time **longjmp** was called, except that the values of objects of automatic storage duration that do not have volatile type and that have been changed between the **setjmp** and **longjmp** calls are indeterminate.

As it bypasses the usual function call and return mechanism, the **longjmp** function executes correctly in contexts of interrupts, signals and any of their associated functions. However, if the **longjmp** function is invoked from a nested signal handler (that is, from a function invoked as a result of a signal raised during the handling of another signal), the behaviour is undefined.

After **longjmp** is completed, program execution continues as if the corresponding call to **setjmp** had just returned the value specified by ***val***. The **longjmp** function cannot cause **setjmp** to return the value 0; if ***val*** is 0, **setjmp** returns the value 1.

signal.h

`Signal` declares a type `(sig_atomic_t)` and two functions.

It also defines several macros for handling various signals (conditions that may be reported during program execution). These are `SIG_DFL` (default routine), `SIG_IGN` (ignore signal routine) and `SIG_ERR` (dummy routine used to flag error return from `signal`).

```
void (*signal (int sig, void (*func)(int)))(int)
```

Think of this as

```
typedef void Handler(int);
Handler *signal(int, Handler *);
```

Chooses one of three ways in which receipt of the signal number `sig` is to be subsequently handled. If the value of `func` is `SIG_DFL`, default handling for that signal will occur. If the value of `func` is `SIG_IGN`, the signal will be ignored. Otherwise `func` points to a function to be called when that signal occurs.

When a signal occurs, if `func` points to a function, first the equivalent of `signal(sig, SIG_DFL)` is executed. (If the value of `sig` is `SIGILL`, whether the reset to `SIG_DFL` occurs is implementation-defined (under RISC OS the reset does occur)). Next, the equivalent of `(*func)(sig);` is executed. The function may terminate by calling the `abort`, `exit` or `longjmp` function. If `func` executes a return statement and the value of `sig` was `SIGFPE` or any other implementation-defined value corresponding to a computational exception, the behaviour is undefined. Otherwise, the program will resume execution at the point it was interrupted.

If the signal occurs other than as a result of calling the `abort` or `raise` function, the behaviour is undefined if the signal handler calls any function in the standard library other than the signal function itself or refers to any object with static storage duration other than by assigning a value to a volatile static variable of type `sig_atomic_t`. At program start-up, the equivalent of `signal(sig, SIG_IGN)` may be executed for some signals selected in an implementation-defined manner (under RISC OS this does not occur); the equivalent of `signal(sig, SIG_DFL)` is executed for all other signals defined by the implementation.

If the request can be honoured, the `signal` function returns the value of `func` for most recent call to `signal` for the specified signal `sig`. Otherwise, a value of `SIG_ERR` is returned and the integer expression `errno` is set to indicate the error.

raise

```
int raise(int /*sig*/)
```

Sends the signal sig to the executing program. Returns zero if successful, non-zero if unsuccessful.

stdarg.h

This file declares a type and defines three macros, for advancing through a list of arguments whose number and types are not known to the called function when it is translated. A function may be called with a variable number of arguments of differing types. Its parameter list contains one or more parameters, the rightmost of which plays a special role in the access mechanism, and will be called **parmN** in this description.

va_list

```
char *va_list[1]
```

An array type suitable for holding information needed by the macro **va_arg** and the function **va_end**. The called function declares a variable (referred to as **ap**) having type **va_list**. The variable **ap** may be passed as an argument to another function. **va_list** is an array type so that when an object of that type is passed as an argument it gets passed by reference, but this is not required by the ANSI specification and cannot be relied on.

va_start

The **va_start** macro will be executed before any access to the unnamed arguments. The parameter **ap** points to an object that has type **va_list**. The **va_start** macro initialises **ap** for subsequent use by **va_arg** and **va_end**. The parameter **parmN** is the identifier of the rightmost parameter in the variable parameter list in the function definition (the one just before the **, ...**). If the parameter **parmN** is declared with the register storage class the behaviour is undefined.

Returns: no value.

va_arg

The **va_arg** macro expands to an expression that has the type and value of the next argument in the call. The parameter **ap** is the same as the **va_list ap** initialised by **va_start**. Each invocation of **va_arg** modifies **ap** so that successive arguments are returned in turn. The parameter ***type*** is a type name such that the type of a pointer to an object that has the specified type can be obtained simply by postfixing a * to ***type***. If ***type*** disagrees with the type of the actual next argument (as promoted according to the default argument promotions), the behaviour is undefined.

Returns: The first invocation of the `va_arg` macro after that of the `va_start` macro returns the value of the argument after that specified by `parmN`. Successive invocations return the values of the remaining arguments in succession. Care is taken in `va_arg` so that illegal things like `va_arg(ap,char)` – which may seem natural but are in fact illegal – are caught. `va_arg(ap,float)` is wrong but cannot be patched up at the C macro level.

va_end

```
#define va_end(ap) ((void)(*(ap) = (char *)-256))
```

The `va_end` macro facilitates a normal return from the function whose variable argument list was referenced by the expansion of `va_start` that initialised the `va_list ap`. If the `va_end` macro is not invoked before the return, the behaviour is undefined.

stddef.h

This file contains a macro for calculating the offset of fields within a structure. It also defines the pointer constant NULL and three types.

`ptrdiff_t(here int)` — the signed integral type of the result of subtracting two pointers

`size_t(here unsigned int)` — the unsigned integral type of the result of the **`sizeof`** operator

`wchar_t(here int)` — also in **`stdlib.h`**. An integral type whose range of values can represent distinct codes for all members of the largest extended character set specified among the supported locales; the null character has the code value zero and each member of the basic character set has a code value when used as the lone character in an integer character constant.

`size_t offsetof(type, member)` Expands to an integral constant expression that has type **`size_t`**, the value of which is the offset in bytes from the beginning of a structure designated by **`type`**, of the member designated by **`member`** (if the specified member is a bit-field, the behaviour is undefined).

stdio.h

stdio declares two types, several macros, and many functions for performing input and output. For a discussion on Streams and Files refer to sections 4.9.2 and 4.9.3 in the ANSI standard or to one of the other references given in the *Introduction* to this Guide.

`fpos_t` — `fpos_t` is an object capable of recording all information needed to specify uniquely every position within a file.

`FILE` — is an object capable of recording all information needed to control a stream, such as its file position indicator, a pointer to its associated buffer, an error indicator that records whether a read/write error has occurred and an end-of-file indicator that records whether the end-of-file has been reached. The objects contained in the `#ifdef __system_io` clause are for system use only, and cannot be relied on between releases of C.

remove

```
int remove(const char * filename)
```

Causes the file whose name is the string pointed to by ***filename*** to be removed. Subsequent attempts to open the file will fail, unless it is created anew. If the file is open, the behaviour of the **remove** function is implementation-defined (under RISC OS the operation fails).

Returns: zero if the operation succeeds, non-zero if it fails.

rename

```
int rename(const char * old, const char * new)
```

Causes the file whose name is the string pointed to by ***old*** to be henceforth known by the name given by the string pointed to by ***new***. The file named ***old*** is effectively removed. If a file named by the string pointed to by ***new*** exists prior to the call of the **rename** function, the behaviour is implementation-defined (under RISC OS, the operation fails).

Returns: zero if the operation succeeds, non-zero if it fails, in which case if the file existed previously it is still known by its original name.

tmpfile

```
FILE *tmpfile(void)
```

Creates a temporary binary file that will be automatically removed when it is closed or at program termination. The file is created if possible in **Wimp$ScrapDir**, or failing that, in the directory **$.tmp**; it is then opened for update.

Returns: a pointer to the stream of the file that it created. If the file cannot be created, a null pointer is returned.

tmpnam

```
char *tmpnam(char * s)
```

Generates a string that is not the same as the name of an existing file. The **tmpnam** function generates a different string each time it is called, up to **TMP_MAX** times. If it is called more than **TMP_MAX** times, the behaviour is implementation-defined (under RISC OS the algorithm for the name generation works just as well after **tmpnam** has been called more than **TMP_MAX** times as before; a name clash is impossible in any single half year period).

Returns: If the argument is a null pointer, the **tmpnam** function leaves its result in an internal static object and returns a pointer to that object. Subsequent calls to the **tmpnam** function may modify the same object. If the argument is not a null pointer, it is assumed to point to an array of at least **L_tmpnam** characters; the **tmpnam** function writes its result in that array and returns the argument as its value.

fclose

```
int fclose(FILE * stream)
```

Causes the stream pointed to by ***stream*** to be flushed and the associated file to be closed. Any unwritten buffered data for the stream are delivered to the host environment to be written to the file; any unread buffered data are discarded. The stream is disassociated from the file. If the associated buffer was automatically allocated, it is deallocated.

Returns: zero if the stream was successfully closed, or EOF if any errors were detected or if the stream was already closed.

fflush

```
int fflush(FILE * stream)
```

If the stream points to an output or update stream in which the most recent operation was output, the **fflush** function causes any unwritten data for that stream to be delivered to the host environment to be written to the file. If the stream points to an input or update stream, the **fflush** function undoes the effect of any preceding **ungetc** operation on the stream.

Returns: EOF if a write error occurs.

fopen

```
FILE *fopen(const char * filename, const char * mode)
```

Opens the file whose name is the string pointed to by ***filename***, and associates a stream with it. The argument ***mode*** points to a string beginning with one of the following sequences:

r	open text file for reading
w	create text file for writing, or truncate to zero length
a	append; open text file or create for writing at eof
rb	open binary file for reading
wb	create binary file for writing, or truncate to zero length
ab	append; open binary file or create for writing at eof
r+	open text file for update (reading and writing)
w+	create text file for update, or truncate to zero length
a+	append; open text file or create for update, writing at eof
r+b or rb+	open binary file for update (reading and writing)
w+b or wb+	create binary file for update, or truncate to zero length
a+b or ab+	append; open binary file or create for update, writing at eof

- Opening a file with read mode (**r** as the first character in the ***mode*** argument) fails if the file does not exist or cannot be read.
- Opening a file with append mode (**a** as the first character in the ***mode*** argument) causes all subsequent writes to be forced to the current end of file, regardless of intervening calls to the **fseek** function.
- In some implementations, opening a binary file with append mode (**b** as the second or third character in the ***mode*** argument) may initially position the file position indicator beyond the last data written, because of null padding (but not under RISC OS).

- When a file is opened with update mode (+ as the second or third character in the *mode* argument), both input and output may be performed on the associated stream. However, output may not be directly followed by input without an intervening call to the **fflush** function or to a file positioning function (**fseek**, **fsetpos**, or **rewind**), nor may input be directly followed by output without an intervening call to the **fflush** function or to a file positioning function, unless the input operation encounters end-of-file.
- Opening a file with update mode may open or create a binary stream in some implementations (but not under RISC OS). When opened, a stream is fully buffered if and only if it does not refer to an interactive device. The error and end-of-file indicators for the stream are cleared.

Returns: a pointer to the object controlling the stream. If the open operation fails, **fopen** returns a null pointer.

freopen

```
FILE *freopen(const char * filename, const char * mode,
     FILE * stream)
```

Opens the file whose name is the string pointed to by ***filename*** and associates the stream pointed to by ***stream*** with it. The ***mode*** argument is used just as in the **fopen** function. The **freopen** function first attempts to close any file that is associated with the specified stream. Failure to close the file successfully is ignored. The error and end-of-file indicators for the stream are cleared.

Returns: a null pointer if the operation fails. Otherwise, **freopen** returns the value of the stream.

setbuf

```
void setbuf(FILE * stream, char * buf)
```

Except that it returns no value, the **setbuf** function is equivalent to the **setvbuf** function invoked with the values _IOFBF for ***mode*** and BUFSIZ for ***size***, or if ***buf*** is a null pointer, with the value _IONBF for ***mode***.

Returns: no value.

setvbuf

```
int setvbuf(FILE * stream, char * buf, int mode, size_t
    size)
```

This may be used after the stream pointed to by ***stream*** has been associated with an open file but before it is read or written. The argument ***mode*** determines how ***stream*** will be buffered, as follows:

- _IOFBF causes input/output to be fully buffered.
- _IOLBF causes output to be line buffered (the buffer will be flushed when a newline character is written, when the buffer is full, or when interactive input is requested).
- _IONBF causes input/output to be completely unbuffered.

If ***buf*** is not the null pointer, the array it points to may be used instead of an automatically allocated buffer (the buffer must have a lifetime at least as great as the open stream, so the stream should be closed before a buffer that has automatic storage duration is deallocated upon block exit). The argument ***size*** specifies the size of the array. The contents of the array at any time are indeterminate. ***buf*** must be non-null.

Returns: zero on success, or non-zero if an invalid value is given for mode or size, or if the request cannot be honoured.

fprintf

```
int fprintf(FILE * stream, const char * format, ...)
```

writes output to the stream pointed to by ***stream***, under control of the string pointed to by ***format*** that specifies how subsequent arguments are converted for output. If there are insufficient arguments for the format, the behaviour is undefined. If the format is exhausted while arguments remain, the excess arguments are evaluated but otherwise ignored. The **fprintf** function returns when the end of the format string is reached. The format must be a multibyte character sequence, beginning and ending in its initial shift state (in all locales supported under RISC OS this is the same as a plain character string). The format is composed of zero or more directives: ordinary multibyte characters (not %), which are copied unchanged to the output stream; and conversion specifiers, each of which results in fetching zero or more subsequent arguments. Each conversion specification is introduced by the character %. For a complete description of the available conversion specifiers refer to section 4.9.6.1 in the ANSI standard or to one of the other references in the *Introduction* to this Guide. The minimum value for the maximum number of characters that can be produced by any single conversion is at least 509.

A brief and incomplete description of conversion specifications is:

`[flags][field width][.precision]specifier-char`

flags is most commonly -, indicating left justification of the output item within the field. If omitted, the item will be right justified.

field width is the minimum width of field to use. If the formatted item is longer, a bigger field will be used; otherwise, the item will be right (left) justified in the field.

precision is the minimum number of digits to print for a d, i, o, u, x or X conversion, the number of digits to appear after the decimal digit for **e**, E and f conversions, the maximum number of significant digits for g and G conversions, or the maximum number of characters to be written from strings in an s conversion.

Either or both of *field width* and *precision* may be *, indicating that the value is an argument to **printf**.

The *specifier chars* are:

d, i	int printed as signed decimal
o, u, x, X	unsigned int value printed as unsigned octal, decimal or hexadecimal
f	double value printed in the style [-]ddd.ddd
e, E	double value printed in the style [-]d.ddd...e dd
g, G	double printed in f or e format, whichever is more appropriate
c	int value printed as unsigned char
s	char * value printed as a string of characters
p	void * argument printed as a hexadecimal address
%	write a literal %

Returns: the number of characters transmitted, or a negative value if an output error occurred.

printf

```
int printf(const char * format, ...)
```

Equivalent to **fprintf** with the argument **stdout** interposed before the arguments to **printf**.

Returns: the number of characters transmitted, or a negative value if an output error occurred.

sprintf

```
int sprintf(char * s, const char * format, ...)
```

Equivalent to **fprintf**, except that the argument ***s*** specifies an array into which the generated output is to be written, rather than to a stream. A null character is written at the end of the characters written; it is not counted as part of the returned sum.

Returns: the number of characters written to the array, not counting the terminating null character.

fscanf

```
int fscanf(FILE * stream, const char * format, ...)
```

Reads input from the stream pointed to by ***stream***, under control of the string pointed to by ***format*** that specifies the admissible input sequences and how they are to be converted for assignment, using subsequent arguments as pointers to the objects to receive the converted input. If there are insufficient arguments for the format, the behaviour is undefined. If the format is exhausted while arguments remain, the excess arguments are evaluated but otherwise ignored. The format is composed of zero or more directives, one or more white-space characters, an ordinary character (not %), or a conversion specification. Each conversion specification is introduced by the character %. For a description of the available conversion specifiers refer to section 4.9.6.2 in the ANSI standard, or to any of the references listed in the chapter *Introduction* on page 1. A brief list is given above, under the entry for **fprintf**.

If end-of-file is encountered during input, conversion is terminated. If end-of-file occurs before any characters matching the current directive have been read (other than leading white space, where permitted), execution of the current directive terminates with an input failure; otherwise, unless execution of the current directive is terminated with a matching failure, execution of the following directive (if any) is terminated with an input failure.

If conversions terminate on a conflicting input character, the offending input character is left unread in the input stream. Trailing white space (including newline characters) is left unread unless matched by a directive. The success of literal matches and suppressed assignments is not directly determinable other than via the %n directive.

Returns: the value of the macro EOF if an input failure occurs before any conversion. Otherwise, the **fscanf** function returns the number of input items assigned, which can be fewer than provided for, or even zero, in the event of an early conflict between an input character and the format.

scanf

```
int scanf(const char * format, ...)
```

Equivalent to **fscanf** with the argument **stdin** interposed before the arguments to **scanf**.

Returns: the value of the macro EOF if an input failure occurs before any conversion. Otherwise, the **scanf** function returns the number of input items assigned, which can be fewer than provided for, or even zero, in the event of an early matching failure.

sscanf

```
int sscanf(const char * s, const char * format, ...)
```

Equivalent to **fscanf** except that the argument ***s*** specifies a string from which the input is to be obtained, rather than from a stream. Reaching the end of the string is equivalent to encountering end-of-file for the **fscanf** function.

Returns: the value of the macro EOF if an input failure occurs before any conversion. Otherwise, the **scanf** function returns the number of input items assigned, which can be fewer than provided for, or even zero, in the event of an early matching failure.

vprintf

```
int vprintf(const char * format, va_list arg)
```

Equivalent to **printf**, with the variable argument list replaced by **arg**, which has been initialised by the **va_start** macro (and possibly subsequent **va_arg** calls). The **vprintf** function does not invoke the **va_end** function.

Returns: the number of characters transmitted, or a negative value if an output error occurred.

vfprintf

```
int vfprintf(FILE * stream,const char * format, va_list
    arg)
```

Equivalent to **fprintf**, with the variable argument list replaced by ***arg***, which has been initialised by the **va_start** macro (and possibly subsequent **va_arg** calls). The **vfprintf** function does not invoke the **va_end** function.

Returns: the number of characters transmitted, or a negative value if an output error occurred.

vsprintf

```
int vsprintf(char * s, const char * format, va_list arg)
```

Equivalent to **sprintf**, with the variable argument list replaced by ***arg***, which has been initialised by the **va_start** macro (and possibly subsequent **va_arg** calls). The **vsprintf** function does not invoke the **va_end** function.

Returns: the number of characters written in the array, not counting the terminating null character.

fgetc

```
int fgetc(FILE * stream)
```

Obtains the next character (if present) as an unsigned char converted to an int, from the input stream pointed to by ***stream***, and advances the associated file position indicator (if defined).

Returns: the next character from the input stream pointed to by ***stream***. If the stream is at end-of-file, the end-of-file indicator is set and **fgetc** returns EOF. If a read error occurs, the error indicator is set and **fgetc** returns EOF.

fgets

```
char *fgets(char * s, int n, FILE * stream)
```

Reads at most one less than the number of characters specified by ***n*** from the stream pointed to by ***stream*** into the array pointed to by ***s***. No additional characters are read after a newline character (which is retained) or after end-of-file. A null character is written immediately after the last character read into the array.

Returns: ***s*** if successful. If end-of-file is encountered and no characters have been read into the array, the contents of the array remain unchanged and a null pointer is returned. If a read error occurs during the operation, the array contents are indeterminate and a null pointer is returned.

fputc

```
int fputc(int c, FILE * stream)
```

Writes the character specified by ***c*** (converted to an unsigned char) to the output stream pointed to by ***stream***, at the position indicated by the associated file position indicator (if defined), and advances the indicator appropriately. If the file cannot support positioning requests, or if the stream was opened with append mode, the character is appended to the output stream.

Returns: the character written. If a write error occurs, the error indicator is set and **fputc** returns EOF.

fputs

```
int fputs(const char * s, FILE * stream)
```

Writes the string pointed to by ***s*** to the stream pointed to by ***stream***. The terminating null character is not written.

Returns: EOF if a write error occurs; otherwise it returns a non-negative value.

getc

```
int getc(FILE * stream)
```

Equivalent to **fgetc** except that it may be (and is under RISC OS) implemented as a macro. ***stream*** may be evaluated more than once, so the argument should never be an expression with side effects.

Returns: the next character from the input stream pointed to by ***stream***. If the stream is at end-of-file, the end-of-file indicator is set and **getc** returns EOF. If a read error occurs, the error indicator is set and **getc** returns EOF.

getchar

```
int getchar(void)
```

Equivalent to **getc** with the argument **stdin**.

Returns: the next character from the input stream pointed to by **stdin**. If the stream is at end-of-file, the end-of-file indicator is set and **getchar** returns EOF. If a read error occurs, the error indicator is set and **getchar** returns EOF.

gets

```
char *gets(char * s)
```

Reads characters from the input stream pointed to by **stdin** into the array pointed to by ***s***, until end-of-file is encountered or a newline character is read. Any newline character is discarded, and a null character is written immediately after the last character read into the array.

Returns: ***s*** if successful. If end-of-file is encountered and no characters have been read into the array, the contents of the array remain unchanged and a null pointer is returned. If a read error occurs during the operation, the array contents are indeterminate and a null pointer is returned.

putc

```
int putc(int c, FILE * stream)
```

Equivalent to **fputc** except that it may be (and is under RISC OS) implemented as a macro. ***stream*** may be evaluated more than once, so the argument should never be an expression with side effects.

Returns: the character written. If a write error occurs, the error indicator is set and **putc** returns **EOF**.

putchar

```
int putchar(int c)
```

Equivalent to **putc** with the second argument **stdout**.

Returns: the character written. If a write error occurs, the error indicator is set and **putc** returns **EOF**.

puts

```
int puts(const char * s)
```

Writes the string pointed to by ***s*** to the stream pointed to by ***stdout***, and appends a newline character to the output. The terminating null character is not written.

Returns: **EOF** if a write error occurs; otherwise it returns a non-negative value.

ungetc

```
int ungetc(int c, FILE * stream)
```

Pushes the character specified by ***c*** (converted to an unsigned char) back onto the input stream pointed to by **stream**. The character will be returned by the next read on that stream. An intervening call to the **fflush** function or to a file positioning function (**fseek**, **fsetpos**, **rewind**) discards any pushed-back characters. The external storage corresponding to the stream is unchanged. One character pushback is guaranteed. If the **unget** function is called too many times on the same stream without an intervening read or file positioning operation on that stream, the operation may fail. If the value of ***c*** equals that of the macro **EOF**, the operation fails and the input stream is unchanged.

A successful call to the **ungetc** function clears the end-of-file indicator. The value of the file position indicator after reading or discarding all pushed-back characters will be the same as it was before the characters were pushed back. For a text stream, the value of the file position indicator after a successful call to the **ungetc** function is unspecified until all pushed-back characters are read or discarded. For a binary stream, the file position indicator is decremented by each successful call to the **ungetc** function; if its value was zero before a call, it is indeterminate after the call.

Returns: the character pushed back after conversion, or **EOF** if the operation fails.

fread

```
size_t fread(void * ptr,size_t size,
       size_t nmemb, FILE * stream)
```

Reads into the array pointed to by ***ptr***, up to ***nmemb*** members whose size is specified by ***size***, from the stream pointed to by ***stream***. The file position indicator (if defined) is advanced by the number of characters successfully read. If an error occurs, the resulting value of the file position indicator is indeterminate. If a partial member is read, its value is indeterminate. The **ferror** or **feof** function shall be used to distinguish between a read error and end-of-file.

Returns: the number of members successfully read, which may be less than ***nmemb*** if a read error or end-of-file is encountered. If ***size*** or ***nmemb*** is zero, **fread** returns zero and the contents of the array and the state of the stream remain unchanged.

fwrite

```
size_t fwrite(const void * ptr,
       size_t size, size_t nmemb, FILE * stream)
```

Writes, from the array pointed to by **ptr** up to ***nmemb*** members whose size is specified by ***size***, to the stream pointed to by ***stream***. The file position indicator (if defined) is advanced by the number of characters successfully written. If an error occurs, the resulting value of the file position indicator is indeterminate.

Returns: the number of members successfully written, which will be less than **nmemb** only if a write error is encountered.

fgetpos

```
int fgetpos(FILE * stream, fpos_t * pos)
```

Stores the current value of the file position indicator for the stream pointed to by ***stream*** in the object pointed to by ***pos***. The value stored contains unspecified information usable by the **fsetpos** function for repositioning the stream to its position at the time of the call to the **fgetpos** function.

Returns: zero, if successful. Otherwise non-zero is returned and the integer expression **errno** is set to an implementation-defined non-zero value (under RISC OS **fgetpos** cannot fail).

fseek

```
int fseek(FILE * stream, long int offset, int whence)
```

Sets the file position indicator for the stream pointed to by ***stream***. For a binary stream, the new position is at the signed number of characters specified by ***offset*** away from the point specified by ***whence***. The specified point is the beginning of the file for **SEEK_SET**, the current position in the file for **SEEK_CUR**, or end-of-file for **SEEK_END**. A binary stream need not meaningfully support **fseek** calls with a ***whence*** value of **SEEK_END**, though the Acorn implementation does. For a text stream, ***offset*** is either zero or a value returned by an earlier call to the **ftell** function on the same stream; ***whence*** is then **SEEK_SET**. The Acorn implementation also allows a text stream to be positioned in exactly the same manner as a binary stream, but this is not portable. The **fseek** function clears the end-of-file indicator and undoes any effects of the **ungetc** function on the same stream. After an **fseek** call, the next operation on an update stream may be either input or output.

Returns: non-zero only for a request that cannot be satisfied.

fsetpos

```
int fsetpos(FILE * stream, const fpos_t * pos)
```

Sets the file position indicator for the stream pointed to by ***stream*** according to the value of the object pointed to by **pos**, which is a value returned by an earlier call to the **fgetpos** function on the same stream. The **fsetpos** function clears the end-of-file indicator and undoes any effects of the **ungetc** function on the same stream. After an **fsetpos** call, the next operation on an update stream may be either input or output.

Returns: zero, if successful. Otherwise non-zero is returned and the integer expression **errno** is set to an implementation-defined non-zero value (under RISC OS the value is that of EDOM in **math.h**).

ftell

```
long int ftell(FILE * stream)
```

Obtains the current value of the file position indicator for the stream pointed to by ***stream***. For a binary stream, the value is the number of characters from the beginning of the file. For a text stream, the file position indicator contains unspecified information, usable by the **fseek** function for returning the file position indicator to its position at the time of the **ftell** call; the difference between two such return values is not necessarily a meaningful measure of the number of characters written or read. However, for the Acorn implementation, the value returned is merely the byte offset into the file, whether the stream is text or binary.

Returns: if successful, the current value of the file position indicator. On failure, the **ftell** function returns –1L and sets the integer expression **errno** to an implementation-defined non-zero value (under RISC OS **ftell** cannot fail).

rewind

```
void rewind(FILE * stream)
```

Sets the file position indicator for the stream pointed to by ***stream*** to the beginning of the file. It is equivalent to **(void)fseek(stream, 0L, SEEK_SET)** except that the error indicator for the stream is also cleared.

Returns: no value.

clearerr

```
void clearerr(FILE * stream)
```

Clears the end-of-file and error indicators for the stream pointed to by ***stream***. These indicators are cleared only when the file is opened or by an explicit call to the **clearerr** function or to the **rewind** function.

Returns: no value.

feof

```
int feof(FILE * stream)
```

Tests the end-of-file indicator for the stream pointed to by ***stream***.

Returns: non-zero if the end-of-file indicator is set for ***stream***.

ferror

```
int ferror(FILE * stream)
```

Tests the error indicator for the stream pointed to by ***stream***.

Returns: non-zero if the error indicator is set for ***stream***.

perror

```
void perror(const char * s)
```

Maps the error number in the integer expression **errno** to an error message. It writes a sequence of characters to the standard error stream thus: first (if ***s*** is not a null pointer and the character pointed to by ***s*** is not the null character), the string pointed to by ***s*** followed by a colon and a space; then an appropriate error message string followed by a newline character. The contents of the error message strings are the same as those returned by the **strerror** function with argument **errno**, which are implementation-defined.

Returns: no value.

stdlib.h

`stdlib.h` declares four types, several general purpose functions, and defines several macros.

atof

```
double atof(const char * nptr)
```

Converts the initial part of the string pointed to by ***nptr*** to double * representation.

Returns: the converted value.

atoi

```
int atoi(const char * nptr)
```

Converts the initial part of the string pointed to by ***nptr*** to int representation.

Returns: the converted value.

atol

```
long int atol(const char * nptr)
```

Converts the initial part of the string pointed to by ***nptr*** to long int representation.

Returns: the converted value.

strtod

```
double strtod(const char * nptr, char ** endptr)
```

Converts the initial part of the string pointed to by ***nptr*** to double representation. First it decomposes the input string into three parts: an initial, possibly empty, sequence of white-space characters (as specified by the `isspace` function), a subject sequence resembling a floating point constant, and a final string of one or more unrecognised characters, including the terminating null character of the input string. It then attempts to convert the subject sequence to a floating point number, and returns the result. A pointer to the final string is stored in the object pointed to by ***endptr***, provided that ***endptr*** is not a null pointer.

Returns: the converted value if any. If no conversion could be performed, zero is returned. If the correct value is outside the range of representable values, plus or minus **HUGE_VAL** is returned (according to the sign of the value), and the value of the macro **ERANGE** is stored in **errno**. If the correct value would cause underflow, zero is returned and the value of the macro **ERANGE** is stored in **errno**.

strtol

```
long int strtol(const char * nptr, char **endptr, int
                base)
```

Converts the initial part of the string pointed to by ***nptr*** to long int representation. First it decomposes the input string into three parts: an initial, possibly empty, sequence of white-space characters (as specified by the **isspace** function), a subject sequence resembling an integer represented in some radix determined by the value of base, and a final string of one or more unrecognised characters, including the terminating null character of the input string.

It then attempts to convert the subject sequence to an integer, and returns the result. If the value of base is 0, the expected form of the subject sequence is that of an integer constant (described precisely in the ANSI standard, section 3.1.3.2), optionally preceded by a + or – sign, but not including an integer suffix. If the value of base is between 2 and 36, the expected form of the subject sequence is a sequence of letters and digits representing an integer with the radix specified by ***base***, optionally preceded by a plus or minus sign, but not including an integer suffix. The letters from a (or A) through z (or Z) are ascribed the values 10 to 35; only letters whose ascribed values are less than that of the base are permitted. If the value of ***base*** is 16, the characters 0x or 0X may optionally precede the sequence of letters and digits following the sign if present. A pointer to the final string is stored in the object pointed to by ***endptr***, provided that ***endptr*** is not a null pointer.

Returns: the converted value if any. If no conversion could be performed, zero is returned. If the correct value is outside the range of representable values, **LONG_MAX** or **LONG_MIN** is returned (according to the sign of the value), and the value of the macro **ERANGE** is stored in **errno**.

strtoul

```
unsigned long int strtoul(const char * nptr, char **
                          endptr, int base)
```

Converts the initial part of the string pointed to by **nptr** to unsigned long int representation. First it decomposes the input string into three parts: an initial, possibly empty, sequence of white space characters (as determined by the

isspace function), a subject sequence resembling an unsigned integer represented in some radix determined by the value of ***base***, and a final string of one or more unrecognised characters, including the terminating null character of the input string.

It then attempts to convert the subject sequence to an unsigned integer, and returns the result. If the value of ***base*** is zero, the expected form of the subject sequence is that of an integer constant (described precisely in the ANSI Draft, section 3.1.3.2), optionally preceded by a + or – sign, but not including an integer suffix. If the value of ***base*** is between 2 and 36, the expected form of the subject sequence is a sequence of letters and digits representing an integer with the radix specified by base, optionally preceded by a + or – sign, but not including an integer suffix. The letters from a (or A) through z (or Z) stand for the values 10 to 35; only letters whose ascribed values are less than that of the base are permitted. If the value of ***base*** is 16, the characters 0x or 0X may optionally precede the sequence of letters and digits following the sign, if present. A pointer to the final string is stored in the object pointed to by ***endptr***, provided that ***endptr*** is not a null pointer.

Returns: the converted value if any. If no conversion could be performed, zero is returned. If the correct value is outside the range of representable values, **ULONG_MAX** is returned, and the value of the * macro **ERANGE** is stored in **errno**.

rand

```
int rand(void)
```

Computes a sequence of pseudo-random integers in the range 0 to **RAND_MAX**, where **RAND_MAX = 0x7fffffff**.

Returns: a pseudo-random integer.

srand

```
void srand(unsigned int seed)
```

Uses its argument as a seed for a new sequence of pseudo-random numbers to be returned by subsequent calls to **rand**. If **srand** is then called with the same seed value, the sequence of pseudo-random numbers will be repeated. If **rand** is called before any calls to **srand** have been made, the same sequence is generated as when **srand** is first called with a seed value of 1.

calloc

```
void *calloc(size_t nmemb, size_t size)
```

Allocates space for an array of ***nmemb*** objects, each of whose size is ***size***. The space is initialised to all bits zero.

Returns: either a null pointer or a pointer to the allocated space.

free

```
void free(void * ptr)
```

Causes the space pointed to by ***ptr*** to be deallocated (made available for further allocation). If ***ptr*** is a null pointer, no action occurs. Otherwise, if ***ptr*** does not match a pointer earlier returned by **calloc**, **malloc** or **realloc** or if the space has been deallocated by a call to **free** or **realloc**, the behaviour is undefined.

malloc

```
void *malloc(size_t size)
```

Allocates space for an object whose size is specified by ***size*** and whose value is indeterminate.

Returns: either a null pointer or a pointer to the allocated space.

realloc

```
void *realloc(void * ptr, size_t size)
```

Changes the size of the object pointed to by ***ptr*** to the size specified by ***size***. The contents of the object is unchanged up to the lesser of the new and old sizes. If the new size is larger, the value of the newly allocated portion of the object is indeterminate. If ***ptr*** is a null pointer, the **realloc** function behaves like a call to **malloc** for the specified size. Otherwise, if ***ptr*** does not match a pointer earlier returned by **calloc**, **malloc** or **realloc**, or if the space has been deallocated by a call to **free** or **realloc**, the behaviour is undefined. If the space cannot be allocated, the object pointed to by ***ptr*** is unchanged. If size is zero and ***ptr*** is not a null pointer, the object it points to is freed.

Returns: either a null pointer or a pointer to the possibly moved allocated space.

abort

```
void abort(void)
```

Causes abnormal program termination to occur, unless the signal **SIGABRT** is being caught and the signal handler does not return. Whether open output streams are flushed or open streams are closed or temporary files removed is implementation-defined (under RISC OS all these occur). An implementation-defined form of the status 'unsuccessful termination' (1 under RISC OS) is returned to the host environment by means of a call to **raise(SIGABRT)**.

atexit

```
int atexit(void (* func)(void))
```

Registers the function pointed to by **func**, to be called without its arguments at normal program termination. It is possible to register at least 32 functions.

Returns: zero if the registration succeeds, non-zero if it fails.

exit

```
void exit(int status)
```

Causes normal program termination to occur. If more than one call to the **exit** function is executed by a program (for example, by a function registered with **atexit**), the behaviour is undefined. First, all functions registered by the **atexit** function are called, in the reverse order of their registration. Next, all open output streams are flushed, all open streams are closed, and all files created by the **tmpfile** function are removed. Finally, control is returned to the host environment. If the value of ***status*** is zero or **EXIT_SUCCESS**, an implementation-defined form of the status 'successful termination' (0 under RISC OS) is returned. If the value of ***status*** is **EXIT_FAILURE**, an implementation-defined form of the status 'unsuccessful termination' (1 under RISC OS) is returned. Otherwise the status returned is implementation-defined (the value of ***status*** is returned under RISC OS).

getenv

```
char *getenv(const char * name)
```

Searches the environment list, provided by the host environment, for a string that matches the string pointed to by ***name***. The set of environment names and the method for altering the environment list are implementation-defined.

Returns: a pointer to a string associated with the matched list member. The array pointed to is not modified by the program, but may be overwritten by a subsequent call to the **getenv** function. If the specified name cannot be found, a null pointer is returned.

system

```
int system(const char * string)
```

Passes the string pointed to by ***string*** to the host environment to be executed by a command processor in an implementation-defined manner. A null pointer may be used for ***string***, to inquire whether a command processor exists. Under RISC OS, care must be taken, when executing a command, that the command does not overwrite the calling program. To control this, the string **chain:** or **call:** may immediately precede the actual command. The effect of **call:** is the same as if **call:** were not present. When a command is called, the caller is first moved to a safe place in application workspace. When the callee terminates, the caller is restored. This requires enough memory to hold caller and callee simultaneously. When a command is chained, the caller may be overwritten. If the caller is not overwritten, the caller exits when the caller terminates. Thus a transfer of control is effected and memory requirements are minimised.

Returns: If the argument is a null pointer, the **system** function returns non-zero only if a command processor is available. If the argument is not a null pointer, it returns an implementation-defined value (under RISC OS 0 is returned for success and –2 for failure to invoke the command; any other value is the return code from the executed command).

bsearch

```
void *bsearch(const void *key, const void * base,
        size_t nmemb, size_t size, int (* compar)
        (const void *, const void *))
```

Searches an array of ***nmemb*** objects, the initial member of which is pointed to by ***base***, for a member that matches the object pointed to by ***key***. The size of each member of the array is specified by ***size***. The contents of the array must be in ascending sorted order according to a comparison function pointed to by ***compar***,

which is called with two arguments that point to the key object and to an array member, in that order. The function returns an integer less than, equal to, or greater than zero if the key object is considered, respectively, to be less than, to match, or to be greater than the array member.

Returns: a pointer to a matching member of the array, or a null pointer if no match is found. If two members compare as equal, which member is matched is unspecified.

qsort

```
void qsort(void * base, size_t nmemb, size_t size,
           int (* compar)(const void *, const void *))
```

Sorts an array of ***nmemb*** objects, the initial member of which is pointed to by ***base***. The size of each object is specified by ***size***. The contents of the array are sorted in ascending order according to a comparison function pointed to by ***compar***, which is called with two arguments that point to the objects being compared. The function returns an integer less than, equal to, or greater than zero if the first argument is considered to be respectively less than, equal to, or greater than the second. If two members compare as equal, their order in the sorted array is unspecified.

abs

```
int abs(int j)
```

Computes the absolute value of an integer ***j***. If the result cannot be represented, the behaviour is undefined.

Returns: the absolute value.

div

```
div_t div(int numer, int denom)
```

Computes the quotient and remainder of the division of the numerator ***numer*** by the denominator ***denom***. If the division is inexact, the resulting quotient is the integer of lesser magnitude that is the nearest to the algebraic quotient. If the result cannot be represented, the behaviour is undefined; otherwise, `quot * denom + rem` equals ***numer***.

Returns: a structure of type `div_t`, comprising both the quotient and the remainder. The structure contains the following members: `int quot`; `int rem`. You may not rely on their order.

labs

```
long int labs(long int j)
```

Computes the absolute value of an long integer *j*. If the result cannot be represented, the behaviour is undefined.

Returns: the absolute value.

ldiv

```
ldiv_t ldiv(long int numer, long int denom)
```

Computes the quotient and remainder of the division of the numerator *numer* by the denominator *denom*. If the division is inexact, the sign of the resulting quotient is that of the algebraic quotient, and the magnitude of the resulting quotient is the largest integer less than the magnitude of the algebraic quotient. If the result cannot be represented, the behaviour is undefined; otherwise, `quot * denom + rem` equals *numer*.

Returns: a structure of type `ldiv_t`, comprising both the quotient and the remainder. The structure contains the following members: `long int quot; long int rem`. You may not rely on their order.

Multibyte character functions

The behaviour of the multibyte character functions is affected by the `LC_CTYPE` category of the current locale. For a state-dependent encoding, each function is placed into its initial state by a call for which its character pointer argument, *s*, is a null pointer. Subsequent calls with *s* as other than a null pointer cause the internal state of the function to be altered as necessary. A call with `s` as a null pointer causes these functions to return a non-zero value if encodings have state dependency, and a zero otherwise. After the `LC_CTYPE` category is changed, the shift state of these functions is indeterminate.

mblen

```
int mblen(const char * s, size_t n)
```

If *s* is not a null pointer, the `mblen` function determines the number of bytes comprising the multibyte character pointed to by *s*. Except that the shift state of the `mbtowc` function is not affected, it is equivalent to `mbtowc((wchar_t *)0, s, n)`.

Returns: If *s* is a null pointer, the `mblen` function returns a non-zero or zero value, if multibyte character encodings, respectively do or do not have state-dependent encodings. If *s* is not a null pointer, the `mblen` function either returns a 0 (if *s*

points to a null character), or returns the number of bytes that comprise the multibyte character (if the next *n* of fewer bytes form a valid multibyte character), or returns –1 (if they do not form a valid multibyte character).

mbtowc

```
int mbtowc(wchar_t * pwc, const char * s, size_t n)
```

If *s* is not a null pointer, the **mbtowc** function determines the number of bytes that comprise the multibyte character pointed to by *s*. It then determines the code for value of type **wchar_t** that corresponds to that multibyte character. (The value of the code corresponding to the null character is zero). If the multibyte character is valid and *pwc* is not a null pointer, the **mbtowc** function stores the code in the object pointed to by *pwc*. At most *n* bytes of the array pointed to by *s* will be examined.

Returns: If *s* is a null pointer, the **mbtowc** function returns a non-zero or zero value, if multibyte character encodings, respectively do or do not have state-dependent encodings. If *s* is not a null pointer, the **mbtowc** function either returns a 0 (if *s* points to a null character), or returns the number of bytes that comprise the converted multibyte character (if the next *n* of fewer bytes form a valid multibyte character), or returns –1 (if they do not form a valid multibyte character).

wctomb

```
int wctomb(char * s, wchar_t wchar)
```

Determines the number of bytes need to represent the multibyte character corresponding to the code whose value is *wchar* (including any change in shift state). It stores the multibyte character representation in the array object pointed to by *s* (if *s* is not a null pointer). At most **MB_CUR_MAX** characters are stored. If the value of *wchar* is zero, the **wctomb** function is left in the initial shift state).

Returns: If *s* is a null pointer, the **wctomb** function returns a non-zero or zero value, if multibyte character encodings, respectively do or do not have state-dependent encodings. If *s* is not a null pointer, the **wctomb** function returns a –1 if the value of *wchar* does not correspond to a valid multibyte character, or returns the number of bytes that comprise the multibyte character corresponding to the value of *wchar*.

Multibyte string functions

The behaviour of the multibyte string functions is affected by the `LC_CTYPE` category of the current locale.

mbstowcs

```
size_t mbstowcs(wchar_t * pwcs, const char * s, size_t n)
```

Converts a sequence of multibyte characters that begins in the initial shift state from the array pointed to by ***s*** into a sequence of corresponding codes and stores not more than ***n*** codes into the array pointed to by ***pwcs***. No multibyte character that follow a null character (which is converted into a code with value zero) will be examined or converted. Each multibyte character is converted as if by a call to the `mbtowc` function. If an invalid multibyte character is found, `mbstowcs` returns `(size_t)-1`. Otherwise, the `mbstowcs` function returns the number of array elements modified, not including a terminating zero code, if any.

wcstombs

```
size_t wcstombs(char * s, const wchar_t * pwcs, size_t n)
```

Converts a sequence of codes that correspond to multibyte characters from the array pointed to by ***pwcs*** into a sequence of multibyte characters that begins in the initial shift state and stores these multibyte characters into the array pointed to by ***s***, stopping if a multibyte character would exceed the limit of ***n*** total bytes or if a null character is stored. Each code is converted as if by a call to the `wctomb` function, except that the shift state of the `wctomb` function is not affected. If a code is encountered which does not correspond to any valid multibyte character, the `wcstombs` function returns `(size_t)-1`. Otherwise, the `wcstombs` function returns the number of bytes modified, not including a terminating null character, if any.

string.h

`string.h` declares one type and several functions, and defines one macro useful for manipulating character arrays and other objects treated as character arrays. Various methods are used for determining the lengths of the arrays, but in all cases a `char *` or `void *` argument points to the initial (lowest addresses) character of the array. If an array is written beyond the end of an object, the behaviour is undefined.

memcpy

```
void *memcpy(void * s1, const void * s2, size_t n)
```

Copies *n* characters from the object pointed to by *s2* into the object pointed to by *s1*. If copying takes place between objects that overlap, the behaviour is undefined.

Returns: the value of s1.

memmove

```
void *memmove(void * s1, const void * s2, size_t n)
```

Copies *n* characters from the object pointed to by *s2* into the object pointed to by *s1*. Copying takes place as if the *n* characters from the object pointed to by *s2* are first copied into a temporary array of *n* characters that does not overlap the objects pointed to by *s1* and s2, and then the *n* characters from the temporary array are copied into the object pointed to by *s1*.

Returns: the value of *s1*.

strcpy

```
char *strcpy(char * s1, const char * s2)
```

Copies the string pointed to by *s2* (including the terminating null character) into the array pointed to by *s1*. If copying takes place between objects that overlap, the behaviour is undefined.

Returns: the value of *s1*.

strncpy

```
char *strncpy(char * s1, const char * s2, size_t n)
```

Copies not more than *n* characters (characters that follow a null character are not copied) from the array pointed to by *s2* into the array pointed to by *s1*. If copying takes place between objects that overlap, the behaviour is undefined. If terminating `nul` has not been copied in chars, no term `nul` is placed in *s2*.

Returns: the value of *s1*.

strcat

```
char *strcat(char * s1, const char * s2)
```

Appends a copy of the string pointed to by *s2* (including the terminating null character) to the end of the string pointed to by *s1*. The initial character of *s2* overwrites the null character at the end of *s1*.

Returns: the value of *s1*.

strncat

```
char *strncat(char * s1, const char * s2, size_t n)
```

Appends not more than *n* characters (a null character and characters that follow it are not appended) from the array pointed to by *s2* to the end of the string pointed to by *s1*. The initial character of *s2* overwrites the null character at the end of *s1*. A terminating null character is always appended to the result.

Returns: the value of *s1*.

The sign of a non-zero value returned by the comparison functions is determined by the sign of the difference between the values of the first pair of characters (both interpreted as unsigned char) that differ in the objects being compared.

memcmp

```
int memcmp(const void * s1, const void * s2, size_t n)
```

Compares the first *n* characters of the object pointed to by *s1* to the first *n* characters of the object pointed to by *s2*.

Returns: an integer greater than, equal to, or less than zero, depending on whether the object pointed to by *s1* is greater than, equal to, or less than the object pointed to by *s2*.

strcmp

```
int strcmp(const char * s1, const char * s2)
```

Compares the string pointed to by *s1* to the string pointed to by *s2*.

Returns: an integer greater than, equal to, or less than zero, depending on whether the string pointed to by *s1* is greater than, equal to, or less than the string pointed to by *s2*.

strncmp

```
int strncmp(const char * s1, const char * s2, size_t n)
```

Compares not more than *n* characters (characters that follow a null character are not compared) from the array pointed to by *s1* to the array pointed to by *s2*.

Returns: an integer greater than, equal to, or less than zero, depending on whether the string pointed to by *s1* is greater than, equal to, or less than the string pointed to by *s2*.

strcoll

```
int strcoll(const char * s1, const char * s2)
```

Compares the string pointed to by *s1* to the string pointed to by *s2*, both interpreted as appropriate to the `LC_COLLATE` category of the current locale.

Returns: an integer greater than, equal to, or less than zero, depending on whether the string pointed to by *s1* is greater than, equal to, or less than the string pointed to by *s2* when both are interpreted as appropriate to the current locale.

strxfrm

```
size_t strxfrm(char * s1, const char * s2, size_t n)
```

Transforms the string pointed to by *s2* and places the resulting string into the array pointed to by *s1*. The transformation function is such that if the `strcmp` function is applied to two transformed strings, it returns a value greater than, equal to or less than zero, corresponding to the result of the `strcoll` function applied to the same two original strings. No more than *n* characters are placed into the resulting array pointed to by *s1*, including the terminating null character. If *n* is zero, *s1* is permitted to be a null pointer. If copying takes place between objects that overlap, the behaviour is undefined.

Returns: The length of the transformed string is returned (not including the terminating null character). If the value returned is *n* or more, the contents of the array pointed to by *s1* are indeterminate.

memchr

```
void *memchr(const void * s, int c, size_t n)
```

Locates the first occurrence of *c* (converted to an unsigned char) in the initial *n* characters (each interpreted as unsigned char) of the object pointed to by *s*.

Returns: a pointer to the located character, or a null pointer if the character does not occur in the object.

strchr

```
char *strchr(const char * s, int c)
```

Locates the first occurrence of *c* (converted to a char) in the string pointed to by *s* (including the terminating null character). The BSD UNIX name for this function is `index()`.

Returns: a pointer to the located character, or a null pointer if the character does not occur in the string.

strcspn

```
size_t strcspn(const char * s1, const char * s2)
```

Computes the length of the initial segment of the string pointed to by *s1* which consists entirely of characters not from the string pointed to by *s2*. The terminating null character is not considered part of *s2*.

Returns: the length of the segment.

strpbrk

```
char *strpbrk(const char * s1, const char * s2)
```

Locates the first occurrence in the string pointed to by *s1* of any character from the string pointed to by *s2*.

Returns: returns a pointer to the character, or a null pointer if no character form *s2* occurs in *s1*.

strrchr

```
char *strrchr(const char * s, int c)
```

Locates the last occurrence of *c* (converted to a char) in the string pointed to by *s*. The terminating null character is considered part of the string. The BSD UNIX name for this function is `rindex()`.

Returns: returns a pointer to the character, or a null pointer if *c* does not occur in the string.

strspn

```
size_t strspn(const char * s1, const char * s2)
```

Computes the length of the initial segment of the string pointed to by *s1* which consists entirely of characters from the string pointed to by *s2*.

Returns: the length of the segment.

strstr

```
char *strstr(const char * s1, const char * s2)
```

Locates the first occurrence in the string pointed to by *s1* of the sequence of characters (excluding the terminating null character) in the string pointed to by *s2*.

Returns: a pointer to the located string, or a null pointer if the string is not found.

strtok

```
char *strtok(char * s1, const char * s2)
```

A sequence of calls to the `strtok` function breaks the string pointed to by *s1* into a sequence of tokens, each of which is delimited by a character from the string pointed to by *s2*. The first call in the sequence has *s1* as its first argument, and is followed by calls with a null pointer as their first argument. The separator string pointed to by *s2* may be different from call to call. The first call in the sequence searches for the first character that is not contained in the current separator string *s2*. If no such character is found, then there are no tokens in *s1* and the `strtok` function returns a null pointer. If such a character is found, it is the start of the first token. The `strtok` function then searches from there for a character that is contained in the current separator string. If no such character is found, the current token extends to the end of the string pointed to by *s1*, and subsequent searches for a token will fail. If such a character is found, it is overwritten by a null character, which terminates the current token. The `strtok` function saves a pointer to the

following character, from which the next search for a token will start. Each subsequent call, with a null pointer as the value for the first argument, starts searching from the saved pointer and behaves as described above.

Returns: pointer to the first character of a token, or a null pointer if there is no token.

memset

```
void *memset(void * s, int c, size_t n)
```

Copies the value of **c** (converted to an unsigned char) into each of the first **n** characters of the object pointed to by **s**.

Returns: the value of **s**.

strerror

```
char *strerror(int errnum)
```

Maps the error number in **errnum** to an error message string.

Returns: a pointer to the string, the contents of which are implementation-defined. Under RISC OS and Arthur the strings for the given **errnum**s are as follows:

- 0 — No error (errno = 0)
- **EDOM** — **EDOM** – function argument out of range
- **ERANGE** — **ERANGE** – function result not representable
- **ESIGNUM** — **ESIGNUM** – illegal signal number to **signal()** or **raise()**
- others — Error code (errno) has no associated message).

The array pointed to may not be modified by the program, but may be overwritten by a subsequent call to the **strerror** function.

strlen

```
size_t strlen(const char * s)
```

Computes the length of the string pointed to by **s**.

Returns: the number of characters that precede the terminating null character.

time.h

`time.h` declares two macros, four types and several functions for manipulating time. Many functions deal with a calendar time that represents the current date (according to the Gregorian calendar) and time. Some functions deal with local time, which is the calendar time expressed for some specific time zone, and with Daylight Saving Time, which is a temporary change in the algorithm for determining local time.

struct tm

`struct tm` holds the components of a calendar time called the broken-down time. The value of `tm_isdst` is positive if Daylight Saving Time is in effect, zero if Daylight Saving Time is not in effect, and negative if the information is not available.

```
struct tm {
  int tm_sec;     /* seconds after the minute, 0 to 60
                     (0-60 allows for the occasional leap
                     second) */
  int tm_min      /* minutes after the hour, 0 to 59 */
  int tm_hour     /* hours since midnight, 0 to 23 */
  int tm_mday     /* day of the month, 0 to 31 */
  int tm_mon      /* months since January, 0 to 11 */
  int tm_year     /* years since 1900 */
  int tm_wday     /* days since Sunday, 0 to 6 */
  int tm_yday     /* days since January 1, 0 to 365 */
  int tm_isdst    /* Daylight Saving Time flag */
};
```

clock

```
clock_t clock(void)
```

Determines the processor time used.

Returns: the implementation's best approximation to the processor time used by the program since program invocation. The time in seconds is the value returned, divided by the value of the macro `CLOCKS_PER_SEC`. The value `(clock_t)-1` is returned if the processor time used is not available. In the desktop, `clock()` returns all processor time, not just that of the program.

difftime

```
double difftime(time_t time1, time_t time0)
```

Computes the difference between two calendar times: *time1 - time0*. Returns: the difference expressed in seconds as a double.

mktime

```
time_t mktime(struct tm * timeptr)
```

Converts the broken-down time, expressed as local time, in the structure pointed to by **timeptr** into a calendar time value with the same encoding as that of the values returned by the **time** function. The original values of the **tm_wday** and **tm_yday** components of the structure are ignored, and the original values of the other components are not restricted to the ranges indicated above. On successful completion, the values of the **tm_wday** and **tm_yday** structure components are set appropriately, and the other components are set to represent the specified calendar time, but with their values forced to the ranges indicated above; the final value of **tm_mday** is not set until **tm_mon** and **tm_year** are determined.

Returns: the specified calendar time encoded as a value of type **time_t**. If the calendar time cannot be represented, the function returns the value **(time_t)-1**.

time

```
time_t time(time_t * timer)
```

Determines the current calendar time. The encoding of the value is unspecified.

Returns: the implementation's best approximation to the current calendar time. The value **(time_t)-1** is returned if the calendar time is not available. If *timer* is not a null pointer, the return value is also assigned to the object it points to.

asctime

```
char *asctime(const struct tm * timeptr)
```

Converts the broken-down time in the structure pointed to by *timeptr* into a string in the style **Sun Sep 16 01:03:52 1973\n\0**.

Returns: a pointer to the string containing the date and time.

ctime

```
char *ctime(const time_t * timer)
```

Converts the calendar time pointed to by ***timer*** to local time in the form of a string. It is equivalent to **asctime(localtime(timer))**.

Returns: the pointer returned by the **asctime** function with that broken-down time as argument.

gmtime

```
struct tm *gmtime(const time_t * timer)
```

Converts the calendar time pointed to by ***timer*** into a broken-down time, expressed as Greenwich Mean Time (GMT).

Returns: a pointer to that object or a null pointer if GMT is not available.

localtime

```
struct tm *localtime(const time_t * timer)
```

Converts the calendar time pointed to by ***timer*** into a broken-down time, expressed a local time.

Returns: a pointer to that object.

strftime

```
size_t strftime(char * s, size_t maxsize, const char *
                format, const struct tm * timeptr)
```

Places characters into the array pointed to by ***s*** as controlled by the string pointed to by ***format***. The format string consists of zero or more directives and ordinary characters. A directive consists of a **%** character followed by a character that determines the directive's behaviour. All ordinary characters (including the terminating null character) are copied unchanged into the array. No more than **maxsize** characters are placed into the array. Each directive is replaced by appropriate characters as described in the following list. The appropriate characters are determined by the **LC_TIME** category of the current locale and by the values contained in the structure pointed to by **timeptr**.

Directive	Replaced by
`%a`	the locale's abbreviated weekday name
`%A`	the locale's full weekday name
`%b`	the locale's abbreviated month name
`%B`	the locale's full month name
`%c`	the locale's appropriate date and time representation
`%d`	the day of the month as a decimal number (01–31)
`%H`	the hour (24-hour clock) as a decimal number (00–23)
`%I`	the hour (12-hour clock) as a decimal number (01–12)
`%j`	the day of the year as a decimal number (001–366)
`%m`	the month as a decimal number (01–12)
`%M`	the minute as a decimal number (00–61)
`%p`	the locale's equivalent of either AM or PM designation associated with a 12-hour clock
`%S`	the second as a decimal number (00–61)
`%U`	the week number of the year (Sunday as the first day of week 1) as a decimal number (00–53)
`%w`	the weekday as a decimal number (0(Sunday) –6)
`%W`	the week number of the year (Monday as the first day of week 1) as a decimal number (00–53)
`%x`	the locale's appropriate date representation
`%X`	the locale's appropriate time representation
`%y`	the year without century as a decimal number (00–99)
`%Y`	the year with century as a decimal number
`%Z`	the time zone name or abbreviation, or by no character if no time zone is determinable
`%%`	`%`.

If a directive is not one of the above, the behaviour is undefined.

Returns: If the total number of resulting characters including the terminating null character is not more than ***`maxsize`***, the **`strftime`** function returns the number of characters placed into the array pointed to by **`s`** not including the terminating null character. Otherwise, zero is returned and the contents of the array are indeterminate.

8 The ANSI library

The ANSI library is a stand-alone version of the shared C library that contains a few extra functions useful in debugging and profiling your code. You should use it for development only, using the shared C library in any final product.

This chapter describes the extra functions provided by the ANSI library. For details of the other functions, see the chapter *The C library* on page 91.

Extra functions

__heap_checking_on_all_allocates
__heap_checking_on_all_deallocates

```
void __heap_checking_on_all_allocates (int on);
void __heap_checking_on_all_deallocates (int on);
```

Calling these functions with a non-zero argument causes `malloc()` and `free()` respectively to check the consistency of the C heap on every call, rather than only when the heap is coalesced. It is especially useful for tracking down exactly where memory corruption is occurring. This feature is disabled by passing an argument of zero.

_mapstore
_fmapstore

```
void _mapstore (void);
void _fmapstore (char *filename);
```

These functions write profiling information for a program to `stderr` or `filename` respectively, if the program has been compiled with profiling enabled.

9 The Event library

The purpose of the 'event' library is to allow the client to more easily dispatch Toolbox and Wimp events within Toolbox based applications.

Introduction

A typical client will register some event handlers, and then enter a poll loop, with events being dispatched for it to its event handler functions by the event library as described below.

When the client has called **toolbox_initialise**, it should call the function **event_initialise** (see page 145), passing a pointer to the *id block* (see the *User Interface Toolbox* manual for a description of this) which was passed to **toolbox_initialise**; this pointer will then be passed to any event handler functions which the client subsequently registers.

The client application enters a poll loop using a call to **event_poll** (see page 146), passing a pointer to a poll block, just as for the SWI Wimp_Poll (which is, in fact, called on the client's behalf). If the client wishes to cause a call to Wimp_PollIdle, then it should call **event_poll_idle** instead (see page 146). The event block is the one which will be filled in by SWI Wimp_Poll. When the Wimp is polled, the mask passed in R0 is determined by the last call made by the client to the function **event_set_mask** (see page 145); the default mask used is to just mask out Null events.

Registering and deregistering event handlers

The event library also allows the client to register functions which will be called back for particular combinations of Toolbox or Wimp events, either on all objects or on a given object. This is done for Toolbox events by calling the function **event_register_toolbox_handler** (see page 147), and for Wimp events by calling the function **event_register_wimp_handler** (see page 147).

These register a *handler function* which will be called back by the event library following a call to **event_poll** (or **event_poll_idle**), if its given conditions are met. The handler function will be passed a client-defined *handle*, a pointer to the poll block passed to **event_poll**, and a pointer to the client's id block (as passed to **event_initialise**).

When **event_poll** is called and an event has arrived, the event library will try to find a matching handler function in the following priority order:

- a handler registered for the object to which this event was delivered
- a handler registered for this event (for all objects).

All handler functions which are registered for the given event are called using the order given above, until the list is exhausted or one of the handlers returns non-zero, indicating that it has 'claimed' the event. If more than one function is registered at the same priority level as defined above, then they are called in the reverse order to that in which they were registered.

In order to deregister event handlers, the client calls **event_deregister_toolbox_handler** (see page 148) and **event_deregister_wimp_handler** (see page 148) with the same parameters as when the handler was registered.

Registering and deregistering message handlers

Wimp messages are delivered on a per-task basis, and not to a particular object (i.e. the id block is not filled in with an object id). A client can register a handler for Wimp messages by calling the function **event_register_message_handler** (see page 148).

If more than one handler is registered for a particular Wimp message, then they are called in the reverse order to that in which they were registered.

In order to deregister message handlers, the client calls **event_deregister_message_handler** (see page 148) with the same parameters as when the handler was registered.

Quitting applications

Event and message handlers are both held in application space. Application tasks therefore do not need to remove them on quitting, nor need they deregister them.

Programmer interface

The rest of this chapter lists the C function calls that are used to control the event library. See the chapter *The Wimp library* on page 153 for a description of the Wimp type definitions in the Wimp SWI veneer library.

Initialisation

event_initialise

```
extern _kernel_oserror *event_initialise (IdBlock *b);
```

The `IdBlock` that was given to `toolbox_initialise` should be passed to `event_initialise`; this is then passed to Toolbox and Wimp handlers when they are called.

event_set_mask

```
extern _kernel_oserror *event_set_mask
                        (unsigned int mask);
```

`mask` is an integer defining what events are to be returned. This has the same meaning as the Wimp_Poll mask described on page 3-115 of the RISC OS 3 *Programmer's Reference Manual*. By default, this just masks out Null events.

event_get_mask

```
extern _kernel_oserror *event_get_mask
                        (unsigned int *mask);
```

`mask` should be the address of an integer where the current mask is to be stored.

Polling

event_poll

```
extern _kernel_oserror *event_poll (int *event_code,
                                    WimpPollBlock *poll_block,
                                    void *poll_word);
```

This function makes calls to the SWI Wimp_Poll. The **poll_block** should be allocated before calling this function and its address passed in. The **poll_word** is optional (i.e. the pointer may be set to zero), and is only used by the Wimp if the mask is set accordingly (see page 3-115 of the RISC OS 3 *Programmer's Reference Manual*) by **event_set_mask** (see page 145).

event_poll_idle

```
extern _kernel_oserror *event_poll_idle (int *event_code,
                                         WimpPollBlock *poll_block,
                                         unsigned int earliest,
                                         void *poll_word);
```

This function makes calls to the SWI Wimp_PollIdle. The **poll_block** should be allocated before calling this function and its address passed in. The **poll_word** is optional (i.e. the pointer may be set to zero), and is only used by the Wimp if the mask is set accordingly (see page 3-115 of the RISC OS 3 *Programmer's Reference Manual*) by **event_set_mask** (see page 145). Like the SWI (page 3-184 of the RISC OS 3 *Programmer's Reference Manual*), control will not return to the client before the earliest time, unless an event other than a Null has occurred.

Registering handlers

These functions allow registering handlers for Wimp events, Toolbox events and Wimp messages. If you wish to register for all events or all objects a value of –1 should be used in place of the `event_code` or `ObjectId`.

If there is not enough memory to register the handler, an error will be raised.

event_register_wimp_handler

```
_kernel_oserror *event_register_wimp_handler
                        (ObjectId object_id,
                        int event_code,
                        WimpEventHandler *handler,
                        void *handle);
```

`handler` is the function that should be called when the given Wimp event code occurs on the object (e.g. a redraw event on a window). The `handle` is a value which will be passed to the `handler` function, and thus may be used to associate a data structure with the given object.

event_register_toolbox_handler

```
_kernel_oserror *event_register_toolbox_handler
                        (ObjectId object_id,
                        int event_code,
                        ToolboxEventHandler *handler,
                        void *handle);
```

`handler` is the function that should be called when the given Toolbox event code occurs on the object (e.g. a DCS_Discard event on a DCS object). The `handle` is a value which will be passed to the `handler` function, and thus may be used to associate a data structure with the given object.

event_register_message_handler

```
_kernel_oserror *event_register_message_handler
                        (int msg_no,
                        WimpMessageHandler *handler,
                        void *handle);
```

handler is the function that should be called when the given Wimp message is received by the task (e.g. Wimp_MQuit). The **handle** is a value which will be passed to the **handler** function, and thus may be used to associate a data structure with the given message.

To deregister a handler, the appropriate function below should be used. Note that the parameters must exactly match those passed to the registration function.

An error will be raised if an attempt is made to deregister a handler that was not previously registered.

event_deregister_wimp_handler

```
_kernel_oserror *event_deregister_wimp_handler
                        (ObjectId object_id,
                        int event_code,
                        WimpEventHandler *handler,
                        void *handle);
```

Deregisters a previously registered Wimp event handler.

event_deregister_toolbox_handler

```
_kernel_oserror *event_deregister_toolbox_handler
                        (ObjectId object_id,
                        int event_code,
                        ToolboxEventHandler *handler,
                        void *handle);
```

Deregisters a previously registered Toolbox event handler.

event_deregister_message_handler

```
_kernel_oserror *event_deregister_message_handler (int
                        msg_no, WimpMessageHandler
                        *handler, void *handle);
```

Deregisters a previously registered Wimp message handler.

Handlers

When a client calls **event_poll**, EventLib issues the SWI Wimp_Poll. If the Wimp returns an event code and poll block that match one of the clients 'interests' then a handler will be called.

The handlers that are registered and deregistered above have the following calling parameters:

- The **event_code** passed in is the actual event that lead to the handler being called.
- The **IdBlock** will be that passed to **event_initialise**, and is updated by the Toolbox to identify which object the event has occurred on.
- The **handle** is the value that was passed through on registration, and is not interpreted by EventLib or the Toolbox.

A handler should return zero if it has not handled the event, so that it may be passed on to other handlers which have been registered for a similar interest. Returning non-zero will 'claim' the event, and **event_poll** will return.

WimpEventHandler

```
typedef int (WimpEventHandler) (int event_code,
                                WimpPollBlock *event,
                                IdBlock *id_block,
                                void *handle);
```

ToolboxEventHandler

```
typedef int (ToolboxEventHandler) (int event_code,
                                ToolboxEvent *event,
                                IdBlock *id_block,
                                void *handle);
```

WimpMessageHandler

```
typedef int (WimpMessageHandler) (WimpMessage *message,
                                void *handle);
```

Example

The following is a simple example of how EventLib might be used. A more complete example covering Wimp and Toolbox events can be found in the *User Interface Toolbox* manual.

```
/* * Minimal Toolbox application, using the event veneers library. */

#include <stdlib.h>
#include "wimp.h"
#include "toolbox.h"
#include "event.h"

#define WimpVersion     310

static  WimpPollBlock   poll_block;
static  MessagesFD      messages;
static  IdBlock         id_block;

static  int             quit=0;

int quit_handler (WimpMessage *message, void *handle);
{
        quit =1;
        return 1;       /* claim the event */
}

int main()
{
        int     event_code;

        /*
         * register ourselves with the Toolbox.
         */

        toolbox_initialise (0, WimpVersion, 0, 0, "<Test$Dir>",
                            &messages, &id_block, 0, 0, 0);

        /*
         * initialise the event library.
         */

        event_initialise (&id_block);

        /*
         * register handlers
         */

        event_register_message_handler (Wimp_MQuit, quit_handler, 0);
```

```
        /*
         * poll loop
         */

        while (!quit)
        {
                event_poll (&event_code, &poll_block, 0);
        }

        exit (EXIT_SUCCESS);
}
```

10 The Wimp library

WimpLib provides a set of C veneers onto the Wimp (or Window Manager) SWI interface. For a description of the exact effect of a particular call, you should see the chapter *The Window Manager* at the start of Volume 3 of the RISC OS 3 *Programmer's Reference Manual*.

The section below lists in alphabetical order the functions provided by WimpLib. The functions' names are derived directly from the SWIs' names: for example, the veneer to call Wimp_CreateWindow is **`wimp_create_window`**. Each function has page references to the RISC OS 3 *Programmer's Reference Manual* – including ones, where relevant, to Volume 5 (the *Supplement for version* 3.5).

WimpLib does not provide access to every Wimp SWI: for example, the Filter related SWIs and Wimp_SetWatchDogState are omitted. Such SWIs still have an entry below under their expected function name, just so you can rapidly determine they are not supported. Although functions are provided for adding and removing Wimp messages, you must not use these in Toolbox applications.

Note that when a value is returned as a parameter (e.g. an integer value is returned by **`function (int input, int *output)`**), the pointer to the return value may be set to zero rather than provide a dummy variable.

Programmer interface

wimp_add_messages

```
_kernel_oserror *wimp_add_messages      (int *list              /* R0 in */);
```

This calls the SWI Wimp_AddMessages (see page 3-226 of the RISC OS 3 *Programmer's Reference Manual*). **You must not use this call in Toolbox applications.**

wimp_base_of_sprites

```
_kernel_oserror *wimp_base_of_sprites   (void **rom,            /* R0 out */
                                        void **ram              /* R1 out */);
```

This calls the SWI Wimp_BaseOfSprites (see page 3-203 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_block_copy

```
_kernel_oserror *wimp_block_copy        (int handle,            /* R0 in */
                                        int sxmin,              /* R1 in */
                                        int symin,              /* R2 in */
                                        int sxmax,              /* R3 in */
                                        int symax,              /* R4 in */
                                        int dxmin,              /* R5 in */
                                        int dymin               /* R6 in */);
```

This calls the SWI Wimp_BlockCopy (see page 3-204 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_claim_free_memory

You might expect a function of this name to be provided to call Wimp_ClaimFreeMemory. However, such a function is not implemented by WimpLib.

wimp_close_down

```
_kernel_oserror *wimp_close_down        (int th                 /* R0 in */);
```

This sets up R1 to be &4B534154 ('TASK'), and then calls the SWI Wimp_CloseDown (see page 3-175 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_close_template

```
_kernel_oserror *wimp_close_template    (void);
```

This calls the SWI Wimp_CloseTemplate (see page 3-169 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_close_window

```
_kernel_oserror *wimp_close_window      (int window_handle      /* R1 in */);
```

This calls the SWI Wimp_CloseWindow (see page 3-114 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_command_window

```
_kernel_oserror *wimp_command_window    (int type               /* R0 in */);
```

This calls the SWI Wimp_CommandWindow (see page 3-212 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_create_icon

```
_kernel_oserror *wimp_create_icon       (int priority,          /* R0 in */
                                         WimpCreateIconBlock *defn, /* R1 in */
                                         int *handle            /* R0 out */);
```

This calls the SWI Wimp_CreateIcon (see pages 3-96 and 5-204 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_create_menu, CloseMenu

```
#define CloseMenu ((void *) -1)

_kernel_oserror *wimp_create_menu       (void * handle,         /* R1 in */
                                         int x,                 /* R2 in */
                                         int y                  /* R3 in */);
```

This calls the SWI Wimp_CreateMenu (see pages 3-156 and 5-205 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_create_submenu

```
_kernel_oserror *wimp_create_submenu    (void * handle,         /* R1 in */
                                         int x,                 /* R2 in */
                                         int y                  /* R3 in */);
```

This calls the SWI Wimp_CreateSubmenu (see page 3-199 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_create_window

```
_kernel_oserror *wimp_create_window     (WimpWindow *defn,       /* R1 in */
                                         int *handle             /* R0 out */);
```

This calls the SWI Wimp_CreateWindow (see pages 3-89 and 5-204 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_decode_menu

```
_kernel_oserror *wimp_decode_menu       (void *data,             /* R1 in */
                                         int *selections,        /* R2 in */
                                         char *buffer            /* R3 in */);
```

This calls the SWI Wimp_DecodeMenu (see page 3-161 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_delete_icon

```
_kernel_oserror *wimp_delete_icon       (WimpDeleteIconBlock *block
                                                                 /* R1 in */);
```

This calls the SWI Wimp_DeleteIcon (see page 3-110 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_delete_window

```
_kernel_oserror *wimp_delete_window     (WimpDeleteWindowBlock *block
                                                                 /* R1 in */);
```

This calls the SWI Wimp_DeleteWindow (see page 3-108 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_drag_box, CancelDrag

```
#define CancelDrag 0

_kernel_oserror *wimp_drag_box          (WimpDragBox *block
                                                                 /* R1 in */);
```

This calls the SWI Wimp_DragBox (see page 3-145 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_extend

You might expect a function of this name to be provided to call Wimp_Extend. However, such a function is not implemented by WimpLib.

wimp_force_redraw

```
_kernel_oserror *wimp_force_redraw      (int window_handle,     /* R0 in */
                                         int xmin,              /* R1 in */
                                         int ymin,              /* R2 in */
                                         int xmax,              /* R3 in */
                                         int ymax               /* R4 in */);
```

This calls the SWI Wimp_ForceRedraw (see page 3-150 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_get_caret_position

```
_kernel_oserror *wimp_get_caret_position(WimpGetCaretPositionBlock *block
                                                                /* R1 in */);
```

This calls the SWI Wimp_GetCaretPosition (see page 3-154 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_get_icon_state

```
_kernel_oserror *wimp_get_icon_state    (WimpGetIconStateBlock *block
                                                                /* R1 in */);
```

This calls the SWI Wimp_GetIconState (see page 3-141 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_get_menu_state

```
_kernel_oserror *wimp_get_menu_state    (int report,            /* R0 in */
                                         int *state,            /* R1 in */
                                         int window,            /* R2 in */
                                         int icon               /* R3 in */);
```

This calls the SWI Wimp_GetMenuState (see page 3-222 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_get_pointer_info

```
_kernel_oserror *wimp_get_pointer_info  (WimpGetPointerInfoBlock *block
                                                                /* R1 in */);
```

This calls the SWI Wimp_GetPointerInfo (see page 3-143 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_get_rectangle

```
_kernel_oserror *wimp_get_rectangle     (WimpRedrawWindowBlock *block,
                                                              /* R1 in */
                                        int *more             /* R0 out */);
```

This calls the SWI Wimp_GetRectangle (see page 3-133 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_get_window_info

```
_kernel_oserror *wimp_get_window_info   (WimpGetWindowInfoBlock *block
                                                              /* R1 in */);
```

This calls the SWI Wimp_GetWindowInfo (see page 3-137 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_get_window_outline

```
_kernel_oserror *wimp_get_window_outline(WimpGetWindowOutlineBlock *block
                                                              /* R1 in */);
```

This calls the SWI Wimp_GetWindowOutline (see page 3-182 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_get_window_state

```
_kernel_oserror *wimp_get_window_state  (WimpGetWindowStateBlock *state
                                                              /* R1 in */);
```

This calls the SWI Wimp_GetWindowState (see page 3-135 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_initialise

```
_kernel_oserror *wimp_initialise        (int version,          /* R0 in */
                                        char *name,           /* R2 in */
                                        int *messages,        /* R3 in */
                                        int *cversion,        /* R0 out */
                                        int *task             /* R1 out */);
```

This sets up R1 to be &4B534154 ('TASK'), and then calls the SWI Wimp_Initialise (see page 3-87 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_load_template

```
_kernel_oserror *wimp_load_template     (_kernel_swi_regs *regs /*R1-6 in*/);
```

This calls the SWI Wimp_LoadTemplate (see page 3-170 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_open_template

```
_kernel_oserror *wimp_open_template     (char *name              /* R1 in */);
```

This calls the SWI Wimp_OpenTemplate (see page 3-168 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_open_window

```
_kernel_oserror *wimp_open_window       (WimpOpenWindowBlock *show
                                                              /* R1 in */);
```

This calls the SWI Wimp_OpenWindow (see page 3-112 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_plot_icon

```
_kernel_oserror *wimp_plot_icon         (WimpPlotIconBlock *block
                                                              /* R1 in */);
```

This calls the SWI Wimp_PlotIcon (see page 3-186 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_poll

```
_kernel_oserror *wimp_poll              (int mask,              /* R0 in */
                                        WimpPollBlock *block,   /* R1 in */
                                        int *pollword,          /* R2 in */
                                        int *event_code         /* R0 out */);
```

This calls the SWI Wimp_Poll (see page 3-115 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_poll_idle

```
_kernel_oserror *wimp_pollidle          (int mask,              /* R0 in */
                                        WimpPollBlock *block,   /* R1 in */
                                        int time,               /* R2 in */
                                        int *pollword,          /* R3 in */
                                        int *event_code         /* R0 out */);
```

This calls the SWI Wimp_PollIdle (see page 3-184 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_process_key

```
_kernel_oserror *wimp_process_key       (int keycode            /* R0 in */);
```

This calls the SWI Wimp_ProcessKey (see page 3-173 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_read_palette

```
_kernel_oserror *wimp_read_palette      (Palette *palette       /* R1 in */);
```

This calls the SWI Wimp_ReadPalette (see page 3-192 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_read_pix_trans

You might expect a function of this name to be provided to call Wimp_ReadPixTrans. However, such a function is not implemented by WimpLib.

wimp_read_sys_info, WimpSysInfo

```
typedef struct { int r0; int r1; } WimpSysInfo;

_kernel_oserror *wimp_read_sys_info     (int reason,            /* R0 in */
                                        WimpSysInfo *results    /* R0 out */);
```

This calls the SWI Wimp_ReadSysInfo (see pages 3-218 and 5-206 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_redraw_window

```
_kernel_oserror *wimp_redraw_window     (WimpRedrawWindowBlock *block,
                                                                /* R1 in */
                                        int *more               /* R0 out */);
```

This calls the SWI Wimp_RedrawWindow (see page 3-129 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_register_filter

You might expect a function of this name to be provided to call Wimp_RegisterFilter. However, such a function is not implemented by WimpLib.

wimp_remove_messages

```
_kernel_oserror *wimp_remove_messages   (int *list              /* R0 in */);
```

This calls the SWI Wimp_RemoveMessages (see page 3-227 of the RISC OS 3 *Programmer's Reference Manual*). **You must not use this call in Toolbox applications.**

wimp_report_error

```
int wimp_report_error                   (_kernel_oserror *er,   /* R0 in */
                                        int flags,              /* R1 in */
                                        char *name,             /* R2 in */
                                        char *sprite,           /* R3 in */
                                        void *area,             /* R4 in */
                                        char *buttons           /* R5 in */);
```

This calls the SWI Wimp_ReportError (see pages 3-179 and 5-205 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_resize_icon

```
_kernel_oserror *wimp_resize_icon       (int window,            /* R0 in */
                                        int icon,               /* R1 in */
                                        int xmin,               /* R2 in */
                                        int ymin,               /* R3 in */
                                        int xmax,               /* R4 in */
                                        int ymax                /* R5 in */);
```

This calls the SWI Wimp_ResizeIcon (see page 5-217 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_send_message

```
_kernel_oserror *wimp_send_message      (int code,              /* R0 in */
                                        void *block,            /* R1 in */
                                        int handle,             /* R2 in */
                                        int icon,               /* R3 in */
                                        int *th                 /* R2 out */);
```

This calls the SWI Wimp_SendMessage (see page 3-196 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_set_caret_position

```
_kernel_oserror *wimp_set_caret_position(int window_handle,     /* R0 in */
                                         int icon_handle,       /* R1 in */
                                         int xoffset,           /* R2 in */
                                         int yoffset,           /* R3 in */
                                         int height,            /* R4 in */
                                         int index              /* R5 in */);
```

This calls the SWI Wimp_SetCaretPosition (see page 3-152 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_set_colour, Wimp_BackgroundColour

```
#define Wimp_BackgroundColour (128)

_kernel_oserror *wimp_set_colour        (int colour             /* R0 in */);
```

This calls the SWI Wimp_SetColour (see page 3-194 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_set_colour_mapping

```
_kernel_oserror *wimp_set_colour_mapping(int which_palette,     /* R1 in */
                                         int *bpp1,             /* R2 in */
                                         int *bpp2,             /* R3 in */
                                         int *bpp4              /* R4 in */);
```

This calls sets R5, R6 and R7 to zero and then calls the SWI Wimp_SetColourMapping (see page 3-228 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_set_extent

```
_kernel_oserror *wimp_set_extent        (int window_handle,     /* R0 in */
                                         BBox *area             /* R1 in */);
```

This calls the SWI Wimp_SetExtent (see page 3-164 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_set_font_colours

```
_kernel_oserror *wimp_set_font_colours  (int fore               /* R1 in */
                                         int back               /* R2 in */);
```

This calls the SWI Wimp_SetFontColours (see page 3-220 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_set_icon_state

```
_kernel_oserror *wimp_set_icon_state    (WimpSetIconStateBlock *block)
                                                              /* R1 in */;
```

This calls the SWI Wimp_SetIconState (see page 3-139 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_set_mode

```
_kernel_oserror *wimp_set_mode          (int mode             /* R0 in */);
```

This calls the SWI Wimp_SetMode (see page 3-188 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_set_palette, Palette

```
typedef struct                          { unsigned int colours[16];
                                        unsigned int border;
                                        unsigned int pointer1;
                                        unsigned int pointer2;
                                        unsigned int pointer3; } Palette;

_kernel_oserror *wimp_set_palette       (Palette *palette     /* R1 in */);
```

This calls the SWI Wimp_SetPalette (see page 3-190 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_set_pointer_shape

```
_kernel_oserror *wimp_set_pointer_shape (int shape,           /* R0 in */
                                        void *data,           /* R1 in */
                                        int width,            /* R2 in */
                                        int height,           /* R3 in */
                                        int activex,          /* R4 in */
                                        int activey           /* R5 in */);
```

This calls the SWI Wimp_SetPointerShape (see page 3-166 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_set_watchdog_state

You might expect a function of this name to be provided to call Wimp_SetWatchdogState. However, such a function is not implemented by WimpLib.

wimp_slot_size

```
_kernel_oserror *wimp_slot_size         (int current,            /* R0 in */
                                        int next,                /* R1 in */
                                        int *current,            /* R0 out */
                                        int *next,               /* R1 out */
                                        int *free                /* R2 out */);
```

This calls the SWI Wimp_SlotSize (see page 3-206 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_sprite_op, SpriteParams

```
typedef struct {int r3; int r4; int r5; int r6; int r7;} SpriteParams;

_kernel_oserror *wimp_sprite_op         (int code,               /* R0 in */
                                        char *name,              /* R2 in */
                                        SpriteParams *p          /* R3… in */);
```

This calls the SWI Wimp_SpriteOp (see page 3-201 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_start_task

```
_kernel_oserror *wimp_start_task        (char *cl,               /* R0 in */
                                        int *handle              /* R0 out */);
```

This calls the SWI Wimp_StartTask (see page 3-177 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_text_colour

```
_kernel_oserror *wimp_text_colour       (int colour              /* R0 in */);
```

This calls the SWI Wimp_TextColour (see page 3-214 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_text_op

```
_kernel_oserror *wimp_text_op           (_kernel_swi_regs *regs /* R0… in */);
```

This calls the SWI Wimp_TextOp (see page 5-210 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_transfer_block

```
_kernel_oserror *wimp_transfer_block    (int sh,                /* R0 in */
                                         void *sbuf,            /* R1 in */
                                         int dh,                /* R2 in */
                                         void *dbuf,            /* R3 in */
                                         int size               /* R4 in */);
```

This calls the SWI Wimp_TransferBlock (see page 3-216 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_update_window

```
_kernel_oserror *wimp_update_window     (WimpRedrawWindowBlock *block,
                                                                /* R1 in */
                                         int *more              /* R0 out */);
```

This calls the SWI Wimp_UpdateWindow (see page 3-131 of the RISC OS 3 *Programmer's Reference Manual*).

wimp_which_icon

```
_kernel_oserror *wimp_which_icon        (int window_handle,     /* R0 in */
                                         int *icons,            /* R1 in */
                                         unsigned int mask,     /* R2 in */
                                         unsigned int match     /* R3 in */);
```

This calls the SWI Wimp_WhichIcon (see page 3-162 of the RISC OS 3 *Programmer's Reference Manual*).

11 The Toolbox library

The Toolbox library provides a set of C veneers onto the Toolbox SWIs. It is described in the *User Interface Toolbox* manual, supplied as a part of this product. For full details of a particular veneer, you should see the documentation of the corresponding SWI call.

12 The Render library

The Render library provides a set of C veneers onto the DrawFile SWIs, used to render Draw files. It is described in the chapter *DrawFile* on page 493 of the *User Interface Toolbox* manual, supplied as a part of this product. For full details of a particular veneer, you should see the documentation of the corresponding SWI call.

Part 3 – C++ language issues

13 C++ implementation details

This chapter describes implementation specific behaviour of the C++ Language System. Implementation specific behaviours can be categorised as follows:

1. Behaviour that the *Reference Manual* defines as 'implementation dependent'
2. Behaviour that depends on the underlying C compiler or preprocessor used with Release 3.0
3. Properties that are defined in the standard header files `stddef.h`, `limits.h`, and `stdlib.h`
4. Translation limits
5. Language constructs that are not implemented in this release.

This chapter addresses categories 1, 2, 4, and 5. For details about properties defined in the standard header files (category 3), see the headers themselves. Additional information about constructs that are not implemented is provided in the appendix C++ *errors and warnings* on page 339, which contains an alphabetical listing of the 'not implemented' error messages.

The ordering and numbering of sections in this chapter corresponds to the order and numbering of the related sections in the *Reference Manual*. The section *Translation Limits* below (which does not have a corresponding section in the *Reference Manual*) precedes the numbered sections.

Translation Limits

Release 3.0 of the Acorn C++ Language System imposes the following translation limits:

- 50 nesting levels of compound statements
- 10 nesting levels of linkage declarations
- 4088 characters in a token
- 22222 virtual functions in a class
- 10000 identifiers generated by the implementation.

Additional translation limits may be inherited from the underlying C compiler and preprocessor.

Identifiers (2.3)

Identifiers reserved by Release 3.0

Release 3.0 reserves identifiers that contain a sequence of two underscores for its own use. In addition, identifiers reserved in the ANSI C standard are also reserved by Release 3.0. Under the +w option, identifiers with double underscores result in a warning in Release 3.0.

Character Constants (2.5.2)

Value of multicharacter constants

The *Reference Manual* states that the value of a multicharacter constant, such as `'abcd'`, is implementation dependent. Release 3.0 passes these constants to the underlying C compiler, which determines their values. A multicharacter constant containing more characters than `sizeof(int)` is reported as an error by Release 3.0.

Value of (single) character constants

The *Reference Manual* states that the value of a character constant is implementation dependent if it exceeds that of the largest `char`. Release 3.0 accepts octal and hexadecimal character literals that do not fit in a `char`. It uses the low order bits that make up the value of the constant. For example, the octal character constant `'\777'` is treated as `'\377'`. The hexadecimal character constant `'\x123'` is treated as `'\x23'`.

Wide character constants

Release 3.0 does not implement wide character constants, such as `L'ab'`. A 'not implemented' error message is reported.

Floating Constants (2.5.3)

Long double floating constants

When compiling with the `+a0` option, Release 3.0 removes an `l` or `L` suffix from a floating constant before passing the constant to the underlying C compiler. Under the `+a1` option such a constant is passed unchanged to the underlying C compiler. In either case, the constant is considered to be of type `long double` for purposes of resolving overloaded function calls.

String Literals (2.5.4)

Distinct string literals

The *Reference Manual* states that it is implementation dependent whether all string literals are distinct. Release 3.0 does not attempt to detect cases where string literals could be represented as overlapping objects. The underlying C compiler may, however, detect such cases and attempt to overlap their storage.

Wide character strings

Release 3.0 does not implement wide character strings, such as `L"abcd"`. A 'not implemented' error message is reported.

Start and Termination (3.4)

Type of main()

The *Reference Manual* states that the type of `main()` is implementation dependent. Release 3.0 itself does not impose any restrictions on the type of `main()`, but the underlying C compiler or the target environment may impose such restrictions.

Linkage of main()

The Acorn C++ Language System treats `main()` as if its linkage were `extern "C"`.

Fundamental Types (3.6.1)

Signed integral types

Release 3.0 does not implement the type specifier `signed`; it issues a warning and proceeds as though the specifier `signed` had not appeared.

Long double type

When Release 3.0 is invoked with the `+a0` option, the type `long double` is considered to be the same size and precision as the type `double` in the underlying C compiler. Under the `+a1` option, `long double` is passed to the underlying C compiler as `long double`. In either case, type `long double` is considered a distinct type for purposes of resolving overloaded function declarations and invocations.

Alignment requirements

Release 3.0 does not impose any alignment restrictions when allocating objects of a particular type. Such restrictions, if they exist, are enforced by the underlying C compiler.

Integral Conversions (4.2)

Conversion to a signed type

When a value of an integral type is converted to a signed integral type with fewer bits in the representation, Release 3.0 issues a warning message if the `+w` option is specified. The runtime behaviour of such a conversion depends on the treatment of the conversion by the underlying C compiler.

Expressions (5)

Overflow and divide check

The *Reference Manual* states that the handling of overflow and divide check in expression evaluation is implementation dependent. When the second operand of a division or modulus operator is known to be zero at compile time, Release 3.0 reports an error. Overflow and other divide check conditions are handled by the underlying C compiler and execution environment.

Function Call (5.2.2)

Evaluation order

The *Reference Manual* states that the order of evaluation of arguments to a function call is implementation dependent; similarly, the order of evaluation of the postfix expression, which designates the function to be called, and the argument expression list are implementation dependent. In both cases the order depends on the treatment by the underlying C compiler.

Explicit Type Conversion (5.4)

Explicit conversions between pointer and integral types

The *Reference Manual* states that the value obtained by explicitly converting a pointer to an integral type large enough to hold it is implementation dependent. This behaviour is defined by the underlying C compiler. Similarly, the behaviour when explicitly converting an integer to a pointer depends on the underlying C compiler.

Multiplicative Operators (5.6)

Sign of the remainder

The *Reference Manual* states that the sign of the result of the modulus operator is non-negative if both operands are non-negative; otherwise, the sign of the result is implementation dependent. This behaviour depends on the underlying C compiler except when the values of both operands are known at compile time. In this case, the sign of the result is the same as the sign of the numerator.

Shift Operators (5.8)

Result of right shift

The *Reference Manual* states that the result of a right shift when the left operand is a signed type with a negative value is implementation dependent. This behaviour depends on the underlying C compiler.

Relational Operators (5.9)

Pointer comparisons

According to the *Reference Manual*, certain pointer comparisons are implementation dependent. For Release 3.0, the results of these comparisons depend on the underlying C compiler.

Storage Class Specifiers (7.1.1)

Inline functions

The *Reference Manual* states that the **inline** specifier is a hint to the compiler.

When compiling with the **+d** option, Release 3.0 always generates out-of-line calls to inline functions.

Type Specifiers (7.1.6)

Volatile

Release 3.0 does not implement the type specifier **volatile**. If it is applied to a member function, a 'not implemented' error message is issued; otherwise it is ignored and a warning message is issued.

Signed

Release 3.0 does not implement the type specifier **signed**; it is ignored and a warning message is issued.

Asm Declarations (7.3)

Effect of an asm declaration

Release 3.0 passes **asm** declarations to the underlying C compiler without modification. However, the compiler supplied with Acorn C/C++ will fault them.

Linkage Specifications (7.4)

Languages supported

Release 3.0 supports linkage to C and C++.

Linkage to functions

The effect of a **"C"** linkage specification (**extern "C"**) on a function that is not a member function is that the function name is not encoded with type information, as is otherwise done for C++ functions. Member functions are not affected by linkage specifications.

Linkage to non-functions

The C linkage specification (`extern "C"`), when applied to a non-function declaration, does not affect the C code generated.

Class Members (9.2)

Allocation of non-static data members

The *Reference Manual* states that the order of allocation of non-static data members across *access-specifiers* is implementation dependent. Release 3.0 allocates non-static data members in declaration order.

Bitfields (9.6)

Allocation and alignment of bitfields

The *Reference Manual* states that the allocation and alignment of bitfields within a class object is implementation dependent. Responsibility for the allocation and alignment of bitfields rests with the underlying C compiler.

Sign of 'plain' bitfields

Whether the high-order bit position of a 'plain' `int` bitfield is treated as a sign bit depends on the behaviour of the underlying C compiler.

Multiple Base Classes (10.1)

Allocation of base classes

The *Reference Manual* states that the order in which storage is allocated for base classes is implementation dependent. For non-virtual base classes, Release 3.0 allocates storage in the order that they are mentioned in the derived class declaration.

Argument Matching (13.2)

Integral arguments

The type of the result of an integral promotion (4.1) depends on the execution environment, as does the type of an unsuffixed integer constant (2.5.1). Consequently, the determination of which overloaded function to call may also depend on the execution environment, as illustrated by an example in 13.2 of the *Reference Manual*.

Exception Handling (experimental) (15)

Release 3.0 does not implement exception handling. The keyword **`catch`** is reserved for future use. A 'not implemented' error message is reported if **`catch`** is seen.

Predefined Names (16.10)

Predefined macros

The following macros are defined by Release 3.0:

`_ _cplusplus`	The decimal constant 1.
`c_plusplus`	The decimal constant 1. This macro is provided for compatibility with previous releases and will **not** be supported in the next major release.

Other macros may be predefined by the underlying preprocessor.

14 The Streams library

The Streams library is a part of the C++ library, ported from that supplied with AT&T's CFront product. The only significant change made in porting the library is the handling of file modes, because of the differences between filing systems in RISC OS and UNIX.

Introduction

iostream – buffering, formatting and input/output

Synopsis

```
#include <iostream.h>
class streambuf ;
class ios ;
class istream : virtual public ios ;
class ostream : virtual public ios ;
class iostream : public istream, public ostream ;
class istream_withassign : public istream ;
class ostream_withassign : public ostream ;
class iostream_withassign : public iostream ;

class Iostream_init ;

extern istream_withassign cin ;
extern ostream_withassign cout ;
extern ostream_withassign cerr ;
extern ostream_withassign clog ;

#include <fstream.h>
class filebuf : public streambuf ;
class fstream : public iostream ;
class ifstream : public istream ;
class ofstream : public ostream ;

#include <strstream.h>
class strstreambuf : public streambuf ;
class istrstream : public istream ;
class ostrstream : public ostream ;

#include <stdiostream.h>
class stdiobuf : public streambuf ;
class stdiostream : public ios ;
```

Description

The C++ iostream package declared in **iostream.h** and other header files consists primarily of a collection of classes. Although originally intended only to support input/output, the package now supports related activities such as incore formatting.

In the iostream sections, *character* refers to a value that can be held in either a **char** or **unsigned char**. When functions that return an **int** are said to return a character, they return a positive value. Usually such functions can also return **EOF**

(–1) as an error indication. The piece of memory that can hold a character is referred to as a *byte*. Thus, either a **char*** or an **unsigned char*** can point to an array of bytes.

The iostream package consists of several core classes, which provide the basic functionality for I/O conversion and buffering, and several specialised classes derived from the core classes. Both groups of classes are listed below.

Core Classes

The core of the iostream package comprises the following classes:

streambuf

This is the base class for buffers. It supports insertion (also known as *storing* or *putting*) and extraction (also known as *fetching* or *getting*) of characters. Most members are inlined for efficiency. The public interface of class **streambuf** is described in *streambuf – public* on page 232, and the protected interface (for derived classes) is described in *streambuf – protected* on page 224.

ios

This class contains state variables that are common to the various stream classes, for example, error states and formatting states. See *ios* on page 195.

istream

This class supports formatted and unformatted conversion from sequences of characters fetched from **streambuf**s. See *istream* on page 206.

ostream

This class supports formatted and unformatted conversion to sequences of characters stored into **streambuf**s. See *ostream* on page 217.

iostream

This class combines **istream** and **ostream**. It is intended for situations in which bidirectional operations (inserting into and extracting from a single sequence of characters) are desired. See *ios* on page 195.

istream_withassign
ostream_withassign
iostream_withassign

These classes add assignment operators and a constructor with no operands to the corresponding class **without assignment**. The predefined streams (see below) **cin**, **cout**, **cerr**, and **clog**, are objects of these classes. See *istream* on page 206, *ostream* on page 217, and *ios* on page 195.

Iostream_init

This class is present for technical reasons relating to initialisation. It has no public members. The **Iostream_init** constructor initialises the predefined streams (listed below). Because an object of this class is declared in the **iostream.h** header file, the constructor is called once each time the header is included (although the real initialisation is only done once), and therefore the predefined streams will be initialised before they are used. In some cases, global constructors may need to call the **Iostream_init** constructor explicitly to ensure the standard streams are initialised before they are used.

Predefined streams

The following streams are predefined:

cin

The standard input (file descriptor 0).

cout

The standard output (file descriptor 1).

cerr

Standard error (file descriptor 2). Output through this stream is unit-buffered, which means that characters are flushed after each inserter operation. (See *osfx*() on page 219 in *ostream*, and *unitbuf* on page 200 in *ios*.)

clog

This stream is also directed to file descriptor 2, but unlike **cerr** its output is buffered.

Note: `cin`, `cerr`, and `clog` are tied to `cout` so that any use of these will cause `cout` to be flushed.

In addition to the core classes enumerated above, the iostream package contains additional classes derived from them and declared in other headers. Programmers may use these, or may choose to define their own classes derived from the core iostream classes.

Classes derived from streambuf

Classes derived from `streambuf` define the details of how characters are produced or consumed. Derivation of a class from `streambuf` (the *protected interface*) is discussed in *streambuf – protected* on page 224. The available buffer classes are:

`filebuf`

This buffer class supports I/O through file descriptors. Members support opening, closing, and seeking. Common uses do not require the program to manipulate file descriptors. See *filebuf* on page 187.

`stdiobuf`

This buffer class supports I/O through stdio `FILE` structs. It is intended for use when mixing C and C++ code. New code should prefer to use `filebuf`s. See *stdiobuf* on page 223.

`strstreambuf`

This buffer class stores and fetches characters from arrays of bytes in memory (i.e. strings). See *strstreambuf* on page 240.

Classes derived from istream, ostream, and iostream

Classes derived from `istream`, `ostream`, and `iostream` specialise the core classes for use with particular kinds of `streambuf`s. These classes are:

`ifstream`
`ofstream`
`fstream`

These classes support formatted I/O to and from files. They use a `filebuf` to do the I/O. Common operations (such as opening and closing) can be done directly on streams without explicit mention of `filebuf`s. See *fstream* on page 191.

istrstream
ostrstream

These classes support 'in core' formatting. They use a **strstreambuf**. See *strstream* on page 237.

stdiostream

This class specialises **iostream** for stdio **FILE**s. See **stdiostream.h**.

See also

ios (page 195), *streambuf – public* (page 232), *streambuf – protected* (page 224), *filebuf* (page 187), *stdiobuf* (page 223), *strstreambuf* (page 240), *istream* (page 206), *ostream* (page 217), *fstream* (page 191), *strstream* (page 237), *manipulators* (page 213)

filebuf

filebuf – buffer for file I/O

Synopsis

```
#include <iostream.h>

typedef long streamoff, streampos;
class ios {
public:
        enum    seek_dir { beg, cur, end };
        enum    open_mode { in, out, ate, app, trunc, nocreate, noreplace } ;
        // and lots of other stuff; see ios on page 195
} ;

#include <fstream.h>

class filebuf : public streambuf {
public:
        static const int openprot ; /* default protection for open */

                        filebuf() ;
                        ~filebuf() ;
                        filebuf(int d);
                        filebuf(int d, char* p, int len) ;

        filebuf*        attach(int d) ;
        filebuf*        close();
        int             fd();
        int             is_open();
        filebuf*        open(char *name, int omode, int prot=openprot) ;
        streampos       seekoff(streamoff, seek_dir, int omode) ;
        streampos       seekpos(streampos, int omode) ;
        streambuf*      setbuf(char* p, int len) ;
        int             sync() ;
};
```

Description

filebufs specialise **streambuf**s to use a file as a source or sink of characters. Characters are consumed by doing writes to the file, and are produced by doing reads. When the file is seekable, a **filebuf** allows seeks. At least 4 characters of putback are guaranteed. When the file permits reading and writing, the **filebuf** permits both storing and fetching. No special action is required between gets and puts (unlike stdio). A **filebuf** that is connected to a file descriptor is said to be **open**.

Under RISC OS **openprot** is ignored.

The *reserve area* (or *buffer*; see *streambuf – public* on page 232 and *streambuf – protected* on page 224) is allocated automatically if one is not specified explicitly with a constructor or a call to `setbuf()`. `filebuf`s can also be made `unbuffered` with certain arguments to the constructor or `setbuf()`, in which case a system call is made for each character that is read or written. The `get` and `put` pointers into the reserve area are conceptually tied together; they behave as a single pointer. Therefore, the descriptions below refer to a single get/put pointer.

In the descriptions below, assume:

- *f* is a `filebuf`.
- *pfb* is a `filebuf*`.
- *psb* is a `streambuf*`.
- *i*, *d*, *len*, and *prot* are `int`s.
- *name* and *ptr* are `char*`s.
- *mode* is an `int` representing an `open_mode`.
- *off* is a `streamoff`.
- *p* and *pos* are `streampos`'s.
- *dir* is a `seek_dir`.

Constructors

`filebuf()`

Constructs an initially closed `filebuf`.

`filebuf(d)`

Constructs a `filebuf` connected to file descriptor *d*.

`filebuf(d, p, len)`

Constructs a `filebuf` connected to file descriptor *d* and initialised to use the reserve area starting at *p* and containing len bytes. If *p* is null or *len* is zero or less, the `filebuf` will be unbuffered.

Members

pfb=*f*.attach(*d*)

Connects *f* to an open file descriptor, *d*. attach() normally returns &*f*, but returns 0 if *f* is already open.

pfb=*f*.close()

Flushes any waiting output, closes the file descriptor, and disconnects *f*. Unless an error occurs, f's error state will be cleared. close() returns &*f* unless errors occur, in which case it returns 0. Even if errors occur, close() leaves the file descriptor and *f* closed.

i=*f*.fd()

Returns *i*, the file descriptor *f* is connected to. If *f* is closed, i is EOF.

i=*f*.is_open()

Returns non-zero when *f* is connected to a file descriptor, and zero otherwise.

pfb=*f*.open(*name*, *mode*, *prot*)

Opens file *name* and connects *f* to it. If the file does not already exist, an attempt is made to create it, unless ios::nocreate is specified in *mode*. Under RISC OS, *prot* is ignored. Failure occurs if *f* is already open. open() normally returns &*f*, but if an error occurs it returns 0. The members of open_mode are bits that may be OR'd together. (Because the OR'ing returns an int, open() takes an int rather than an open_mode argument.) The meanings of these bits in *mode* are described in detail in *fstream* on page 191.

p=*f*.seekoff(*off*, *dir*, *mode*)

Moves the get/put pointer as designated by *off* and *dir*. It may fail if the file that *f* is attached to does not support seeking, or if the attempted motion is otherwise invalid (such as attempting to seek to a position before the beginning of file). *off* is interpreted as a count relative to the place in the file specified by dir as described in *streambuf – public* on page 232. *mode* is ignored. seekoff() returns *p*, the new position, or EOF if a failure occurs. The position of the file after a failure is undefined.

`p=f.seekpos(pos, mode)`

Moves the file to a position *`pos`* as described in *streambuf – public* on page 232. *`mode`* is ignored. **`seekpos()`** normally returns *`pos`*, but on failure it returns **`EOF`**.

`psb=f.setbuf(ptr, len)`

Sets up the reserve area as *`len`* bytes beginning at *`ptr`*. If *`ptr`* is null or *`len`* is less than or equal to 0, *`f`* will be unbuffered. **`setbuf()`** normally returns **`&f`**. However, if *`f`* is open and a buffer has been allocated, no changes are made to the reserve area or to the buffering status, and **`setbuf()`** returns 0.

`i=f.sync()`

Attempts to force the state of the get/put pointer of *`f`* to agree (be synchronised) with the state of the file **`f.fd()`**. This means it may write characters to the file if some have been buffered for output or attempt to reposition (seek) the file if characters have been read and buffered for input. Normally, **`sync()`** returns 0, but it returns **`EOF`** if synchronisation is not possible.

Sometimes it is necessary to guarantee that certain characters are written together. To do this, the program should use **`setbuf()`** (or a constructor) to guarantee that the reserve area is at least as large as the number of characters that must be written together. It can then call **`sync()`**, then store the characters, then call **`sync()`** again.

See also

streambuf – public (page 232), *streambuf – protected* (page 224), *fstream* (page 191).

fstream

fstream – iostream and streambuf specialised to files

Synopsis

```
#include <fstream.h>

typedef long streamoff, streampos;
class ios {
public:
        enum    seek_dir { beg, cur, end } ;
        enum    open_mode { in, out, ate, app, trunc, nocreate, noreplace } ;
        enum    io_state { goodbit=0, eofbit, failbit, badbit } ;
        // and lots of other stuff; see ios on page 195
};

class ifstream : istream {
                        ifstream() ;
                        ~ifstream() ;
                        ifstream(const char* name, int =ios::in,
                                int prot =filebuf::openprot) ;
                        ifstream(int fd) ;
                        ifstream(int fd, char* p, int l) ;

        void            attach(int fd) ;
        void            close() ;
        void            open(char* name, int =ios::in,
                                int prot=filebuf::openprot) ;
        filebuf*        rdbuf() ;
        void            setbuf(char* p, int l) ;
};

class ofstream : ostream {
                        ofstream() ;
                        ~ofstream() ;
                        ofstream(const char* name, int =ios::out,
                                int prot =filebuf::openprot) ;
                        ofstream(int fd) ;
                        ofstream(int fd, char* p, int l) ;

        void            attach(int fd) ;
        void            close() ;
        void            open(char* name, int =ios::out,
                                int prot=filebuf::openprot) ;
        filebuf*        rdbuf() ;
        void            setbuf(char* p, int l) ;
};
```

```
class fstream : iostream {
                        fstream() ;
                        ~fstream() ;
                        fstream(const char* name, int mode,
                                int prot =filebuf::openprot) ;
                        fstream(int fd) ;
                        fstream(int fd, char* p, int l) ;

        void            attach(int fd) ;
        void            close() ;
        void            open(char* name, int mode,
                                int prot=filebuf::openprot) ;
        filebuf*        rdbuf() ;
        void            setbuf(char* p, int l) ;
};
```

Description

ifstream, **ofstream**, and **fstream** specialise **istream**, **ostream**, and **iostream**, respectively, to files. That is, the associated **streambuf** will be a **filebuf**.

In the following descriptions, assume:

- *f* is any of **ifstream**, **ofstream**, or fstream.
- *pfb* is a **filebuf*.**
- *psb* is a **streambuf***.
- *name* and *ptr* are **char***s.
- *i*, *fd*, *len*, and *prot* are **int**s.
- *mode* is an **int** representing an **open_mode**.

Constructors

The constructors for ***x*stream**, where *x* is either **if**, **of**, or **f**, are:

***x*stream()**

Constructs an unopened ***x*stream**.

***x*stream(*name*, *mode*, *prot*)**

Constructs an ***x*stream** and opens file *name* using *mode* as the open mode. Under RISC OS *prot* is ignored. The error state (**io_state**) of the constructed ***x*stream** will indicate failure in case the **open** fails.

xstream(d)

Constructs an **xstream** connected to file descriptor *d*, which must be already open.

xstream(d,ptr,len)

Constructs an **xstream** connected to file descriptor *d*, and, in addition, initialises the associated **filebuf** to use the *len* bytes at *ptr* as the reserve area. If *ptr* is null or *len* is 0, the **filebuf** will be unbuffered.

Member functions

f.attach(d)

Connects *f* to the file descriptor *d*. A failure occurs when *f* is already connected to a file. A failure sets **ios::failbit** in *f*'s error state.

f.close()

Closes any associated **filebuf** and thereby breaks the connection of the *f* to a file.

f's error state is cleared except on failure. A failure occurs when the call to **f.rdbuf()->close()** fails.

f.open(name,mode,prot)

Opens file *name* and connects *f* to it. If the file does not already exist, an attempt is made to create it unless **ios::nocreate** is set. Under RISC OS *prot* is ignored. Failure occurs if *f* is already open, or the call to **f.rdbuf()->open()** fails. **ios::failbit** is set in *f*'s error status on failure. The members of **open_mode** are bits that may be OR'd together. (Because the OR'ing returns an **int**, **open()** takes an **int** rather than an **open_mode** argument.) The meanings of these bits in mode are:

ios::app	A seek to the end of file is performed. Subsequent data written to the file is always added (appended) at the end of file. **ios::app** implies **ios::out**.
ios::ate	A seek to the end of the file is performed during the **open()**. **ios::ate** does not imply **ios::out**.
ios::in	The file is opened for input. **ios::in** is implied by construction and opens of **ifstream**s. For **fstream**s it indicates that input operations should be allowed if possible. Is is legal to include **ios::in** in the modes of

	an `ostream` in which case it implies that the original file (if it exists) should not be truncated. If the file being opened for input does not exist, the open will fail.
`ios::out`	The file is opened for output. `ios::out` is implied by construction and opens of `ofstream`s. For `fstream` it says that output operations are to be allowed. `ios::out` may be specified.
`ios::trunc`	If the file already exists, its contents will be truncated (discarded). This mode is implied when `ios::out` is specified (including implicit specification for `ofstream`) and neither `ios::ate` nor `ios::app` is specified.
`ios::nocreate`	If the file does not already exist, the `open()` will fail.
`ios::noreplace`	If the file already exists, the `open()` will fail. Only valid with `ios::out`.

***pfb=f*`.rdbuf()`**

Returns a pointer to the `filebuf` associated with *`f`*. `fstream::rdbuf()` has the same meaning as `iostream::rdbuf()` but is typed differently.

***f*`.setbuf(`*`p,len`*`)`**

Has the usual effect of a `setbuf()` (see *filebuf* on page 187), offering space for a reserve area or requesting unbuffered I/O. Normally the returned *`psb`* is *`f`*`.rdbuf()`, but it is 0 on failure. A failure occurs if *`f`* is open or the call to *`f`*`.rdbuf()->setbuf` fails.

See also

filebuf (page 187), *istream* (page 206), *ios* (page 195), *ostream* (page 217), *streambuf – public* (page 232)

ios

ios – input/output formatting

Synopsis

```
#include <iostream.h>

class ios {
public:
        enum    io_state { goodbit=0, eofbit, failbit, badbit };
        enum    open_mode { in, out, ate, app, trunc, nocreate, noreplace };
        enum    seek_dir { beg, cur, end };
        /* flags for controlling format */
        enum    { skipws=01,
                  left=02, right=04, internal=010,
                  dec=020, oct=040, hex=0100,
                  showbase=0200, showpoint=0400,
                  uppercase=01000, showpos=02000,
                  scientific=04000, fixed=010000,
                  unitbuf=020000, stdio=040000 };
        static const long basefield;
                /* dec|oct|hex */
        static const long adjustfield;
                /* left|right|internal */
        static const long floatfield;
                /* scientific|fixed */

public:
                        ios(streambuf*);
        int             bad();
        static long     bitalloc();
        void            clear(int state =0);
        int             eof();
        int             fail();
        char            fill();
        char            fill(char);
        long            flags();
        long            flags(long);
        int             good();
        long&           iword(int);
        int             operator!();
                        operator void*();
        int             precision();
        int             precision(int);
        streambuf*      rdbuf();
        void* &         pword(int);
        int             rdstate();
        long            setf(long setbits, long field);
        long            setf(long);
        static void     sync_with_stdio();
```

```
        ostream*        tie();
        ostream*        tie(ostream*);
        long            unsetf(long);
        int             width();
        int             width(int);
        static int      xalloc();

protected:
                        ios();
                        init(streambuf*);
private:
                        ios(ios&);
        void            operator=(ios&);
};

        /* Manipulators */
ios&            dec(ios&) ;
ios&            hex(ios&) ;
ios&            oct(ios&) ;
ostream&        endl(ostream& i) ;
ostream&        ends(ostream& i) ;
ostream&        flush(ostream&) ;
istream&        ws(istream&) ;
```

Description

The stream classes derived from class **ios** provide a high level interface that supports transferring formatted and unformatted information into and out of **streambuf**s. This section describes the operations common to both input and output.

Several enumerations are declared in class **ios**, **open_mode**, **io_state**, **seek_dir**, and format flags, to avoid polluting the global name space. The **io_state**s are described in *Error states* on page 197. The format fields are described in *Formatting* on page 198. The **open_mode**s are described in detail under *pfb=f.open(name, mode, prot)* on page 189, in the section *fstream*. The **seek_dir**s are described under *pos=sb->seekoff(off, dir, mode)* on page 229, in the section *streambuf – public*.

In the following descriptions assume:

- *s* and *s2* are **ios**s.
- *sr* is an **ios&**.
- *sp* is a **ios***.
- *i*, *oi*, *j*, and *n* are **int**s.
- *l*, *f*, and *b* are **long**s.
- *c* and *oc* are **char**s.
- *osp* and *oosp* are **ostream***s.

- *sb* is a `streambuf*`.
- *pos* is a `streampos`.
- *off* is a `streamoff`.
- *dir* is a `seek_dir`.
- *mode* is an `int` representing an `open_mode`.
- *fct* is a function with type `ios& (*)(ios&)`.
- *vp* is a `void*&`.

Constructors and assignment

`ios(sb)`

The `streambuf` denoted by *sb* becomes the `streambuf` associated with the constructed `ios`. If *sb* is null, the effect is undefined.

`ios(sr)`
s2=s

Copying of `ios`s is not well-defined in general, therefore the constructor and assignment operators are private so that the compiler will complain about attempts to copy `ios` objects. Copying pointers to `iostream`s is usually what is desired.

`ios()`
`init(sb)`

Because class `ios` is now inherited as a virtual base class, a constructor with no arguments must be used. This constructor is declared protected. Therefore `ios::init(streambuf*)` is declared protected and must be used for initialisation of derived classes.

Error states

An `ios` has an internal error state (which is a collection of the bits declared as `io_states`). Members related to the error state are:

***i=s*.rdstate()**

Returns the current error state.

***s*.clear(*i*)**

Stores *i* as the error state. If *i* is zero, this clears all bits. To set a bit without clearing previously set bits requires something like
`s.clear(ios::badbit|s.rdstate())`.

i=s.good()

Returns non-zero if the error state has no bits set, zero otherwise.

i=s.eof()

Returns non-zero if **eofbit** is set in the error state, zero otherwise. Normally this bit is set when an end-of-file has been encountered during an extraction.

i=s.fail()

Returns non-zero if either **badbit** or **failbit** is set in the error state, zero otherwise. Normally this indicates that some extraction or conversion has failed, but the stream is still usable. That is, once the **failbit** is cleared, I/O on ***s*** can usually continue.

i=s.bad()

Returns non-zero if **badbit** is set in the error state, zero otherwise. This usually indicates that some operation on **s.rdbuf()** has failed, a severe error, from which recovery is probably impossible. That is, it will probably be impossible to continue I/O operations on ***s***.

Operators

Two operators are defined to allow convenient checking of the error state of an **ios**: **operator!()** and **operator void*()**. The latter converts an **ios** to a pointer so that it can be compared to zero. The conversion will return 0 if **failbit** or **badbit** is set in the error state, and will return a pointer value otherwise. This pointer is not meant to be used. This allows one to write expressions such as:

```
if ( cin ) ...
if ( cin >> x ) ...
```

The **!** operator returns non-zero if **failbit** or **badbit** is set in the error state, which allows expressions like the following to be used:

```
if ( !cout ) ...
```

Formatting

An **ios** has a format state that is used by input and output operations to control the details of formatting operations. For other operations the format state has no particular effect and its components may be set and examined arbitrarily by user code. Most formatting details are controlled by using the **flags()**, **setf()**, and **unsetf()** functions to set the following flags, which are declared in an enumeration in class **ios**. Three other components of the format state are controlled separately with the functions **fill()**, **width()**, and **precision()**.

skipws

If **skipws** is set, whitespace will be skipped on input. This applies to scalar extractions. When **skipws** is not set, whitespace is not skipped before the extractor begins conversion. If **skipws** is not set and a zero length field is encountered, the extractor will signal an error. Additionally, the arithmetic extractors will signal an error if **skipws** is not set and a whitespace is encountered.

left
right
internal

These flags control the padding of a value. When **left** is set, the value is left-adjusted, that is, the fill character is added after the value. When **right** is set, the value is right-adjusted, that is, the fill character is added before the value. When **internal** is set, the fill character is added after any leading sign or base indication, but before the value. Right-adjustment is the default if none of these flags is set. These fields are collectively identified by the static member, **ios::adjustfield**. The fill character is controlled by the **fill()** function, and the width of padding is controlled by the **width()** function.

dec
oct
hex

These flags control the conversion base of a value. The conversion base is 10 (decimal) if **dec** is set, but if **oct** or **hex** is set, conversions are done in octal or hexadecimal, respectively. If none of these is set, insertions are in decimal, but extractions are interpreted according to the C++ lexical conventions for integral constants. These fields are collectively identified by the static member, **ios::basefield**. The manipulators **hex**, **dec**, and **oct** can also be used to set the conversion base; see the section *Built-in Manipulators* on page 204.

showbase

If **showbase** is set, insertions will be converted to an external form that can be read according to the C++ lexical conventions for integral constants. **showbase** is unset by default.

showpos

If **showpos** is set, then a '**+**' will be inserted into a decimal conversion of a positive integral value.

uppercase

If **uppercase** is set, then an uppercase '**X**' will be used for hexadecimal conversion when **showbase** is set, or an uppercase '**E**' will be used to print floating point numbers in scientific notation.

showpoint

If **showpoint** is set, trailing zeros and decimal points appear in the result of a floating point conversion.

scientific
fixed

These flags control the format to which a floating point value is converted for insertion into a stream. If scientific is set, the value is converted using scientific notation, where there is one digit before the decimal point and the number of digits after it is equal to the **precision** (see below), which is six by default. An uppercase '**E**' will introduce the exponent if **uppercase** is set, a lowercase '**e**' will appear otherwise. If **fixed** is set, the value is converted to decimal notation with **precision** digits after the decimal point, or six by default. If neither **scientific** nor **fixed** is set, then the value will be converted using either notation, depending on the value; scientific notation will be used if the exponent resulting from the conversion is less than –4 or greater than or equal to **precision** digits. Otherwise the value will be converted to decimal notation with **precision** digits total. If **showpoint** is not set, trailing zeroes are removed from the result and a decimal point appears only if it is followed by a digit. **scientific** and **fixed** are collectively identified by the static member **ios::floatfield**.

unitbuf

When set, a flush is performed by **ostream::osfx()** after each insertion. Unit buffering provides a compromise between buffered output and unbuffered output. Performance is better under unit buffering than unbuffered output, which makes a system call for each character output. Unit buffering makes a system call for each insertion operation, and doesn't require the user to call **ostream::flush()**.

stdio

When set, **stdout** and **stderr** are flushed by **ostream::osfx()** after each insertion.

The following functions use and set the format flags and variables:

`oc=s.fill(c)`

Sets the *fill character* format state variable to `c` and returns the previous value. `c` will be used as the padding character, if one is necessary (see `width()` below). The default fill or padding character is a space. The positioning of the fill character is determined by the `right`, `left`, and `internal` flags; see above. A parameterised manipulator, `setfill`, is also available for setting the fill character; see *manipulators* on page 213.

`c=s.fill()`

Returns the 'fill character' format state variable.

`l=s.flags()`

Returns the current format flags.

`l=s.flags(f)`

Resets all the format flags to those specified in `f` and returns the previous settings.

`oi=s.precision(i)`

Sets the `precision` format state variable to `i` and returns the previous value. This variable controls the number of significant digits inserted by the floating point inserter. The default is 6. A parameterised manipulator, `setprecision`, is also available for setting the precision; see *manipulators* on page 213.

`i=s.precision()`

Returns the `precision` format state variable.

`l=s.setf(b)`

Turns on in `s` the format flags marked in `b` and returns the previous settings. A parameterised manipulator, `setiosflags`, performs the same function; see *manipulators* on page 213.

`l=s.setf(b,f)`

Resets in `s` only the format flags specified by `f` to the settings marked in `b`, and returns the previous settings. That is, the format flags specified by `f` are cleared in `s`, then reset to be those marked in `b`. For example, to change the conversion base in `s` to be `hex`, one could write: `s.setf(ios::hex,ios::basefield)`. `ios::basefield` specifies the conversion base bits as candidates for change.

and `ios::hex` specifies the new value. `s.setf(0,f)` will clear all the bits specified by `f`, as will a parameterised manipulator, `resetiosflags`; see *manipulators* on page 213.

`l=s.unsetf(b)`

Unsets in `s` the bits set in `b` and returns the previous settings.

`oi=s.width(i)`

Sets the *field-width* format variable to `i` and returns the previous value. When the field width is zero (the default), inserters will insert only as many characters as necessary to represent the value being inserted. When the *field-width* is non-zero, the inserters will insert at least that many characters, using the fill character to pad the value, if the value being inserted requires fewer than *field-width* characters to be represented. However, the numeric inserters never truncate values, so if the value being inserted will not fit in *field-width* characters, more than *field-width* characters will be output. The *field-width* is always interpreted as a minimum number of characters; there is no direct way to specify a maximum number of characters. The *field-width* format variable is reset to the default (zero) after each insertion or extraction, and in this sense it behaves as a parameter for insertions and extractions. A parameterised manipulator, `setw`, is also available for setting the width; see *manipulators* on page 213.

`i=s.width()`

Returns the *field-width* format variable.

User-defined Format Flags

Class `ios` can be used as a base class for derived classes that require additional format flags or variables. The iostream library provides several functions to do this. The two static member functions `ios::xalloc` and `ios::bitalloc`, allow several such classes to be used together without interference.

`b=ios::bitalloc()`

Returns a `long` with a single, previously unallocated, bit set. This allows users who need an additional flag to acquire one, and pass it as an argument to `ios::setf()`, for example.

`i=ios::xalloc()`

Returns a previously unused index into an array of words available for use as format state variables by derived classes.

`l=s.iword(i)`

When `i` is an index allocated by `ios::xalloc`, `iword()` returns a reference to the `i`th user-defined word.

`vp=s.pword(i)`

When `i` is an index allocated by `ios::xalloc`, `pword()` returns a reference to the `i`th user-defined word. `pword()` is the same as `iword` except that it is typed differently.

Other members

`sb=s.rdbuf()`

Returns a pointer to the `streambuf` associated with `s` when `s` was constructed.

`ios::sync_with_stdio()`

Solves problems that arise when mixing stdio and iostreams. The first time it is called it will reset the standard iostreams (`cin`, `cout`, `cerr`, `clog`) to be streams using `stdiobuf`s. After that, input and output using these streams may be mixed with input and output using the corresponding `FILE`s (`stdin`, `stdout`, and `stderr`) and will be properly synchronised. `sync_with_stdio()` makes `cout` and `cerr` unit buffered (see `ios::unitbuf` and `ios::stdio` above). Invoking `sync_with_stdio()` degrades performance a variable amount, depending on the length of the strings being inserted (shorter strings incur a larger performance hit).

`oosp=s.tie(osp)`

Sets the `tie` variable to `osp`, and returns its previous value. This variable supports automatic 'flushing' of `ios`s. If the `tie` variable is non-null and an `ios` needs more characters or has characters to be consumed, the `ios` pointed at by the `tie` variable is flushed. By default, `cin` is tied initially to `cout` so that attempts to get more characters from standard input result in flushing standard output. Additionally, `cerr` and `clog` are tied to `cout` by default. For other `ios`s, the `tie` variable is set to zero by default.

`osp=s.tie()`

Returns the `tie` variable.

Built-in Manipulators

Some convenient manipulators (functions that take an **ios&**, an **istream&**, or an **ostream&** and return their argument; see *manipulators* on page 213) are:

***sr*<<dec**
***sr*>>dec**

These set the conversion base format flag to 10.

***sr*<<hex**
***sr*>>hex**

These set the conversion base format flag to 16.

***sr*<<oct**
***sr*>>oct**

These set the conversion base format flag to 8.

***sr*>>ws**

Extracts whitespace characters. See *istream* on page 206.

***sr*<<endl**

Ends a line by inserting a newline character and flushing. See *ostream* on page 217.

***sr*<<ends**

Ends a string by inserting a null (0) character. See *ostream* on page 217.

***sr*<<flush**

Flushes **outs**. See *ostream* on page 217.

Several parameterised manipulators that operate on ios objects are described in *manipulators* on page 213: **setw**, **setfill**, **setprecision**, **setiosflags**, and **resetiosflags**.

The **streambuf** associated with an **ios** may be manipulated by other methods than through the **ios**. For example, characters may be stored in a queuelike **streambuf** through an **ostream** while they are being fetched through an **istream**. Or for efficiency some part of a program may choose to do **streambuf** operations directly rather than through the **ios**. In most cases the program does not have to worry about this possibility, because an **ios** never saves information about the internal state of a **streambuf**. For example, if the **streambuf** is repositioned between extraction operations the extraction (input) will proceed normally.

See also

Introduction (page 182), *streambuf – protected* (page 224), *streambuf – public* (page 232), *istream* (page 206), *ostream* (page 217), *manipulators* (page 213)

istream

istream – formatted and unformatted input

Synopsis

```
#include <iostream.h>

typedef long streamoff, streampos;
class ios {
public:
        enum    seek_dir { beg, cur, end };
        enum    open_mode { in, out, ate, app, trunc, nocreate, noreplace } ;
        /* flags for controlling format */
        enum    { skipws=01,
                  left=02, right=04, internal=010,
                  dec=020, oct=040, hex=0100,
                  showbase=0200, showpoint=0400,
                  uppercase=01000, showpos=02000,
                  scientific=04000, fixed=010000,
                  unitbuf=020000, stdio=040000 };
        // and lots of other stuff; see ios on page 195
} ;

class istream : public ios {
public:
                        istream(streambuf*);
        int             gcount();
        istream&        get(char* ptr, int len, char delim='\n');
        istream&        get(unsigned char* ptr,int len, char delim='\n');

        istream&        get(unsigned char&);
        istream&        get(char&);
        istream&        get(streambuf& sb, char delim ='\n');
        int             get();
        istream&        getline(char* ptr, int len, char delim='\n');
        istream&        getline(unsigned char* ptr, int len, char delim='\n');
        istream&        ignore(int len=1,int delim=EOF);
        int             ipfx(int need=0);
        int             peek();
        istream&        putback(char);
        istream&        read(char* s, int n);
        istream&        read(unsigned char* s, int n);
        istream&        seekg(streampos);
        istream&        seekg(streamoff, seek_dir);
        int             sync();
        streampos       tellg();
```

```
        istream&        operator>>(char*);
        istream&        operator>>(char&);
        istream&        operator>>(short&);
        istream&        operator>>(int&);
        istream&        operator>>(long&);
        istream&        operator>>(float&);
        istream&        operator>>(double&);
        istream&        operator>>(unsigned char*);
        istream&        operator>>(unsigned char&);
        istream&        operator>>(unsigned short&);
        istream&        operator>>(unsigned int&);
        istream&        operator>>(unsigned long&);
        istream&        operator>>(streambuf*);
        istream&        operator>>(istream& (*)(istream&));
        istream&        operator>>(ios& (*)(ios&));
};

class istream_withassign : public istream {
                        istream_withassign();
        istream&        operator=(istream&);
        istream&        operator=(streambuf*);
};

extern istream_withassign cin;

istream&        ws(istream&);
ios&            dec(ios&) ;
ios&            hex(ios&) ;
ios&            oct(ios&) ;
```

Description

istreams support interpretation of characters fetched from an associated **streambuf**. These are commonly referred to as input or extraction operations. The **istream** member functions and related functions are described below.

In the following descriptions assume that

- *ins* is an **istream**.
- *inswa* is an **istream_withassign**.
- *insp* is an **istream***.
- *c* is a **char&**
- *delim* is a **char**.
- *ptr* is a **char*** or **unsigned char***.
- *sb* is a **streambuf&**.
- *i*, *n*, *len*, *d*, and *need* are **int**s.
- *pos* is a **streampos**.
- *off* is a **streamoff**.

- *dir* is a `seek_dir`.
- *manip* is a function with type `istream& (*)(istream&)`.

Constructors and assignment

`istream(sb)`

Initialises `ios` state variables and associates buffer *sb* with the `istream`.

`istream_withassign()`

Does no initialisation.

inswa=sb

Associates *sb* with *inswa* and initialises the entire state of *inswa*.

inswa=ins

Associates *ins*`->rdbuf()` with *inswa* and initialises the entire state of *inswa*.

Input prefix function

***i = ins*`.ipfx(`*need*`)`**

If *ins*'s error state is non-zero, returns zero immediately. If necessary (and if it is non-null), any `ios` tied to *ins* is flushed (see the description of `ios::tie()` on page 203 onwards of *ios*. Flushing is considered necessary if either *need*`==0` or if there are fewer than *need* characters immediately available. If `ios::skipws` is set in *ins*`.flags()` and *need* is zero, then leading whitespace characters are extracted from *ins*. `ipfx()` returns zero if an error occurs while skipping whitespace; otherwise it returns non-zero.

Formatted input functions call `ipfx(0)`, while unformatted input functions call `ipfx(1)`; see below.

Formatted input functions (extractors)

ins>>x

Calls `ipfx(0)` and if that returns non-zero, extracts characters from *ins* and converts them according to the type of *x*. It stores the converted value in *x*. Errors are indicated by setting the error state of *ins*. `ios::failbit` means that characters in *ins* were not a representation of the required type. `ios::badbit` indicates that attempts to extract characters failed. *ins* is always returned.

The details of conversion depend on the values of ins's format state flags and variables (see *ios* on page 195) and the type of x. Except that extractions that use width reset it to 0, the extraction operators do not change the value of ostream's format state. Extractors are defined for the following types, with conversion rules as described below.

`char*`, `unsigned char*`	Characters are stored in the array pointed at by ***x*** until a whitespace character is found in ***ins***. The terminating whitespace is left in ***ins***. If ***ins*****`.width()`** is non-zero it is taken to be the size of the array, and no more than ***ins*****`.width()-1`** characters are extracted. A terminating null character (0) is always stored (even when nothing else is done because of ***ins***'s error status). ***ins*****`.width()`** is reset to 0.
`char&`, `unsigned char&`	A character is extracted and stored in ***x***.
`short&`, `unsigned short&`, `int&`, `unsigned int&`, `long&`, `unsigned long&`	Characters are extracted and converted to an integral value according to the conversion specified in ***ins***'s format flags. Converted characters are stored in ***x***. The first character may be a sign (+ or -). After that, if **`ios::oct`**, **`ios::dec`**, or **`ios::hex`** is set in ***ins*****`.flags()`**, the conversion is octal, decimal, or hexadecimal, respectively. Conversion is terminated by the first 'non-digit,' which is left in ***ins***. Octal digits are the characters '0' to '7'. Decimal digits are the octal digits plus '8' and '9'. Hexadecimal digits are the decimal digits plus the letters 'a' through 'f' (in either upper or lower case). If none of the conversion base format flags is set, then the number is interpreted according to C++ lexical conventions. That is, if the first characters (after the optional sign) are **`0x`** or **`0X`** a hexadecimal conversion is performed on following hexadecimal digits. Otherwise, if the first character is a **`0`**, an octal conversion is performed, and in all other cases a decimal conversion is performed. **`ios::failbit`** is set if there are no digits (not counting the **`0`** in **`0x`** or **`0X`**) during hex conversion) available.
`float&`, `double&`	Converts the characters according to C++ syntax for a float or double, and stores the result in ***x***. **`ios::failbit`** is set if there are no digits available in ***ins*** or if it does not begin with a well formed floating point number.

The type and name (`operator>>`) of the extraction operations are chosen to give a convenient syntax for sequences of input operations. The operator overloading of C++ permits extraction functions to be declared for user-defined classes. These operations can then be used with the same syntax as the member functions described here.

ins>>sb

If `ios.ipfx(0)` returns non-zero, extracts characters from `ios` and inserts them into *sb*. Extraction stops when `EOF` is reached. Always returns *ins*.

Unformatted input functions

These functions call `ipfx(1)` and proceed only if it returns non-zero:

insp=&ins.get(ptr,len,delim)

Extracts characters and stores them in the byte array beginning at *ptr* and extending for *len* bytes. Extraction stops when *delim* is encountered (*delim* is left in *ins* and not stored), when *ins* has no more characters, or when the array has only one byte left. `get` always stores a terminating null, even if it doesn't extract any characters from *ins* because of its error status. `ios::failbit` is set only if get encounters an end of file before it stores any characters.

insp=&ins.get(c)

Extracts a single character and stores it in *c*.

insp=&ins.get(sb,delim)

Extracts characters from *ins*`.rdbuf()` and stores them into *sb*. It stops if it encounters end of file or if a store into *sb* fails or if it encounters *delim* (which it leaves in *ins*). `ios::failbit` is set if it stops because the store into *sb* fails.

i=ins.get().

Extracts a character and returns it. *i* is `EOF` if extraction encounters end of file. `ios::failbit` is never set.

insp=&ins.getline(ptr,len,delim)

Does the same thing as *ins*`.get(`*ptr,len,delim*`)` with the exception that it extracts a terminating *delim* character from *ins*. In case *delim* occurs when exactly *len* characters have been extracted, termination is treated as being due to the array being filled, and this *delim* is left in *ins*.

***insp*=&*ins*.ignore(*n*,*d*)**

Extracts and throws away up to *n* characters. Extraction stops prematurely if *d* is extracted or end of file is reached. If *d* is **EOF** it can never cause termination.

***insp*=&*ins*.read(*ptr*,*n*)**

Extracts *n* characters and stores them in the array beginning at *ptr*. If end of file is reached before *n* characters have been extracted, **read** stores whatever it can extract and sets **ios::failbit**. The number of characters extracted can be determined via *ins*.gcount().

Other members

***i*=*ins*.gcount()**

Returns the number of characters extracted by the last unformatted input function. Formatted input functions may call unformatted input functions and thereby reset this number.

***i*=*ins*.peek()**

Begins by calling *ins*.ipfx(1). If that call returns zero or if *ins* is at end of file, it returns **EOF**. Otherwise it returns the next character without extracting it.

***insp*=&*ins*.putback(*c*)**

Attempts to back up *ins*.rdbuf(). *c* must be the character before *ins*.rdbuf()'s get pointer. (Unless other activity is modifying *ins*.rdbuf() this is the last character extracted from *ins*.) If it is not, the effect is undefined. **putback** may fail (and set the error state). Although it is a member of **istream**, **putback** never extracts characters, so it does not call *ipfx*. It will, however, return without doing anything if the error state is non-zero.

***i*=&*ins*.sync()**

Establishes consistency between internal data structures and the external source of characters. Calls *ins*.rdbuf()->sync(), which is a virtual function, so the details depend on the derived class. Returns **EOF** to indicate errors.

***ins*>>manip**

Equivalent to **manip(*ins*)**. Syntactically this looks like an extractor operation, but semantically it does an arbitrary operation rather than converting a sequence of characters and storing the result in **manip**. A predefined manipulator, *ws*, is described below.

Member functions related to positioning

insp=&ins.seekg(off,dir)

Repositions ***ins.rdbuf()***'s get pointer. See *streambuf – public* on page 232 for a discussion of positioning.

insp=&ins.seekg(pos)

Repositions ***ins.rdbuf()***'s get pointer. See *streambuf – public* on page 232 for a discussion of positioning.

pos=ins.tellg()

The current position of **ios.rdbuf()**'s get pointer. See *streambuf – public* on page 232 for a discussion of positioning.

Manipulator

ins>>ws

Extracts whitespace characters.

ins>>dec

Sets the conversion base format flag to 10. See *ios* on page 195.

ins>>hex

Sets the conversion base format flag to 16. See *ios* on page 195.

ins>>oct

Sets the conversion base format flag to 8. See *ios* on page 195.

Caveats

There is no overflow detection on conversion of integers.

See also

ios (page 195), *streambuf – public* (page 232), *manipulators* (page 213)

manipulators

manipulators – iostream out of band manipulations

Synopsis

```
#include <iostream.h>
#include <iomanip.h>

template <class T>

class SMANIP {
        SMANIP( ios& (*)(ios&,T), T);
        friend  istream& operator>>(istream&, SMANIP<T>&);
        friend  ostream& operator<<(ostream&, SMANIP<T>&);
};
template <class T>
class SAPP {
        SAPP(T)( ios& (*)(ios&,T));
        SMANIP<T> operator()(T);
};
template <class T>
class IMANIP {
        IMANIP( istream& (*)(istream&,T), T);
        friend  istream& operator>>(istream&, IMANIP<T>&);
};
template <class T>
class IAPP {
        IAPP( istream& (*)(istream&,T));
        IMANIP<T> operator()(T);
};
template <class T>
class OMANIP {
        OMANIP( ostream& (*)(ostream&,T), T);
        friend  ostream& operator<<(ostream&, OMANIP<T>&);
};
template <class T>
class OAPP {
        OAPP( ostream& (*)(ostream&,T));
        OMANIP<T> operator()(T);
};
template <class T>
class IOMANIP {
        IOMANIP( iostream& (*)(iostream&,T), T);
        friend  istream& operator>>(iostream&, IOMANIP<T>&);
        friend  ostream& operator<<(iostream&, IOMANIP<T>&);
};
template <class T>
class IOAPP {
        IOAPP( iostream& (*)(iostream&,T));
        IOMANIP<T> operator()(T);
};
```

```
SMANIP<long>    resetiosflags(long);
SMANIP<int>     setfill(int);
SMANIP<long>    setiosflags(long);
SMANIP<int>     setprecision(int);
SMANIP<int>     setw(int w);
```

Description

Manipulators are values that may be 'inserted into' or 'extracted from' streams to achieve some effect (other than to insert or extract a value representation), with a convenient syntax. They enable one to embed a function call in an expression containing a series of insertions or extractions. For example, the predefined manipulator for **ostream**s, **flush**, can be used as follows:

```
cout << flush
```

to flush **cout**. Several iostream classes supply manipulators: see *ios* on page 195, *istream* on page 206, and *ostream* on page 217. **flush** is a simple manipulator; some manipulators take arguments, such as the predefined **ios** manipulators, **setfill** and **setw** (see below).

In the following descriptions, assume:

- *t* is a **T**, or type name.
- *s* is an **ios**.
- *i* is an **istream**.
- *o* is an **ostream**.
- *io* is an **iostream**.
- *f* is an **ios& (*)(ios&)**.
- *if* is an **istream& (*)(istream&)**.
- *of* is an **ostream& (*)(ostream&)**.
- *iof* is an **iostream& (*)(iostream&)**.
- *n* is an **int**.
- *l* is a **long**.

```
s<<SMANIP<T>(f,t)
s>>SMANIP<T>(f,t)
s<<SAPP<T>(f)(t)
s>>SAPP<T>(f)(t)
```

Returns `f(s,t)`, where `s` is the left operand of the insertion or extractor operator (i.e. `s`, `i`, `o`, or `io`).

```
i>>IMANIP<T>(if,t)
i>>IAPP<T>(if)(t)
```

Returns `if(i,t)`.

```
o<<OMANIP<T>(of,t)
o<<OAPP<T>(of)(t)
```

Returns `of(o,t)`.

```
io<<IOMANIP<T>(iof,t)
io>>IOMANIP<T>(iof,t)
io<<IOAPP<T>(iof)(t)
io>>IOAPP<T>(iof)(t)
```

Returns `iof(io,t)`.

`iomanip.h` contains declarations of some manipulators that take an `int` or a `long` argument. These manipulators all have to do with changing the format state of a stream; see *ios* on page 195 for further details.

```
o<<setw(n)
i>>setw(n)
```

Sets the field width of the stream (left-hand operand: `o` or `i`) to `n`.

```
o<<setfill(n)
i>>setfill(n)
```

Sets the fill character of the stream (`o` or `i`) to be `n`.

```
o<<setprecision(n)
i>>setprecision(n)
```

Sets the precision of the stream (`o` or `i`) to be `n`.

o<<setiosflags(l)
i>>setiosflags(l)

Turns on in the stream (`o` or `i`) the format flags marked in `l`. (Calls `o.setf(l)` or `i.setf(l)`).

o<<resetiosflags(l)
i>>resetiosflags(l)

Clears in the stream (`o` or `i`) the format bits specified by `l`. (Calls `o.setf(0,l)` or `i.setf(0,l)`).

See also

ios (page 195), *istream* (page 206), *ostream* (page 217)

ostream

ostream – formatted and unformatted output

Synopsis

```
#include <iostream.h>

typedef long streamoff, streampos;
class ios {
public:
        enum    seek_dir { beg, cur, end };
        enum    open_mode { in, out, ate, app, trunc, nocreate, noreplace } ;
        enum    { skipws=01,
                  left=02, right=04, internal=010,
                  dec=020, oct=040, hex=0100,
                  showbase=0200, showpoint=0400,
                  uppercase=01000, showpos=02000,
                  scientific=04000, fixed=010000,
                  unitbuf=020000, stdio=040000 };
        // and lots of other stuff; see ios on page 195
} ;

class ostream : public ios {
public:
                        ostream(streambuf*);
        ostream&        flush();
        int             opfx();
        ostream&        put(char);
        ostream&        seekp(streampos);
        ostream&        seekp(streamoff, seek_dir);
        streampos       tellp();
        ostream&        write(const char* ptr, int n);
        ostream&        write(const unsigned char* ptr, int n);
        ostream&        operator<<(const char*);
        ostream&        operator<<(char);
        ostream&        operator<<(short);
        ostream&        operator<<(int);
        ostream&        operator<<(long);
        ostream&        operator<<(float);
        ostream&        operator<<(double);
        ostream&        operator<<(unsigned char);
        ostream&        operator<<(unsigned short);
        ostream&        operator<<(unsigned int);
        ostream&        operator<<(unsigned long);
        ostream&        operator<<(void*);
        ostream&        operator<<(streambuf*);
        ostream&        operator<<(ostream& (*)(ostream&));
        ostream&        operator<<(ios& (*)(ios&));
};
```

```
class ostream_withassign {
                        ostream_withassign();
        istream&        operator=(istream&);
        istream&        operator=(streambuf*);
};

extern ostream_withassign cout;
extern ostream_withassign cerr;
extern ostream_withassign clog;

ostream&        endl(ostream&) ;
ostream&        ends(ostream&) ;
ostream&        flush(ostream&) ;
ios&            dec(ios&) ;
ios&            hex(ios&) ;
ios&            oct(ios&) ;
```

Description

ostreams support insertion (storing) into a **streambuf**. These are commonly referred to as output operations. The **ostream** member functions and related functions are described below.

In the following descriptions, assume:

- *outs* is an **ostream**.
- *outswa* is an **ostream_withassign**.
- *outsp* is an **ostream***.
- *c* is a **char**.
- *ptr* is a **char*** or **unsigned char***.
- *sb* is a **streambuf***
- *i* and *n* are **int**s.
- *pos* is a **streampos**.
- *off* is a **streamoff**.
- *dir* is a **seek_dir**.
- *manip* is a function with type **ostream& (*)(ostream&)**.

Constructors and assignment

`ostream(sb)`

Initialises `ios` state variables and associates buffer *`sb`* with the `ostream`.

`ostream_withassign()`

Does no initialisation. This allows a file static variable of this type (`cout`, for example) to be used before it is constructed, provided it is assigned to first.

`outswa=sb`

Associates *`sb`* with *`swa`* and initialises the entire state of *`outswa`*.

`inswa=ins`

Associates *`ins`*`->rdbuf()` with *`swa`* and initialises the entire state of *`outswa`*.

Output prefix function

***`i=outs`*`.opfx()`**

If *`outs`*'s error state is non-zero, returns immediately. If *`outs`*`.tie()` is non-null, it is flushed. Returns non-zero except when *`outs`*'s error state is non-zero.

Output suffix function

`osfx()`

Performs 'suffix' actions before returning from inserters. If `ios::unitbuf` is set, `osfx()` flushes the `ostream`. If `ios::stdio` is set, `osfx()` flushes `stdout` and `stderr`.

`osfx()` is called by all predefined inserters, and should be called by user-defined inserters as well, after any direct manipulation of the `streambuf`. It is not called by the binary output functions.

Formatted output functions (inserters)

outs*<<*x

First calls ***outs*.opfx()** and if that returns 0, does nothing. Otherwise inserts a sequence of characters representing ***x*** into ***outs*.rdbuf()**. Errors are indicated by setting the error state of ***outs***. ***outs*** is always returned.

x is converted into a sequence of characters (its representation) according to rules that depend on ***x***'s type and ***outs***'s format state flags and variables (see *ios* on page 195. Inserters are defined for the following types, with conversion rules as described below:

char*	The representation is the sequence of characters up to (but not including) the terminating null of the string ***x*** points at.
any integral type except **char** and **unsigned char**	If ***x*** is positive the representation contains a sequence of decimal, octal, or hexadecimal digits with no leading zeros according to whether **ios::dec**, **ios::oct**, or **ios::hex**, respectively, is set in **ios**'s format flags. If none of those flags are set, conversion defaults to decimal. If ***x*** is zero, the representation is a single zero character(0). If ***x*** is negative, decimal conversion converts it to a minus sign (–) followed by decimal digits. If ***x*** is positive and **ios::showpos** is set, decimal conversion converts it to a plus sign (+) followed by decimal digits. The other conversions treat all values as unsigned. If **ios::showbase** is set in **ios**'s format flags, the hexadecimal representation contains **0x** before the hexadecimal digits, or **0X** if **ios::uppercase** is set. If **ios::showbase** is set, the octal representation contains a leading 0.
void*	Pointers are converted to integral values and then converted to hexadecimal numbers as if **ios::showbase** were set.
float, **double**	The arguments are converted according to the current values of ***outs*.precision()**, ***outs*.width()** and ***outs***'s format flags **ios::scientific**, **ios::fixed**, and **ios::uppercase**. (See *ios* on page 195.) The default value for ***outs*.precision()** is 6. If neither **ios::scientific** nor **ios::fixed** is set, either fixed or scientific notation is chosen for the representation, depending on the value of ***x***.
char, **unsigned char**	No special conversion is necessary.

After the representation is determined, padding occurs. If *outs*`.width()` is greater than 0 and the representation contains fewer than *outs*`.width()` characters, then enough *outs*`.fill()` characters are added to bring the total number of characters to `ios.width()`. If `ios::left` is set in `ios`'s format flags, the sequence is left-adjusted, that is, characters are added after the characters determined above. If `ios::right` is set, the padding is added before the characters determined above. If `ios::internal` is set, the padding is added after any leading sign or base indication and before the characters that represent the value. `ios.width()` is reset to 0, but all other format variables are unchanged. The resulting sequence (padding plus representation) is inserted into *outs*`.rdbuf()`.

outs*<<*sb

If *outs*`.opfx()` returns non-zero, the sequence of characters that can be fetched from *sb* are inserted into *outs*`.rdbuf()`. Insertion stops when no more characters can be fetched from *sb*. No padding is performed. Always returns *outs*.

Unformatted output functions

***outsp*=&*outs*`.put(`*c*`)`**

Inserts *c* into *outs*`.rdbuf()`. Sets the error state if the insertion fails.

***outsp*=&*outs*`.write(`*s*`,`*n*`)`**

Inserts the *n* characters starting at *s* into *outs*`.rdbuf()`. These characters may include zeros (i.e. *s* need not be a null terminated string).

Other member functions

***outsp*=&*outs*`.flush()`**

Storing characters into a `streambuf` does not always cause them to be consumed (e.g. written to the external file) immediately. `flush()` causes any characters that may have been stored but not yet consumed to be consumed by calling *outs*`.rdbuf()->sync`.

***outs*<<`manip`**

Equivalent to `manip(`*outs*`)`. Syntactically this looks like an insertion operation, but semantically it does an arbitrary operation rather than converting `manip` to a sequence of characters as do the insertion operators. Predefined manipulators are described below.

Positioning functions

`outsp=&ins.seekp(off,dir)`

Repositions `outs.rdbuf()`'s put pointer. See *streambuf – public* on page 232 for a discussion of positioning.

`outsp=&outs.seekp(pos)`

Repositions `outs.rdbuf()`'s put pointer. See *streambuf – public* on page 232 for a discussion of positioning.

`pos=outs.tellp()`

The current position of `outs.rdbuf()`'s put pointer. See *streambuf – public* on page 232 for a discussion of positioning.

Manipulators

`outs<<endl`

Ends a line by inserting a newline character and flushing.

`outs<<ends`

Ends a string by inserting a null (0) character.

`outs<<flush`

Flushes `outs`.

`outs<<dec`

Sets the conversion base format flag to 10. See *ios* on page 195.

`outs<<hex`

Sets the conversion base format flag to 16. See *ios* on page 195.

`outs<<oct`

Sets the conversion base format flag to 8. See *ios* on page 195.

See also

ios (page 195), *streambuf – public* (page 232), *manipulators* (page 213)

stdiobuf

stdiobuf – iostream specialised to stdio FILE

Synopsis

```
#include <iostream.h>
#include <stdiostream.h>
#include <stdio.h>

class stdiobuf : public streambuf {
                 stdiobuf(FILE* f);
        FILE*    stdiofile();
};
```

Description

Operations on a **stdiobuf** are reflected on the associated **FILE**. A **stdiobuf** is constructed in unbuffered mode, which causes all operations to be reflected immediately in the **FILE**. **seekg()**s and **seekp()**s are translated into **fseek()**s. **setbuf()** has its usual meaning; if it supplies a reserve area, buffering will be turned back on.

Caveats

stdiobuf is intended to be used when mixing C and C++ code. New C++ code should prefer to use **filebuf**s, which have better performance.

See also

filebuf (page 187), *istream* (page 206), *ostream* (page 217), *streambuf – public* (page 232)

streambuf – protected

streambuf – interface for derived classes

Synopsis

```
#include <iostream.h>

typedef long streamoff, streampos;
class ios {
public:
        enum    seek_dir { beg, cur, end };
        enum    open_mode { in, out, ate, app, trunc, nocreate, noreplace } ;
        // and lots of other stuff; see ios on page 195
} ;

class streambuf {
public:
                        streambuf() ;
                        streambuf(char* p, int len);
        void            dbp() ;

protected:
        int             allocate();
        char*           base();
        int             blen();
        char*           eback();
        char*           ebuf();
        char*           egptr();
        char*           epptr();
        void            gbump(int n);
        char*           gptr();
        char*           pbase();
        void            pbump(int n);
        char*           pptr();
        void            setg(char* eb, char* g, char* eg);
        void            setp(char* p, char* ep);
        void            setb(char* b, char* eb, int a=0);
        int             unbuffered();
        void            unbuffered(int);

        virtual int     doallocate();
        virtual         ~streambuf() ;
```

```
public:
        virtual int     pbackfail(int c);
        virtual int     overflow(int c=EOF);
        virtual int     underflow();
        virtual         streambuf*
                        setbuf(char* p, int len);
        virtual         streampos
                        seekpos(streampos, int =ios::in|ios:out);
        virtual         streampos
                        seekoff(streamoff, seek_dir, int =ios::in|ios:out);
        virtual int     sync();
};
```

Description

streambufs implement the buffer abstraction described in *streambuf – public* on page 232. However, the **streambuf** class itself contains only basic members for manipulating the characters and normally a class derived from **streambuf** will be used. This section describes the interface needed by programmers who are coding a derived class. Broadly speaking there are two kinds of member functions described here. The non-virtual functions are provided for manipulating a **streambuf** in ways that are appropriate in a derived class. Their descriptions reveal details of the implementation that would be inappropriate in the public interface. The virtual functions permit the derived class to specialise the **streambuf** class in ways appropriate to the specific sources and sinks that it is implementing. The descriptions of the virtual functions explain the obligations of the virtuals of the derived class. If the virtuals behave as specified, the **streambuf** will behave as specified in the public interface. However, if the virtuals do not behave as specified, then the **streambuf** may not behave properly, and an **iostream** (or any other code) that relies on proper behaviour of the **streambuf** may not behave properly either.

In the following descriptions assume:

- *sb* is a **streambuf***.
- *i* and *n* are **int**s.
- *ptr*, *b*, *eb*, *p*, *ep*, *eb*, *g*, and *eg* are **char***s.
- *c* is an **int** character (positive or **EOF**)).
- *pos* is a **streampos**. (See *streambuf – public* on page 232.)
- *off* is a **streamoff**.
- *dir* is a **seekdir**.
- *mode* is an **int** representing an **open_mode**.

Constructors

`streambuf()`

Constructs an empty buffer corresponding to an empty sequence.

`streambuf(b,len)`

Constructs an empty buffer and then sets up the reserve area to be the *`len`* bytes starting at *`b`*.

The Get, Put, and Reserver area

The protected members of **`streambuf`** present an interface to derived classes organised around three areas (arrays of bytes) managed cooperatively by the base and derived classes. They are the *get area*, the *put area*, and the *reserve area* (or *buffer*). The get and the put areas are normally disjoint, but they may both overlap the reserve area, whose primary purpose is to be a resource in which space for the put and get areas can be allocated. The get and the put areas are changed as characters are put into and got from the buffer, but the reserve area normally remains fixed. The areas are defined by a collection of **`char*`** values. The buffer abstraction is described in terms of pointers that point between characters, but the **`char*`** values must point at **`char`**s. To establish a correspondence the **`char*`** values should be thought of as pointing just before the byte they really point at.

Functions to examine the pointers

`ptr=sb->base()`

Returns a pointer to the first byte of the reserve area. Space between ***`sb->base()`*** and ***`sb->ebuf()`*** is the reserve area.

`ptr=sb->eback()`

Returns a pointer to a lower bound on ***`sb->gptr()`***. Space between ***`sb->eback()`*** and ***`sb->gptr()`*** is available for putback.

`ptr=sb->ebuf()`

Returns a pointer to the byte after the last byte of the reserve area.

`ptr=sb->egptr()`

Returns a pointer to the byte after the last byte of the get area.

`ptr=sb->epptr()`

Returns a pointer to the byte after the last byte of the put area.

ptr=sb->gptr()

Returns a pointer to the first byte of the get area. The available characters are those between *sb->gptr()* and *sb->egptr()*. The next character fetched will be **sb->gptr()*) unless *sb->egptr()* is less than or equal to *sb->gptr()*.

ptr=sb->pbase()

Returns a pointer to the put area base. Characters between *sb->pbase()* and *sb->pptr()* have been stored into the buffer and not yet consumed.

ptr=sb->pptr()

Returns a pointer to the first byte of the put area. The space between *sb->pptr()* and *sb->epptr()* is the put area and characters will be stored here.

Functions for setting the pointers

Note that to indicate that a particular area (get, put, or reserve) does not exist, all the associated pointers should be set to zero.

sb->setb(b, eb, i)

Sets `base()` and `ebuf()` to *b* and *eb* respectively. *i* controls whether the area will be subject to automatic deletion. If *i* is non-zero, then *b* will be deleted when base is changed by another call of `setb()`, or when the destructor is called for **sb*. If *b* and *eb* are both null then we say that there is no reserve area. If *b* is non-null, there is a reserve area even if *eb* is less than *b* and so the reserve area has zero length.

sb->setp(p, ep)

Sets `pptr()` to *p*, `pbase()` to *p*, and `epptr()` to *ep*.

sb->setg(eb, g, eg)

Sets `eback()` to *eb*, `gptr()` to *g*, and `egptr()` to *eg*.

Other non-virtual members

`i=sb->allocate()`

Tries to set up a reserve area. If a reserve area already exists or if `sb->unbuffered()` is non-zero, `allocate()` returns 0 without doing anything. If the attempt to allocate space fails, `allocate()` returns `EOF`, otherwise (i.e. allocation succeeds) `allocate()` returns 1. `allocate()` is not called by any non-virtual member function of `streambuf`.

`i=sb->blen()`

Returns the size (in `char`s) of the current reserve area.

`dbp()`

Writes directly on file descriptor 1 information in ASCII about the state of the buffer. It is intended for debugging and nothing is specified about the form of the output. It is considered part of the protected interface because the information it prints can only be understood in relation to that interface, but it is a public function so that it can be called anywhere during debugging.

`sb->gbump(n)`

Increments `gptr()` by *n* which may be positive or negative. No checks are made on whether the new value of `gptr()` is in bounds.

`sb->pbump(n)`

Increments `pptr()` by *n* which may be positive or negative. No checks are made on whether the new value of `pptr()` is in bounds.

`sb->unbuffered(i)`
`i=sb->unbuffered()`

There is a private variable known as *sb*'s buffering state. `sb->unbuffered(i)` sets the value of this variable to *i* and `sb->unbuffered()` returns the current value. This state is independent of the actual allocation of a reserve area. Its primary purpose is to control whether a reserve area is allocated automatically by `allocate`.

Virtual member functions

Virtual functions may be redefined in derived classes to specialise the behaviour of `streambuf`s. This section describes the behaviour that these virtual functions should have in any derived classes; the next section describes the behaviour that these functions are defined to have in base class `streambuf`.

i=*sb*->doallocate()

Is called when `allocate()` determines that space is needed. `doallocate()` is required to call `setb()` to provide a reserve area or to return `EOF` if it cannot. It is only called if *sb*->`unbuffered()` is zero and *sb*->`base()` is zero.

i=overflow(*c*)

Is called to consume characters. If *c* is not `EOF`, `overflow()` also must either save *c* or consume it. Usually it is called when the put area is full and an attempt is being made to store a new character, but it can be called at other times. The normal action is to consume the characters between `pbase()` and `pptr()`, call `setp()` to establish a new put area, and if *c*`!=EOF` store it (using `sputc()`). *sb*->`overflow()` should return `EOF` to indicate an error; otherwise it should return something else.

i=*sb*->pbackfail(*c*)

Is called when `eback()` equals `gptr()` and an attempt has been made to putback *c*. If this situation can be dealt with (e.g. by repositioning an external file), `pbackfail()` should return *c*; otherwise it should return `EOF`.

pos=*sb*->seekoff(*off*, *dir*, *mode*)

Repositions the get and/or put pointers (i.e. the abstract get and put pointers, not `pptr()` and `gptr()`). The meanings of *off* and *dir* are discussed in *streambuf – public* on page 232. *mode* specifies whether the put pointer (`ios::out` bit set) or the get pointer (`ios::in` bit set) is to be modified. Both bits may be set in which case both pointers should be affected. A class derived from `streambuf` is not required to support repositioning. `seekoff()` should return `EOF` if the class does not support repositioning. If the class does support repositioning, `seekoff()` should return the new position or `EOF` on error.

pos=*sb*->seekpos(*pos*, *mode*)

Repositions the `streambuf` get and/or put pointer to *pos*. *mode* specifies which pointers are affected as for `seekoff()`. Returns *pos* (the argument) or `EOF` if the class does not support repositioning or an error occurs.

sb=sb->setbuf(ptr, len)

Offers the array at *ptr* with *len* bytes to be used as a reserve area. The normal interpretation is that if *ptr* or *len* are zero then this is a request to make the *sb* unbuffered. The derived class may use this area or not as it chooses. It may accept or ignore the request for unbuffered state as it chooses. **setbuf()** should return *sb* if it honours the request. Otherwise it should return 0.

i=sb->sync()

Is called to give the derived class a chance to look at the state of the areas, and synchronise them with any external representation. Normally **sync()** should consume any characters that have been stored into the put area, and if possible give back to the source any characters in the get area that have not been fetched. When **sync()** returns there should not be any unconsumed characters, and the get area should be empty. **sync()** should return **EOF** if some kind of failure occurs.

i=sb->underflow()

Is called to supply characters for fetching, i.e. to create a condition in which the get area is not empty. If it is called when there are characters in the get area it should return the first character. If the get area is empty, it should create a non-empty get area and return the next character (which it should also leave in the get area). If there are no more characters available, **underflow()** should return **EOF** and leave an empty get area.

The default definitions of the virtual functions:

i=sb->streambuf::doallocate()

Attempts to allocate a reserve area using **operator new**.

i=sb->streambuf::overflow(c)

streambuf::overflow() should be treated as if it had undefined behaviour. That is, derived classes should always define it.

i=sb->streambuf::pbackfail(c)

Returns **EOF**.

pos=sb->streambuf::seekpos(pos, mode)

Returns *sb*->**seekoff(streamoff(***pos***),ios::beg,***mode***)**. Thus to define seeking in a derived class, it is frequently only necessary to define **seekoff()** and use the inherited **streambuf::seekpos()**.

pos=sb->streambuf::seekoff(off, dir, mode)

Returns EOF.

sb=sb->streambuf::setbuf(ptr, len)

Will honour the request when there is no reserve area.

i=sb->streambuf::sync()

Returns 0 if the get area is empty and there are no unconsumed characters. Otherwise it returns EOF.

i=sb->streambuf::underflow()

Is compatible with the old stream package, but that behaviour is not considered part of the specification of the iostream package. Therefore, `streambuf::underflow()` should be treated as if it had undefined behaviour. That is, it should always be defined in derived classes.

See also

streambuf – public (page 232), *ios* (page 195), *istream* (page 206), *ostream* (page 217)

streambuf – public

streambuf – public interface of character buffering class

Synopsis

```
#include <iostream.h>

typedef long streamoff, streampos;
class ios {
public:
        enum    seek_dir { beg, cur, end };
        enum    open_mode { in, out, ate, app, trunc, nocreate, noreplace } ;
        // and lots of other stuff; see ios on page 195
} ;

class streambuf {
public :

        int             in_avail();
        int             out_waiting();
        int             sbumpc();
        streambuf*      setbuf(char* ptr, int len);
        streampos       seekpos(streampos, int =ios::in|ios::out);
        streampos       seekoff(streamoff, seek_dir, int =ios::in|ios::out);
        int             sgetc();
        int             sgetn(char* ptr, int n);
        int             snextc();
        int             sputbackc(char);
        int             sputc(int c);
        int             sputn(const char* s, int n);
        void            stossc();
        virtual int     sync();
};
```

Description

The **streambuf** class supports buffers into which characters can be inserted (put) or from which characters can be fetched (got). Abstractly, such a buffer is a sequence of characters together with one or two pointers (a get and/or a put pointer) that define the location at which characters are to be inserted or fetched. The pointers should be thought of as pointing between characters rather than at them. This makes it easier to understand the boundary conditions (a pointer before the first character or after the last). Some of the effects of getting and putting are defined by this class but most of the details are left to specialised classes derived from **streambuf**. (See *filebuf* on page 187, *strstreambuf* on page 240, and *stdiobuf* on page 223.)

Classes derived from **streambuf** vary in their treatments of the get and put pointers. The simplest are unidirectional buffers which permit only gets or only puts. Such classes serve as pure sources (producers) or sinks (consumers) of characters. Queuelike buffers (e.g. see *strstream* on page 237 and *strstreambuf* on page 240) have a put and a get pointer which move independently of each other. In such buffers characters that are stored are held (i.e. queued) until they are later fetched. Filelike buffers (e.g. **filebuf**, see *filebuf* on page 187) permit both gets and puts but have only a single pointer. (An alternative description is that the get and put pointers are tied together so that when one moves so does the other.)

Most **streambuf** member functions are organised into two phases. As far as possible, operations are performed inline by storing into or fetching from arrays (the *get area* and the *put area*, which together form the *reserve area*, or *buffer*). From time to time, virtual functions are called to deal with collections of characters in the get and put areas. That is, the virtual functions are called to fetch more characters from the ultimate producer or to flush a collection of characters to the ultimate consumer. Generally the user of a **streambuf** does not have to know anything about these details, but some of the public members pass back information about the state of the areas. Further detail about these areas is provided in *streambuf – protected* on page 224, which describes the protected interface.

The public member functions of the **streambuf** class are described below. In the following descriptions assume:

- *i*, *n*, and *len* are **int**s.
- *c* is an **int**. It always holds a 'character' value or **EOF**. A 'character' value is always positive even when **char** is normally sign extended.
- *sb* and *sb1* are **streambuf***s.
- *ptr* is a **char***.
- *off* is a **streamoff**.
- *pos* is a **streampos**.
- *dir* is a **seek_dir**.
- *mode* is an **int** representing an **open_mode**.

Public member functions:

`i=sb->in_avail()`

Returns the number of characters that are immediately available in the get area for fetching. `i` characters may be fetched with a guarantee that no errors will be reported.

`i=sb->out_waiting()`

Returns the number of characters in the put area that have not been consumed (by the ultimate consumer.

`c=sb->sbumpc()`

Moves the get pointer forward one character and returns the character it moved past. Returns **EOF** if the get pointer is currently at the end of the sequence.

`pos=sb->seekoff(off, dir, mode)`

Repositions the get and/or put pointers. *mode* specifies whether the put pointer (`ios::out` bit set) or the get pointer (`ios::in` bit set) is to be modified. Both bits may be set in which case both pointers should be affected. *off* is interpreted as a byte offset. (Notice that it is a signed quantity.) The meanings of possible values of *dir* are

`ios::beg`	The beginning of the stream.
`ios::cur`	The current position.
`ios::end`	The end of the stream (end of file.)

Not all classes derived from **streambuf** support repositioning. **seekoff()** will return **EOF** if the class does not support repositioning. If the class does support repositioning, **seekoff()** will return the new position or **EOF** on error.

`pos=sb->seekpos(pos, mode)`

Repositions the **streambuf** get and/or put pointer to *pos*. *mode* specifies which pointers are affected as for **seekoff()**. Returns *pos* (the argument) or **EOF** if the class does not support repositioning or an error occurs. In general a **streampos** should be treated as a 'magic cookie' and no arithmetic should be performed on it. Two particular values have special meaning:

`streampos(0)`	The beginning of the file.
`streampos(EOF)`	Used as an error indication.

`c=sb->sgetc()`

Returns the character after the get pointer. Contrary to what most people expect from the name **it does not move the get pointer**. Returns `EOF` if there is no character available.

`sb1=sb->setbuf(ptr, len, i)`

Offers the `len` bytes starting at `ptr` as the reserve area. If `ptr` is null or `len` is zero or less, then an unbuffered state is requested. Whether the offered area is used, or a request for unbuffered state is honoured depends on details of the derived class. `setbuf()` normally returns `sb`, but if it does not accept the offer or honour the request, it returns 0.

`i=sb->sgetn(ptr, n)`

Fetches the `n` characters following the get pointer and copies them to the area starting at `ptr`. When there are fewer than `n` characters left before the end of the sequence `sgetn()` fetches whatever characters remain. `sgetn()` repositions the get pointer following the fetched characters and returns the number of characters fetched.

`c=sb->snextc()`

Moves the get pointer forward one character and returns the character following the new position. It returns `EOF` if the pointer is currently at the end of the sequence or is at the end of the sequence after moving forward.

`i=sb->sputbackc(c)`

Moves the get pointer back one character. `c` must be the current content of the sequence just before the get pointer. The underlying mechanism may simply back up the get pointer or may rearrange its internal data structures so the `c` is saved. Thus the effect of `sputbackc()` is undefined if `c` is not the character before the get pointer. `sputbackc()` returns `EOF` when it fails. The conditions under which it can fail depend on the details of the derived class.

`i=sb->sputc(c)`

Stores `c` after the put pointer, and moves the put pointer past the stored character; usually this extends the sequence. It returns `EOF` when an error occurs. The conditions that can cause errors depend on the derived class.

`i=sb->sputn(ptr, n)`

Stores the `n` characters starting at `ptr` after the put pointer and moves the put pointer past them. `sputn()` returns `i`, the number of characters stored successfully. Normally `i` is `n`, but it may be less when errors occur.

`sb->stossc()`

Moves the get pointer forward one character. If the pointer started at the end of the sequence this function has no effect.

`i=sb->sync()`

Establishes consistency between the internal data structures and the external source or sink. The details of this function depend on the derived class. Usually this 'flushes' any characters that have been stored but not yet consumed, and 'gives back' any characters that may have been produced but not yet fetched. `sync()` returns `EOF` to indicate errors.

See also

ios (page 195), *istream* (page 206), *ostream* (page 217), *streambuf – protected* (page 224)

strstream

strstream – iostream specialised to arrays

Synopsis

```
#include <strstream.h>

class ios {
public:
        enum    open_mode { in, out, ate, app, trunc, nocreate, noreplace } ;
        // and lots of other stuff; see ios on page 195
} ;

class istrstream : public istream {
public:
                        istrstream(char*) ;
                        istrstream(char*, int) ;
        strstreambuf*   rdbuf() ;
} ;

class ostrstream : public ostream {
public:
                        ostrstream();
                        ostrstream(char*, int, int=ios::out) ;
        int             pcount() ;
        strstreambuf*   rdbuf() ;
        char*           str();
};

class strstream : public strstreambase, public iostream {
public:
                        strstream();
                        strstream(char*, int, int mode);
        strstreambuf*   rdbuf() ;
        char*           str();
};
```

Description

strstream specialises iostream for 'incore' operations, that is, storing and fetching from arrays of bytes. The **streambuf** associated with a **strstream** is a **strstreambuf** (see *strstreambuf* on page 240).

In the following descriptions assume:

- *ss* is a **strstream**.
- *iss* is an **istrstream**.
- *oss* is an **ostrstream**.

- *cp* is a `char*`.
- *mode* is an `int` representing an `open_mode`.
- *i* and *len* are `int`s.
- *ssb* is a `strstreambuf*`.

Constructors

`istrstream(cp)`

Characters will be fetched from the (null-terminated) string *cp*. The terminating null character will not be part of the sequence. Seeks (`istream::seekg()`) are allowed within that space.

`istrstream(cp, len)`

Characters will be fetched from the array beginning at *cp* and extending for *len* bytes. Seeks (`istream::seekg()`) are allowed anywhere within that array.

`ostrstream()`

Space will be dynamically allocated to hold stored characters.

`ostrstream(cp,n,mode)`

Characters will be stored into the array starting at *cp* and continuing for *n* bytes. If `ios::ate` or `ios::app` is set in *mode*, *cp* is assumed to be a null-terminated string and storing will begin at the null character. Otherwise storing will begin at *cp*. Seeks are allowed anywhere in the array.

`strstream()`

Space will be dynamically allocated to hold stored characters.

`strstream(cp,n,mode)`

Characters will be stored into the array starting at *cp* and continuing for *n* bytes. If `ios::ate` or `ios::app` is set in *mode*, *cp* is assumed to be a null-terminated string and storing will begin at the null character. Otherwise storing will begin at *cp*. Seeks are allowed anywhere in the array.

istrstream members

***ssb* = *iss*.`rdbuf()`**

Returns the `strstreambuf` associated with *iss*.

ostrstream members

***ssb* = *oss*.rdbuf()**

Returns the `strstreambuf` associated with *oss*.

***cp*=*oss*.str()**

Returns a pointer to the array being used and 'freezes' the array. Once `str` has been called the effect of storing more characters into *oss* is undefined. If *oss* was constructed with an explicit array, *cp* is just a pointer to the array. Otherwise, *cp* points to a dynamically allocated area. Until `str` is called, deleting the dynamically allocated area is the responsibility of *oss*. After `str` returns, the array becomes the responsibility of the user program.

***i*=*oss*.pcount()**

Returns the number of bytes that have been stored into the buffer. This is mainly of use when binary data has been stored and *oss*.str() does not point to a null terminated string.

strstream members

***ssb* = *ss*.rdbuf()**

Returns the `strstreambuf` associated with *ss*.

***cp*=*ss*.str()**

Returns a pointer to the array being used and 'freezes' the array. Once `str` has been called the effect of storing more characters into *ss* is undefined. If *ss* was constructed with an explicit array, *cp* is just a pointer to the array. Otherwise, *cp* points to a dynamically allocated area. Until `str` is called, deleting the dynamically allocated area is the responsibility of *ss*. After `str` returns, the array becomes the responsibility of the user program.

See also

strstreambuf (page 240), *ios* (page 195), *istream* (page 206), *ostream* (page 217)

strstreambuf

strstreambuf – streambuf specialised to arrays

Synopsis

```
#include <iostream.h>
#include <strstream.h>

class strstreambuf : public streambuf {
public:
                strstreambuf() ;
                strstreambuf(char*, int, char*);
                strstreambuf(int);
                strstreambuf(unsigned char*, int, unsigned char*);
                strstreambuf(void* (*a)(long), void(*f)(void*));

        void            freeze(int n=1) ;
        char*           str();
        virtual streambuf*      setbuf(char*, int)
};
```

Description

A **strstreambuf** is a **streambuf** that uses an array of bytes (a string) to hold the sequence of characters. Given the convention that a **char*** should be interpreted as pointing just before the char it really points at, the mapping between the abstract get/put pointers (see *streambuf – public* on page 232) and **char*** pointers is direct. Moving the pointers corresponds exactly to incrementing and decrementing the **char*** values.

To accommodate the need for arbitrary length strings **strstreambuf** supports a dynamic mode. When a **strstreambuf** is in dynamic mode, space for the character sequence is allocated as needed. When the sequence is extended too far, it will be copied to a new array.

In the following descriptions assume:

- *ssb* is a **strstreambuf***.
- *n* is an **int**.
- *ptr* and *pstart* are **char***s or **unsigned char***s.
- *a* is a **void* (*)(long)**.
- *f* is a **void* (*)(void*)**.

Constructors

`strstreambuf()`

Constructs an empty `strstreambuf` in dynamic mode. This means that space will be automatically allocated to accommodate the characters that are put into the `strstreambuf` (using operators `new` and `delete`). Because this may require copying the original characters, it is recommended that when many characters will be inserted, the program should use `setbuf()` (described below) to inform the `strstreambuf`.

`strstreambuf(a, f)`

Constructs an empty `strstreambuf` in dynamic mode. *a* is used as the allocator function in dynamic mode. The argument passed to *a* will be a `long` denoting the number of bytes to be allocated. If *a* is null, operator `new` will be used. *f* is used to free (or delete) areas returned by *a*. The argument to *f* will be a pointer to the array allocated by *a*. If *f* is null, operator `delete` is used.

`strstreambuf(n)`

Constructs an empty `strstreambuf` in dynamic mode. The initial allocation of space will be at least *n* bytes.

`strstreambuf(ptr, n, pstart)`

Constructs a `strstreambuf` to use the bytes starting at *ptr*. The `strstreambuf` will be in static mode; it will not grow dynamically. If *n* is positive, then the *n* bytes starting at *ptr* are used as the `strstreambuf`. If *n* is zero, *ptr* is assumed to point to the beginning of a null terminated string and the bytes of that string (not including the terminating null character) will constitute the `strstreambuf`. If *n* is negative, the `strstreambuf` is assumed to continue indefinitely. The get pointer is initialised to *ptr*. The put pointer is initialised to *pstart*. If *pstart* is null, then stores will be treated as errors. If *pstart* is non-null, then the initial sequence for fetching (the get area) consists of the bytes between *ptr* and *pstart*. If *pstart* is null, then the initial get area consists of the entire array.

Member functions

ssb->freeze(*n*)

Inhibits (when *n* is non-zero) or permits (when *n* is zero) automatic deletion of the current array. Deletion normally occurs when more space is needed or when *ssb* is being destroyed. Only space obtained via dynamic allocation is ever freed. It is an error (and the effect is undefined) to store characters into a `strstreambuf` that was in dynamic allocation mode and is now frozen. It is possible, however, to thaw (unfreeze) such a `strstreambuf` and resume storing characters.

ptr=*ssb*->str()

Returns a pointer to the first `char` of the current array and freezes *ssb*. If *ssb* was constructed with an explicit array, *ptr* will point to that array. If *ssb* is in dynamic allocation mode, but nothing has yet been stored, *ptr* may be null.

ssb->setbuf(0,*n*)

ssb remembers *n* and the next time it does a dynamic mode allocation, it makes sure that at least *n* bytes are allocated.

See also

streambuf – public (page 232), *strstream* (page 237)

15 The Complex Math library

The Complex Math library is a part of the C++ library, ported from that supplied with AT&T's CFront product.

Introduction

complex – introduction to C++ complex mathematics library

Synopsis

```
#include <complex.h>
class   complex;
```

Description

This section describes complex mathematics functions and operators found in the C++ Library.

The Complex Mathematics library implements the data type of complex numbers as a class, **complex**. It overloads the standard input, output, arithmetic, assignment, and comparison operators, discussed in *complex operators* on page 252. It also overloads the standard exponential, logarithm, power, and square root functions, discussed in *exp, log, pow, sqrt* on page 250, and the trigonometric functions of sine, cosine, hyperbolic sine, and hyperbolic cosine, discussed in *cplxtrig* on page 255, for the class **complex**. Routines for converting between Cartesian and polar coordinate systems are discussed in *cartesian/polar* on page 245. Error handling is described in *complex_error* on page 247.

Diagnostics

Functions in the Complex Mathematics Library may return the conventional values **(0, 0)**, **(0, ±HUGE)**, **(±HUGE, 0)**, or **(±HUGE, ±HUGE)**, when the function is undefined for the given arguments or when the value is not representable. (**HUGE** is the largest-magnitude single-precision floating-point number and is defined in the file **<math.h>**. The header file **<math.h>** is included in the file **<complex.h>**.) In these cases, the external variable **errno** is set to the value **EDOM** or **ERANGE**.

See also

cartesian/polar (page 245), *complex_error* (page 247), *complex operators* (page 252), *exp, log, pow, sqrt* (page 250), *cplxtrig* (page 255).

cartesian/polar

cartesian/polar – functions for the C++ Complex Math Library

Synopsis

```
#include <complex.h>

class complex {

public:

        friend double   abs(complex);
        friend double   arg(complex);
        friend complex  conj(complex);
        friend double   imag(complex);
        friend double   norm(complex);
        friend complex  polar(double, double = 0);
        friend double   real(complex);

};
```

Description

The following functions are defined for complex, where:

- *d*, *m*, and *a* are of type `int`
- *x* and *y* are of type `complex`.

`d = abs(x)`

Returns the absolute value or magnitude of *x*.

`d = norm(x)`

Returns the square of the magnitude of *x*. It is faster than `abs`, but more likely to cause an overflow error. It is intended for comparison of magnitudes.

`d = arg(x)`

Returns the angle of *x*, measured in radians in the range $-\pi$ to π.

`y = conj(x)`

Returns the complex conjugate of *x*. That is, if *x* is `(real, imag)`, then `conj(x)` is `(real, -imag)`.

y = polar(m, a)

Creates a complex given a pair of polar coordinates, magnitude *m*, and angle *a*, measured in radians.

d = real(x)

Returns the real part of *x*.

d = imag(x)

Returns the imaginary part of *x*.

See also

Introduction (page 244), *complex_error* (page 247), *complex operators* (page 252), *exp, log, pow, sqrt* (page 250), *cplxtrig* (page 255)

complex_error

complex_error – error-handling function for the C++ Complex Math Library

Synopsis

```
#include <complex.h>

class c_exception
{
        int             type;
        char            *name;
        complex         arg1;
        complex         arg2;
        complex         retval;

public:

        c_exception( char *n, const complex& a1,
                const complex& a2 = complex_zero );

        friend int      complex_error( c_exception& );

        friend complex  exp( complex );
        friend complex  sinh( complex );
        friend complex  cosh( complex );
        friend complex  log( complex );

};
```

Description

In the following description of the complex error handling routine:

- *i* is of type `int`
- *x* is of type `c_exception`.

***i* = complex_error(*x*)**

Invoked by functions in the C++ Complex Mathematics Library when errors are detected.

Users may define their own procedures for handling errors, by defining a function named `complex_error` in their programs. `complex_error` must be of the form described above.

The element type is an integer describing the type of error that has occurred, from the following list of constants (defined in the header file):

`SING`	argument singularity
`OVERFLOW`	overflow range error
`UNDERFLOW`	underflow range error

The element name points to a string containing the name of the function that incurred the error. The variables `arg1` and `arg2` are the arguments with which the function was invoked. `retval` is set to the default value that will be returned by the function unless the user's `complex_error` sets it to a different value.

If the user's `complex_error` function returns non-zero, no error message will be printed, and *`errno`* will not be set.

If `complex_error` is not supplied by the user, the default error-handling procedures, described with the complex math functions involved, will be invoked upon error. These procedures are also summarised in the table below. In every case, *`errno`* is set to `EDOM` or `ERANGE` and the program continues.

Note that complex math functions call functions included in the math library which has its own error handling routine, `matherr`. Users may also override this routine by supplying their own version.

Default error handling procedures

		Types of Errors		
type		**SING**	**OVERFLOW**	**UNDERFLOW**
errno		**EDOM**	**ERANGE**	**ERANGE**
EXP	real too large/small	—	(±H, ±H)	(0, 0)
	imag too large	—	(0, 0)	—
LOG	arg = (0, 0)	M, (H, 0)	—	—
SINH	real too large	—	(±H, ±H)	—
	imag too large	—	(0, 0)	—
COSH	real too large	—	(±H, ±H)	—
	imag too large	—	(0, 0)	—

Key:

M	Message is printed (`EDOM` error)
(H, 0)	`(HUGE, 0)` is returned
(±H, ±H)	`(±HUGE, ±HUGE)` is returned
(0, 0)	`(0, 0)` is returned

See also

Introduction (page 244), *cartesian/polar* (page 245), *complex operators* (page 252), *exp, log, pow, sqrt* (page 250), *cplxtrig* (page 255)

exp, log, pow, sqrt

exp, log, pow, sqrt – exponential, logarithm, power, square root functions for the C++ complex library

Synopsis

```
#include <complex.h>

class complex {

public:
        friend complex  exp(complex);
        friend complex  log(complex);
        friend complex  pow(double, complex);
        friend complex  pow(complex, int);
        friend complex  pow(complex, double);
        friend complex  pow(complex, complex);
        friend complex  sqrt(complex);

};
```

Description

The following math functions are overloaded by the complex library, where:

- *x*, *y*, and *z* are of type **complex**.

z = exp(x)

Returns e^x.

z = log(x)

Returns the natural logarithm of *x*.

z = pow(x, y)

Returns x^y

z = sqrt(x)

Returns the square root of *x*, contained in the first or fourth quadrants of the complex plane.

Diagnostics

exp returns **(0, 0)** when the real part of ***x*** is so small, or the imaginary part is so large, as to cause overflow. When the real part is large enough to cause overflow, **exp** returns **(HUGE, HUGE)** if the cosine and sine of the imaginary part of ***x*** are positive, **(HUGE, -HUGE)** if the cosine is positive and the sine is not, **(-HUGE, HUGE)** if the sine is positive and the cosine is not, and **(-HUGE, -HUGE)** if neither sine nor cosine is positive. In all these cases, ***errno*** is set to **ERANGE**.

log returns **(-HUGE, 0)** and sets ***errno*** to **EDOM** when ***x*** is **(0, 0)**. A message indicating **SING** error is printed on the standard error output.

These error-handling procedures may be changed with the function **complex_error** (see page 247).

See also

Introduction (page 244), *cartesian/polar* (page 245), *complex_error* (page 247), *complex operators* (page 252), *cplxtrig* (page 255)

complex operators

complex_operators: operators for the C++ complex math library

Synopsis

```
#include <complex.h>

class complex {

public:
        friend complex  operator+(complex, complex);
        friend complex  operator-(complex);
        friend complex  operator-(complex, complex);
        friend complex  operator*(complex, complex);
        friend complex  operator/(complex, complex);

        friend int      operator==(complex, complex);
        friend int      operator!=(complex, complex);

        void            operator+=(complex);
        void            operator-=(complex);
        void            operator*=(complex);
        void            operator/=(complex);

};
```

Description

The basic arithmetic operators, comparison operators, and assignment operators are overloaded for complex numbers. The operators have their conventional precedences. In the following descriptions for complex operators:

- *x*, *y*, and *z* are of type `complex`.

Arithmetic operators:

z = x + y

Returns a `complex` which is the arithmetic sum of complex numbers ***x*** and ***y***.

z = -x

Returns a `complex` which is the arithmetic negation of complex number ***x***.

z = x - y

Returns a `complex` which is the arithmetic difference of complex numbers ***x*** and ***y***.

`z = x * y`

Returns a `complex` which is the arithmetic product of complex numbers *x* and *y*.

`z = x / y`

Returns a `complex` which is the arithmetic quotient of complex numbers *x* and *y*.

Comparison operators

`x == y`

Returns non-zero if complex number *x* is equal to complex number *y*; returns 0 otherwise.

`x != y`

Returns non-zero if complex number *x* is not equal to complex number *y*; returns 0 otherwise.

Assignment operators

`x += y`

Complex number *x* is assigned the value of the arithmetic sum of itself and complex number *y*.

`x -= y`

Complex number *x* is assigned the value of the arithmetic difference of itself and complex number *y*.

`x *= y`

Complex number *x* is assigned the value of the arithmetic product of itself and complex number *y*.

`x /= y`

Complex number *x* is assigned the value of the arithmetic quotient of itself and complex number *y*.

Warning

The assignment operators do not produce a value that can be used in an expression. That is, the following construction is syntactically invalid:

```
complex    x, y, z;
x = ( y += z );
```

whereas:

```
x = ( y + z );
```

```
x = ( y == z );
```

are valid.

See also

Introduction (page 244), *cartesian/polar* (page 245), *complex_error* (page 247), *exp*, *log*, *pow*, *sqrt* (page 250), *cplxtrig* (page 255)

cplxtrig

cplxtrig – trigonometric and hyperbolic functions for the C++ complex library

Synopsis

```
#include <complex.h>

class complex {

public:
        friend complexsin(complex);
        friend complexcos(complex);

        friend complexsinh(complex);
        friend complexcosh(complex);


};
```

Description

The following trigonometric functions are defined for complex, where:

- *x* and *y* are of type **complex**.

y = sin(x)

Returns the sine of ***x***.

y = cos(x)

Returns the cosine of ***x***.

y = sinh(x)

Returns the hyperbolic sine of ***x***.

y = cosh(x)

Returns the hyperbolic cosine of ***x***.

Diagnostics

If the imaginary part of ***x*** would cause overflow **sinh** and **cosh** return **(0, 0)**. When the real part is large enough to cause overflow, **sinh** and **cosh** return **(HUGE, HUGE)** if the cosine and sine of the imaginary part of ***x*** are non-negative, **(HUGE, -HUGE)** if the cosine is non-negative and the sine is less than 0.

`(-HUGE, HUGE)` if the sine is non-negative and the cosine is less than 0, and `(-HUGE, –HUGE)` if both sine and cosine are less than 0. In all these cases, *`errno`* is set to **`ERANGE`**.

These error-handling procedures may be changed with the function `complex_error` (see page 247).

See also

Introduction (page 244), *cartesian/polar* (page 245), *complex_error* (page 247), *complex operators* (page 252), *exp, log, pow, sqrt* (page 250)

Part 4 – Developing software for RISC OS

16 Portability

The C programming language has gained a reputation for being portable across machines, while still providing capabilities at a machine-specific level. The fact that a program is written in C by no means indicates the effort required to port software from one machine to another, or indeed from one compiler to another. Obviously the most time-consuming task is porting between two entirely different hardware environments, running different operating systems with different compilers. Since many users of the Acorn C compiler will find themselves in this situation, this chapter deals with a number of issues you should be aware of when porting software to or from our environment. The chapter covers the following:

- general portability considerations
- major differences between ANSI C and the well-known 'K&R' C as defined in the book *The C Programming Language*, (first edition) by Kernighan and Ritchie
- using the Acorn C compiler in 'pcc' compatibility mode
- environmental aspects of portability.

General portability considerations

If you intend your code to be used on a variety of different systems, there are certain aspects which you should bear in mind in order to make porting an easy and relatively error-free process. It is essential to single out items which may make software system-specific, and to employ techniques to avoid non-portable use of such items. In this section, we describe general portability issues for C programs.

Fundamental data types

The size of fundamental data types such as `char`, `int`, `long int`, `short int` and `float` will depend mainly on the underlying architecture of the machine on which the C program is to run. Compiler writers usually implement these types in a manner which best fits the architectures of machines for which their compilers are targeted. For example, Release 5 of the Microsoft C Compiler has `int`, `short int` and `long int` occupying 2, 2 and 4 bytes respectively, where the Acorn C Compiler uses 4, 2 and 4 bytes. Certain relations are guaranteed by the ANSI C Standard (such as the fact that the size of `long int` is at least that of `short int`), but code which makes any assumptions regarding implementation-defined issues such as whether `int` and `long int` are the same size will not be maximally portable.

A common non-portable assumption is embedded in the use of hexadecimal constant values. For example:

```
int i;
i = i & 0xfffffff8; /* set bottom 3 bits to zero, assuming 32-bit int */
```

Such non-portability can be avoided by using:

```
int i;
i = i & ~0x07; /* set bottom 3 bits to zero, whatever sizeof(int) */
```

If you find that some size assumptions are inevitable, then at least use a series of **assert** calls when the program starts up, to indicate any conditions under which successful operation is not guaranteed. Alternatively, write macros for frequently-used operations so that size assumptions are localised and can be altered locally.

Byte ordering

A highly non-portable feature of many C programs is the implicit or explicit exploitation of byte ordering within a word of store. Such assumptions tend to arise when copying objects word by word (rather than byte by byte), when inputting and outputting binary values, and when extracting bytes from or inserting bytes into words using a mix of shift-and-mask and byte addressing. A contrived example is the following code which copies individual bytes from an **int** variable **w** into an **int** variable pointed to by **p**, until a null byte is encountered. The code assumes that **w** does contain a null byte.

```
int a;
char *p = (char *)&a;
int w = AN_ARBITRARY_VALUE;

for (;;)
{
  if ((*p++ = w) == 0) break;
  w >>= 8;
}
```

This code will only work on a machine with even (or little-endian) byte-sex, and so is not portable. The best solution to such problems is either to write code which does not rely on byte-sex, or to have different code to deal appropriately with different byte-sex and to compile the correct variant conditionally, depending on your target machine architecture.

Store alignment

The only guarantee given in the ANSI C Standard regarding alignment of members of a **struct**, is that a 'hole' (caused by padding) cannot exist at the beginning of the **struct**. The values of 'holes' created by alignment restrictions are undefined, and you should not make assumptions about these values. In particular, two structures with identical members, each having identical values, will only be considered equal if field-by-field comparison is used; a byte-by-byte, or word-by-word comparison may not indicate equality.

This may also have implications on the size requirements of large arrays of **struct**s. Given the following declarations:

```
#define ARRSIZE 10000
typedef struct
        {
          int i;
          short s;
         } ELEM;
ELEM arr[ARRSIZE];
```

this may require significantly different amounts of store under, say, a compiler which aligns **int**s on even boundaries, as opposed to one which aligns them on word boundaries.

Pointers and pointer arithmetic

A deficiency of the original definition of C, and of its subsequent use, has been the relatively unrestrained interchanging between pointers to different data types and integers or longs. Much existing code makes the assumption that a pointer can safely be held in either a **long int** or **int** variable. While such an assumption may indeed be true in many implementations on many machines, it is a highly non-portable feature on which to rely.

This problem is further compounded when taking the difference of two pointers by performing a subtraction. When the difference is large, this approach is full of possible errors. For this purpose, ANSI C defines a type **ptrdiff_t**, which is capable of reliably storing the result of subtracting two pointer values of the same type; a typical use of this mechanism would be to apply it to pointers into the same array.

Function argument evaluation

Whilst the evaluation of operands to such operators as `&&` and || is defined to be strictly left-to-right (including all side-effects), the same does not apply to function argument evaluation. For example, in the function call `f(i, i++);`, the issue of whether the post-increment of `i` is performed after the first use of `i` is implementation-dependent. In any case, this is an unwise form of statement, since it may be decided later to implement `f` as a macro, instead of a function.

System-specific code

The direct use of operating system calls is, as you would expect, non-portable. If you use code which is obviously targeted for a particular environment, then it should be clearly documented as such, and should preferably be isolated into a system-specific module, which needs to be modified when porting to a new machine or operating system. Pathnames of system files should be #defined and not hard-coded into the program, and, as far as possible, all processing of filenames should be made easy to modify. Many file operations can be written in terms of the ANSI input/output library functions, which will make an application more portable. Obviously, binary data files are inherently non-portable, and the only solution to this problem may be the use of some portable external representation.

ANSI C vs K&R C

The ANSI C Standard has succeeded in tightening up many of the vague areas of K&R C. This results in a much clearer definition of a correct C program. However, if programs have been written to exploit particular vague features of K&R C, then their authors may find surprises when porting to an ANSI C environment. In the following sections, we present a list of what we consider to be the major differences between ANSI and K&R C. These differences are at the language level, and we defer discussion of library differences until a later section. The order in which this list is presented follows approximately relevant parts of the ANSI C Standard Document.

Lexical elements

The ordering of phases of translation is well-defined. Of special note is the preprocessor which is conceptually token-based (which does not yield the same results as might naively be expected from pure text manipulation).

A number of new keywords have been introduced with the following meanings:

- The type qualifier **volatile** which means that the object may be modified in ways unknown to the implementation, or have other unknown side effects. Examples of objects correctly described as **volatile** include device registers, semaphores and flags shared with asynchronous signal handlers. In general, expressions involving **volatile** objects cannot be optimised by the compiler.
- The type qualifier **const** which indicates that a variable's value should not be changed.
- The type specifier **void** to indicate a non-existent value for an expression.
- The type specifier **void *** , which is a generic pointer to or from which pointer variables can be assigned, without loss of information.
- The **signed** type qualifier, to sign any integral types explicitly.
- **struct**s and **union**s have their own distinct name spaces.
- There is a new floating-point type **long double**.
- The K&R C practice of using **long float** to denote **double** is now outlawed in ANSI C.
- Suffixes U and L (or u and l), can be used to explicitly denote **unsigned** and **long** constants (eg. 32L, 64U, 1024UL etc).
- The use of 'octal' constants 8 and 9 (previously defined to be octal 10 and 11 respectively) is no longer supported.
- Literal strings are to be considered as read-only, and identical strings may be stored as one shared version (as indeed they are, in the Acorn C Compiler). For example, given:

  ```
  char *p1 = "hello";
  char *p2 = "hello";
  ```

  p1 and **p2** will point at the same store location, where the string **hello** is held. Programs should not therefore modify literal strings.
- Variadic functions (ie those which take a variable number of arguments) are declared explicitly using an ellipsis (...). For example, **int printf(const char *fmt, ...);**
- Empty comments /**/ are replaced by a single space (use the preprocessor directive ## to do token-pasting if you previously used /**/ to do this).

Conversions

ANSI C uses value-preserving rules for arithmetic conversions (whereas K&R C implementations tend to use unsigned-preserving rules). Thus, for example:

```
int f(int x, unsigned char y)
{
  return (x+y)/2;
}
```

does signed division, where unsigned-preserving implementations would do unsigned division.

Aside from value-preserving rules, arithmetic conversions follow those of K&R C, with additional rules for **long double** and **unsigned long int**. It is now also possible to perform **float** arithmetic without widening to **double**. Floating-point values truncate towards zero when they are converted to integral types.

It is illegal to attempt to assign function pointers to data pointers and vice versa (even using explicit casts). The only exception to this is the value 0, as in:

```
int (*pfi)();
pfi = 0;
```

Assignment compatibility between **struct**s and **union**s is now stricter. For example, consider the following:

```
struct {char a; int b;} v1;
struct {char a; int b;} v2;
v1 = v2; /* illegal because v1 and v2
            strictly have different types*/
```

Expressions

- **struct**s and **union**s may be passed by value as arguments to functions.
- Given a pointer to function declared as, say, `int (*pfi)();`, then the function to which it points can be called either by `pfi();` or `(*pfi)();`.
- Due to the use of distinct name spaces for **struct** and **union** members absolute machine addresses must be explicitly cast before being used as **struct** and **union** pointers. For example:

  ```
  ((struct io_space *)0x00ff)->io_buf;
  ```

Declarations

Perhaps the greatest impact on C of the ANSI Standard has been the adoption of function prototypes. A function prototype declares the return type and argument types of a function. For example, `int f(int, float);` declares a function returning `int` with one `int` and one `float` argument. This means that a function's argument types are part of the type of that function, thus giving the advantage of stricter argument type-checking, especially across source files. A function definition (which is also a prototype) is similar except that identifiers must be given for the arguments. For example, `int f(int i, float f);`. It is still possible to use 'old style' function declarations and definitions, but you are advised to convert to the 'new style'. It is also possible to mix old and new styles of function declaration. If the function declaration which is in scope is an old style one, normal integral promotions are performed for integral arguments, and `float`s are converted to `double`. If the function declaration which is in scope is a new style one, arguments are converted as in normal assignment statements.

Empty declarations are now illegal.

Arrays cannot be defined to have zero or negative size.

Statements

- ANSI has defined the minimum attributes of control statements (eg the minimum number of case limbs which must be supported by a compiler). These values are almost invariably greater than those supported by PCCs, and so should not present a problem.
- A value returned from `main()` is guaranteed to be used as the program's exit code.
- Values used in the controlling statement and labels of a `switch` can be of any integral type.

Preprocessor

- Preprocessor directives cannot be redefined.
- There is a new ## directive for token-pasting.
- There is a directive # which produces a string literal from its following characters. This is useful for cases where you want replacement of macro arguments in strings.

- The order of phases of translation is well defined and is as follows for the preprocessing phases:
  1. Map source file characters to the source character set (this includes replacing trigraphs).
  2. Delete all newline characters which are immediately preceded by \.
  3. Divide the source file into preprocessing tokens and sequences of white space characters (comments are replaced by a single space).
  4. Execute preprocessing directives and expand macros.

  Any `#include` files are passed through steps 1-4 recursively.

  The macro __STDC__ is #defined to 1 in ANSI-conforming compilers.

The ToPCC and ToANSI tools

The desktop tools ToPCC and ToANSI help you to translate C programs and headers between the ANSI and PCC dialects of C. For more details of their use and capabilities see the earlier chapters *To*ANSI and *To*PCC.

pcc compatibility mode

This section discusses the differences apparent when the compiler is used in 'PCC' mode. When the **UNIX pcc** setup option is enabled, the C compiler will accept (Berkeley) UNIX-compatible C, as defined by the implementation of the Portable C Compiler and subject to the restrictions which are noted below.

In essence, PCC-style C is K&R C, as defined by B Kernighan and D Ritchie in their book *The C Programming Language*, with a small number of extensions and clarifications of language features that the book leaves undefined.

Language and preprocessor compatibility

In `UNIX pcc` mode, the Acorn C compiler accepts K&R C, but it does not accept many of the old-style compatibility features, the use of which has been deprecated and warned against for many years. Differences are listed briefly below:

- Compound assignment operators where the = sign comes first are accepted (with a warning) by some PCCs. An example is =+ instead of +=. Acorn C does not allow this ordering of the characters in the token.
- The = sign before a `static` initialiser was not required by some very old C compilers. Acorn C does not support this syntax.

- The following very peculiar usage is found in some UNIX tools pre-dating UNIX Version 7:

```
struct {int a, b;};
double d;

d.a = 0;
d.b = 0x....;
```

  This is accepted by some UNIX PCCs and may cause problems when porting old (and badly written) code.

- **enums** are less strongly typed than is usual under PCCs. **enum** is a non-K&R extension to C which has been standardised by ANSI somewhat differently from the usual PCC implementation.
- chars are signed by default in **UNIX pcc** mode.
- In **UNIX pcc** mode, the compiler permits the use of the ANSI **'...'** notation which signifies that a variable number of formal arguments follow.
- In order to cater for PCC-style use of variadic functions, a version of the PCC header file **varargs.h** is supplied with the release.
- With the exception of enums, the compiler's type checking is generally stricter than PCC's – much more akin to lint's, in fact. In writing the Acorn C compiler, we have attempted to strike a balance between generating too many warnings when compiling known, working code, and warning of poor or non-portable programming practices. Many PCCs silently compile code which has no chance of executing in just a slightly different environment. We have tried to be helpful to those who need to port C among machines in which the following varies:
  - the order of bytes within a word (eg little-endian ARM, VAX, Intel versus big-endian Motorola, IBM370)
  - the default size of **int** (four bytes versus two bytes in many PC implementations)
  - the default size of pointers (not always the same as **int**)
  - whether values of type **char** default to signed or unsigned **char**
  - the default handling of undefined and implementation-defined aspects of the C language.

  If the verbosity of **CC** in **UNIX pcc** mode is found undesirable, all warnings and/or errors can be turned off using the **Suppress warnings** and/or **Suppress errors** setup options.

- The compiler's preprocessor is believed to be equivalent to UNIX's `cpp`, except for the points listed below. Unfortunately, `cpp` is only defined by its implementation, and although equivalence has been tested over a large body of UNIX source code, completely identical behaviour cannot be guaranteed. Some of the points listed below only apply when the **Preprocess only** option is used with the CC tool.
  - There is a different treatment of whitespace sequences (benign).
  - `nl` is processed by `CC` with **Preprocess only** enabled, but passed by `cpp` (making lines longer than expected).
  - `Cpp` breaks long lines at a token boundary; `CC` with **Preprocess only** enabled doesn't (this may break line-size constraints when the source is later consumed by another program).
  - The handling of unrecognised # directives is different (this is mostly benign).

Standard headers and libraries

Use of the compiler in `UNIX pcc` mode precludes neither the use of the standard ANSI headers built in to the compiler nor the use of the run-time library supplied with the C compiler. Of course, the ANSI library does not contain the whole of the UNIX C library, but it does contain almost all the commonly used functions. However, look out for functions with different names, or a slightly different definition, or those in different 'standard' places. Unless the user directs otherwise using **Default path**, the C compiler will attempt to satisfy references to, say, `<stdio.h>` from its in-store filing system.

Listed below are a number of differences between the ANSI C Library, and the BSD UNIX library. They are placed under headings corresponding to the ANSI header files:

ctype.h

There are no `isascii()` and `toascii()` functions, since ANSI C is not character-set specific.

errno.h

On BSD systems there are `sys_nerr` and `sys_errlist()` defined to give error messages corresponding to error numbers. ANSI C does not have these, but provides similar functionality via `perror(const char *s)`, which displays the string pointed to by `s` followed by a system error message corresponding to the current value of `errno`.

There is also `char *strerror(int errnum)` which, when given a purported value of `errno`, returns its textual equivalent.

math.h

The #defined value `HUGE`, found in BSD libraries, is called `HUGE_VAL` in ANSI C. ANSI C does not have `asinh()`, `acosh()`, `atanh()`.

signal.h

In ANSI C the `signal()` function's prototype is:

```
extern void (*signal(int, void(*func)(int)))(int);
```

`signal()` therefore expects its second argument to be a pointer to a function returning `void` with one `int` argument. In BSD-style programs it is common to use a function returning `int` as a signal handler. The PCC-style function definitions shown below will therefore produce a compiler warning about an implicit cast between different function pointers (since `f()` defaults to `int f()`). This is just a warning, and correct code will be generated anyway.

```
f(signo)
int signo;
{
.........
}

main()
{
extern f();
signal(SIGINT, f);
}
```

stdio.h

`sprintf()` now returns the number of characters 'printed' (following UNIX System V), whereas the BSD `sprintf()` returns a pointer to the start of the character buffer.

The BSD functions `ecvt()`, `fcvt()` and `gcvt()` are not included in ANSI C, since their functionality is provided by `sprintf()`.

string.h

On BSD systems, string manipulation functions are found in `strings.h`, whereas ANSI C places them in `<string.h>`. The Acorn C Compiler also has `strings.h` for PCC-compatibility.

The BSD functions `index()` and `rindex()` are replaced by the ANSI functions `strchr()` and `strrchr()` respectively.

Functions which refer to string lengths (and other sizes) now use the ANSI type `size_t`, which in our implementation is `unsigned int`.

stdlib.h

`malloc()` returns `void *`, rather than the `char *` of the BSD `malloc()`.

float.h

A new header added by ANSI giving details of floating point precision etc.

limits.h

A new header added by ANSI to give maximum and minimum limit values for data types.

locale.h

A new header added by ANSI to provide local environment-specific features.

Environmental aspects

When porting an application, the most extensive changes will probably need to be made at the operating system interface level. The following is a brief description of aspects of RISC OS and Acorn C which differ from systems such as UNIX and MS-DOS.

The most apparent interface between a C program and its environment is via the arguments to `main()`. The ANSI Standard declares that `main()` is a function defined as the program entry point with either no arguments or two arguments

(one giving a count of command line arguments, commonly called **int argc**, the other an array of pointers to the text of the arguments themselves, after removal of input/output redirection, commonly called **char *argv[]**). As discussed in the section *Environment* (A.6.3.2) on page 77, Acorn C supports the style of input/output redirection used by UNIX BSD4.3, but does not support filename wildcarding. Further parameters to **main()** are not supported.

Under UNIX and MS-DOS, it is common to use a third parameter, normally called **char *environ[]** under UNIX and **char *envp[]** under Microsoft C for MS-DOS, to give access to environment variables. The same effect can be achieved in our system by using **getenv()** to request system variable values explicitly; the names of these variables are as they appear from a RISC OS *Show command. The string pointed at by **argv[0]** is the program name (similar to UNIX and MS-DOS, except the name is exactly that typed on invocation, so if a full pathname is used to invoke the program, this is what appears in **argv[0]**).

File naming is one of the least portable aspects in any programming environment. RISC OS uses a full stop (.) as a separator in pathnames and does not support filename extensions (nor does UNIX, but existing UNIX tools make assumptions about file naming conventions). The best way to simulate extensions is to create a directory whose name corresponds to the required extension (in a manner similar to the use of **c** and **h** directories for C source and header files). RISC OS filename components are limited to 10 characters.

The Acorn C compiler has support for making Software Interrupt (SWI) calls to RISC OS routines, which can be used to replace any system calls which you make under UNIX or MS-DOS. The include file **kernel.h** has function prototypes and appropriate **typedef**s for issuing SWIs. Briefly, the type **_kernel_swi_regs** allows values to be placed in registers R0-R9, and **_kernel_swi()** can then be used to issue the SWI; a list of SWI numbers can be found in the include file **swis.h**. File information, for example, can be obtained in a way similar to **stat()** under UNIX, by making an OS_GBPB SWI with R0 set to the reason code 11 (full file information). Most of the UNIX/MS-DOS low-level I/O can be simulated in this way, but the ANSI C run-time library provides sufficient support for most applications to be written in a portable style.

You'll find some more information on **kernel.h** in comments within the header file itself.

RISC OS does not support different memory models as in MS-DOS, so programs which have been written to exploit this will need modification; this should only require the removal of Microsoft C keywords such as **near**, **far** and **huge**, if the program has otherwise been written with portability in mind.

17 Assembly language interface

Interworking assembly language and C – writing programs with both assembly language and C parts – requires use both of ObjAsm and of CC and/or C++. Further explanation of examples is provided in the chapter *Interworking assembler with* C on page 175 of the *Acorn Assembler* guide.

Interworking assembly language and C can be very useful for construction of top quality RISC OS applications. Using this technique you can take advantage of many of the strong points of both languages. Writing most of the bulk of your application in C allows you to take advantage of the portability of C, the maintainability of a high level language and the power of the C libraries and language. Writing critical portions of code in assembler allows you to take advantage of all the speed of the Archimedes and all the features of the machine (eg use the complete floating-point instruction set).

The key to interworking C and assembler is writing assembly language procedures that obey the ARM Procedure Call Standard (APCS). This is a contract between two procedures, one calling the other. The called procedure needs to know which ARM and floating-point registers it can freely change without restoring them before returning, and the caller needs to know which registers it can rely on not being corrupted over a procedure call.

Additionally, both procedures need to know which registers contain input arguments and return arguments, and the arrangement of the stack has to follow a pattern that debuggers and so on can understand. For the specification of the APCS, see the appendix ARM *procedure call standard* on page 247 of the *Desktop Tools* guide.

This chapter explains how C uses the APCS, in terms of the appearance of assembly language optionally output by CC and the way the stack set up by the C run-time library works.

Register names

The following names are used in referring to ARM registers:

`a1`	R0	Argument 1, also integer result, temporary
`a2`	R1	Argument 2, temporary
`a3`	R2	Argument 3, temporary
`a4`	R3	Argument 4, temporary
`v1`	R4	Register variable
`v2`	R5	Register variable
`v3`	R6	Register variable
`v4`	R7	Register variable
`v5`	R8	Register variable
`v6`	R9	Register variable
`sl`	R10	Stack limit
`fp`	R11	Frame pointer
`ip`	R12	Temporary work register
`sp`	R13	Lower end of current stack frame
`lr`	R14	Link address on calls, or workspace
`pc`	R15	Program counter and processor status
`f0`	F0	Floating point result
`f1`	F1	Floating-point work register
`f2`	F2	Floating-point work register
`f3`	F3	Floating-point work register
`f4`	F4	Floating-point register variable (must be preserved)
`f5`	F5	Floating-point register variable (must be preserved)
`f6`	F6	Floating-point register variable (must be preserved)
`f7`	F7	Floating-point register variable (must be preserved)

In this section, 'at `[r]`' means at the location pointed to by the value in register `r`; 'at `[r,#n]`' refers to the location pointed to by `r+n`. This accords with ObjAsm's syntax.

Register usage

The following points should be noted about the contents of registers across function calls.

- Calling a function (potentially) corrupts the argument registers `a1` to `a4`, `ip`, `lr`, and `f0-f3`. The calling function should save the contents of any of these registers it may need.
- Register `lr` is used at the time of a function call to pass the return link to the called function; it is not necessarily preserved during or by the function call.

- The stack pointer `sp` is not altered across the function call itself, though it may be adjusted in the course of pushing arguments inside a function. The limit register `sl` may change at any time, but should always represent a valid limit to the downward growth of `sp`. User code will not normally alter this register.
- Registers `v1` to `v6`, and the frame pointer `fp`, are expected to be preserved across function calls. The called procedure is responsible for saving and restoring the contents of any of these registers which it may need to use.

Control arrival

At a procedure call, the convention is that the registers are used as follows:

- `a1` to `a4` contain the first four arguments. If there are fewer than four arguments, just as many of `a1` to `a4` as are needed are used.
- If there are more than four arguments, `sp` points to the fifth argument; any further arguments will be located in succeeding words above `[sp]`.
- `fp` points to a backtrace structure.
- `sp` and `sl` define a temporary workspace of at least 256 bytes available to the procedure.
- `sl` contains a stack chunk handle, which is used by stack handling code to extend the stack in a non-contiguous manner.
- `lr` contains the value which should be restored into `pc` on exit from the called procedure.
- `pc` contains the entry address of the called procedure.

Passing arguments

All integral and pointer arguments are passed as 32-bit words. Floating point 'float' arguments are 32-bit values, 'double'-argument 64-bit values. These follow the memory representation of the IEEE single and double precision formats.

Arguments are passed **as if** by the following sequence of operations:

- Push each argument onto the stack, last argument first.
- Pop the first four words (or as many as were pushed, if fewer) of the arguments into registers `a1` to `a4`.
- Call the function, for example by the `branch with link` instruction:

```
BL functionname
```

In many cases it is possible to use a simplified sequence with the same effect (eg load three argument words into `a1-a3`).

If more than four words of arguments are passed, the calling procedure should adjust the stack pointer after the call, incrementing it by four for each argument word which was pushed and not popped.

Return link

On return from a procedure, the registers are set up as follows:

- `fp`, `sp`, `sl`, `v1` to `v6` and `f4` to `f7` have the same values that they contained at the procedure call.
- Any result other than a floating point or a multi-word structure value is placed in register `a1`.
- A floating point result should be placed in register `f0`.

Structure values returned as function results are discussed below.

Structure results

A C function which returns a multi-word structure result is treated in a slightly different manner from other functions by the compiler. A pointer to the location which should receive the result is added to the argument list as the first argument, so that a declaration such as the following:

```
s_type afunction(int a, int b, int c)
{
        s_type d;
        /* ... */
        return d;
}
```

is in effect converted to this form:

```
void afunction(s_type *p, int a, int b, int c)
{
        s_type d;
        /* ... */
        *p = d;
        return;
}
```

Any assembler-coded functions returning structure results, or calling such functions, must conform to this convention in order to interface successfully with object code from the C compiler.

Storage of variables

The code produced by the C compiler uses argument values from registers where possible; otherwise they are addressed relative to `fp`, as illustrated in *Examples* below.

Local variables, by contrast, are always addressed with positive offsets relative to `sp`. In code which alters `sp`, this means that the offset for the same variable will differ from place to place. The reason for this approach is that it permits the stack overflow procedure to recover by changing `sp` and `sl` to point to a new stack segment as necessary.

Function workspace

The values of `sp` and `sl` passed to a called function define an area of readable, writable memory available to the called function as workspace. All words below `[sp]` and at or above `[sl,#-512]` are guaranteed to be available for reading and writing, and the minimum allowed value of `sp` is `sl-256`. Thus the minimum workspace available is 256 bytes.

The C run-time system, in particular the stack extension code, requires up to 256 bytes of additional workspace to be left free. Accordingly, all called functions which require no more than 256 bytes of workspace should test that `sp` does not point to a location below `sl`, in other words that at least 512 bytes remain. If the value in `sp` is less than that in `sl`, the function should call the stack extension function `x$stack_overflow`. Functions which need more than 256 bytes of workspace should amend the test accordingly, and call `x$stack_overflow1`, as described below. The following examples illustrate a method of performing this test.

Note that these are the C-specific aliases for the kernel functions `_kernel_stkovf_split_0frame` and `_kernel_stkovf_split_frame` respectively, described in the chapter *The shared C library* in the RISC OS 3 *Programmer's Reference Manual*.

Examples

The following fragments of assembler code illustrate the main points to consider in interfacing with the C compiler. If you want to examine the code produced by the compiler in more detail for particular cases, you can request an assembler listing by enabling the **Assembler** option on the CC SetUp menu.

This is a function **gggg** which expects two integer arguments and uses only one register variable, **v1**. It calls another function **ffff**.

```
        AREA    |C$$code|, CODE, READONLY
        IMPORT  |ffff|
        IMPORT  |x$stack_overflow|
        EXPORT  |gggg|
gggx    DCB     "gggg", 0           ;name of function, 0 terminated
        ALIGN                       ;padded to word boundary
gggy    DCD     &ff000000 + gggy - gggx
                                    ;dist. to start of name
;Function entry: save necessary regs. and args. on stack
gggg    MOV     ip, sp
        STMFD   sp!, {a1, a2, v1, fp, ip, lr, pc}
        SUB     fp, ip, #4          ;points to saved pc
;Test workspace size
        CMPS    sp, sl
        BLLT    |x$stack_overflow|
;Main activity of function
; ....
        ADD     v1, v1, #1          ;use a register variable
        BL      |ffff|              ;call another function
        CMP     v1, #99             ;rely on reg. var. after call
; ....
;Return: place result in a1, and restore saved registers
        MOV     a1, result
        LDMEA   fp, {v1, fp, sp, pc}^
```

If a function will need more than 256 bytes of workspace, it should replace the two-instruction workspace test shown above with the following:

```
        SUB     ip, sp, #n
        CMP     ip, sl
        BLLT    |x$stack_overflow1|
```

where **n** is the number of bytes needed. Note that **x$stack_overflow1** must be called if more than 256 bytes of frame are needed. **ip** must contain **sp_needed**, as shown in the example above.

A function which expects a variable number of arguments should store its arguments in the following manner, so that the whole list of arguments is addressable as a contiguous array of values:

```
MOV   ip, sp    ;copy value of sp
STMFD sp!, {a1, a2, a3, a4};save 4 words of args.
STMFD sp!, {v1, v2, fp, ip, lr, pc}
                ;save v1-v6 needed
SUB   fp, ip, #20;fp points to saved pc
CMPS  sp, sl    ;test workspace
BLLT  |x$stack_overflow|
```

Some complete program examples are described in the chapter *Interworking assembler with* C on page 175 of the *Acorn Assembler* guide.

18 How to write relocatable modules in C

Relocatable modules are the basic building blocks of RISC OS and the means by which RISC OS can be extended by a user. The archetypal use for RISC OS extensions is the provision of device drivers for devices attached to Archimedes hardware.

Relocatable modules also provide mechanisms which can be exploited to:

- extend RISC OS's repertoire of built-in commands (* commands) (analogous to plugging additional ROMs into a BBC microcomputer of pre-Archimedes vintages)
- provide services to applications (for example, as does the shared C library module)
- implement 'terminate and stay resident' (TSR) applications.

The idea of TSR applications will be most familiar to PC users, whereas extending the * command set (via 'software ROM modules') will seem most familiar to those with a background in the BBC computer. A complete discussion of these topics is beyond the scope of this chapter.

For modules which provide services, the principal mechanism for accessing those services from user code is the SoftWare Interrupt (SWI). For example, the shared C library implements a handler for a single SWI which, when called from the library stubs linked with the application, returns the address of the C library module which in turn allows the library stubs to be initialised to point to the correct addresses within the library module. Thereafter, library services are accessed directly by procedure call, rather than by SWI call. All this illustrates is the rich variety of mechanism available to be exploited.

Getting started

To write a module in C you will need:

- the CC and CMHG tools supplied with Acorn C/C++
- the C Library stubs supplied with Acorn C/C++
- a thorough understanding of RISC OS modules (read the *Modules* chapter of the RISC OS 3 *Programmer's Reference Manual*).

Constraints on modules written in C

A module written in C **must** use the shared C library module via the library stubs. Use of the stand-alone C library (ANSILib) is **not** a supported option.

All components of a module written in C **must** be compiled with the compiler SetUp menu option **Module code** enabled. This allows the module's static data to be separated from its code and multiply instantiated.

Overview of modules written in C

A module written in C includes the following:

- a Module Header (described in the *Modules* chapter of the RISC OS 3 *Programmer's Reference Manual*), constructed using CMHG;
- a set of entry and exit 'veneers', interfacing the module header to the C run-time environment (also constructed using CMHG);
- the stubs of the shared C library;
- code written by you to implement the module's functionality – for example: *command handlers, SWI handlers and service call handlers.

These parts must be linked together using the Link tool with the SetUp box **Module** option enabled.

The next section describes:

- how to write a CMHG input file to make a module header and any necessary entry veneers
- the interface definitions to which each component of your module must conform
- how to write a CMHG input file to generate entry veneers for IRQ and event handlers written in C.

Functional components of modules written in C

The following components may be present in a module written in C (all are optional except for the title string and the help string which are obligatory):

- Runnable application code (called start code in the module header description). This will be present if you tell CMHG that the module is runnable and include a `main()` function amongst your module code.
- Initialisation code. 'System' initialisation code is always present, as the shared library must be initialised. Your initialisation function will be called after the system has been initialised if you declare its name to CMHG.

- Finalisation code. The C library has to be closed down properly on module termination. Your own finalisation code will be called before the system has been closed down if you declare its name to CMHG.
- Service call handler. This will be present if you declare the name of a handler function to CMHG. In addition, you can give a list of service call numbers which you wish to deal with and CMHG will generate fast code to ignore other calls without calling your handler.
- A title string in the format described in the RISC OS 3 *Programmer's Reference Manual*. CMHG will insist that you give it a valid title string.
- A help string in the format described in the RISC OS 3 *Programmer's Reference Manual*. Again, CMHG will insist that you give a valid help string.
- Help and command keyword table. This section is optional and will be present only if you describe it to CMHG and declare the names of the command handlers to CMHG. Obviously, their implementations must be included in the linked module.
- SWI chunk base number. Present only if declared to CMHG.
- SWI handler code. Present if you declare the name of a handler function to CMHG.
- SWI decoding table. Present only if described to CMHG.
- SWI decoding code. Present only if you declare the name of your decoding function to CMHG.
- IRQ handlers. Though not associated with the module header, CMHG will generate entry veneers for IRQ handlers. You can register these veneers with RISC OS using SWI OS_Claim, etc; you have to provide implementations of the handlers themselves. The names of the handler functions and of the entry veneers have to be given to CMHG.
- An event handler. Though not associated with the module header, CMHG will generate entry veneers for an event handler. You can register these veneers with RISC OS using SWI OS_Claim, etc; you have to provide implementations of the handlers themselves. The names of the handler functions and of the entry veneers have to be given to CMHG.

Each component that you wish to use must be described in your input to CMHG. Use of most components also requires that you write some C code which must conform to the interface descriptions given in the sections below.

The C module header generator

The C Module Header Generator (CMHG) is a special-purpose assembler of module headers. It accepts as input a text file describing which module facilities you wish to use and generates as output a linkable object module (in ARM Object Format). For details of how to run the CMHG tool, see the chapter entitled CMHG earlier in this manual.

The format of input to CMHG

Input to CMHG is in free format and consists of a sequence of 'logical lines'. Each logical line starts with a keyword which is followed by some number of parameters and (sometimes) keywords. The precise form of each kind of logical input line is described in the following sections.

A logical line can be continued on the next line of input immediately after a comma (that it, if the next non-white-space character after a comma is a newline then the line is considered to be continued).

Lists of parameters can be separated by commas or spaces, but use of comma is required if the line is to be continued.

A comment begins with a **;** and continues to the end of the current line. A comment is valid anywhere that trailing white space is valid (and, in particular, after a comma).

A keyword consists of a sequence of alphabetic characters and minus signs. Often, a keyword is the same as the description of the corresponding field of the module header (as described in the RISC OS 3 *Programmer's Reference Manual*) but with spaces replaced by minus signs. For example: **initialisation-code**; **title-string**; **service-call-handler**.

Keywords are always written entirely in lower case and are always immediately followed by a **:**. Character case is significant in all contexts: in keywords, in identifiers, and in strings.

Numbers used as parameters are unsigned. Three formats are recognised:

- unsigned decimal
- 0xhhh... (up to 8 hex digits)
- &hhh... (up to 8 hex digits).

In the following sections, the parts headed ***CMHG** description* tell you what you have to describe to CMHG in order to use the facility described in that section; the parts headed C *interface* introduce a description of the interface to which the handler function you write must conform. You may omit any trailing arguments that you don't need from your handler implementations.

Runnable application code

CMHG description:

```
module-is-runnable:             ; No parameters.
```

C interface:

```
int main(int argc, char *argv[]);
/*
 * Entered in user-mode with argc and argv
 * set up as for any other application. Malloc
 * obtains storage from application workspace.
 */
```

To be useful (ie re-runnable) as a 'terminate and stay resident' application, a runnable application must implement at least one * command handler (see below) for its command line, which, when invoked, enters the module (calls SWI OS_Module with the Enter reason code).

Initialisation code

CMHG description:

```
initialisation-code: user_init  ; The name of your initialisation function.
                                ; Any valid C function name will do.
```

C interface:

```
_kernel_oserror *user_init(char *cmd_fail, int podule_base, void *pw);
/*
 * Return NULL if your initialisation succeeds; otherwise return a pointer to an
 * error block. cmd_tail points to the string of arguments with which the
 * module is invoked (may be "").
 * podule_base is 0 unless the code has been invoked from a podule.
 * pw is the 'r12' value established by module initialisation. You may assume
 * nothing about its value (in fact it points to some RMA space claimed and
 * used by the module veneers). All you may do is pass it back for your module
 * veneers via an intermediary such as SWI OS_Call Every (use _kernel_swi() to
 * issue the SWI call).
 */
```

Note that you can choose any valid C function name as the name of your initialisation code (CMHG insists on no more than 31 characters).

Finalisation code

CMHG description:

```
finalisation-code: user_final    ; The name of your finalisation function.
                                 ; Any valid C function name will do.
```

C interface:

```
extern _kernel_oserror *user_final(int fatal, int podule, void *pw);
/*
 * Return NULL if your finalisation succeeds. Otherwise return a pointer to an
 * error block if your finalisation handler does not wish to die (e.g. toolbox
 * modules return a 'Task(s) active' error).
 * fatal, podule and pw are the values of R10, R11 and R12 (respectively)
 * on entry to the finalisation code.
 */
```

A call to library finalisation code is inserted automatically by CMHG; the C library finalisation code will call your finalisation handler immediately before closing down the library (on module finalisation).

Service call handler

CMHG description:

```
service-call-handler:  sc_handler <number> <number> ...
```

C interface:

```
void sc_handler(int service_number, _kernel_swi_regs *r, void *pw);
/*
 * Return values should be poked directly into r->r[n];
 * the right value/register to use depends on the service number
 * (see the relevant RISC OS Programmer's Reference Manual section for details).
 * pw is the private word (the 'r12' value.
 */
```

Service calls provide a generic mechanism. Some need to be handled quickly; others are not time critical. Because of this, you may give a list of service numbers in which you are interested and CMHG will generate code to ignore the rest quickly. The fast recognition code looks like:

```
CMPS    r1, #FirstInterestingServiceNumber
CMPNES  r1, #SecondInterestingServiceNumber
...
CMPNES  r1, #NthInterestingServiceNumber
MOVNES  pc, lr                  ; drop into service call entry veneer.
```

If you give no list of interesting service numbers then all service calls will be passed to your handler.

In order to construct a relocatable module which implements a RISC OS application (a TSR application) you must claim and deal with the Service_Memory service call. See the relevant section in the Programmer's Reference Manual for details of this service call.

The following is a suitable handler written in C for this service call:

```
#define Service_Memory  0x11
extern void FrontEnd_services(int service_number, _kernel_swi_regs *r, void
*pw)
{
        IGNORE(pw);
        /* keep application workspace (r2 holds CAO pointer) */
        if (service_number == Service_Memory && r->r[2] ==
        (int)Image__RO_Base)
        {
                r->r[1] = 0;  /* refuse to relinquish app. workspace */
        }
}
```

The above handler needs to compare the contents of r[2] with the address of the base of your module containing it. This is not a value directly available in C, so the following assembly language fragment can be used to gain access to the symbol Image$$RO$$Base, which is defined by Link when your module is linked together:

```
        IMPORT  |Image$$RO$$Base|
        EXPORT  Image__RO_Base

        AREA    Code_Description, DATA, REL
Image__RO_Base
        DCD     |Image$$RO$$Base|

        END
```

Title string

CMHG description:

```
title-string: title
```

title must consist entirely of printable, non-space ASCII characters.

Any underscores in the title are replaced by spaces. CMHG will fault any title longer than 31 characters and warn if the length of the title string is more than 16.

Help string

CMHG description:

```
help-string: help d.dd comment ; help string and version number
```

The help string is restricted to 15 or fewer alphanumeric, ASCII characters and underscores. Longer strings are truncated (with a warning) to 15 characters then padded with a single space. Shorter titles are padded with one or two TAB characters so they will appear exactly 16 characters long.

The version number must consist of a digit, a dot, then 2 consecutive digits. Conventionally, the first digit denotes major releases; the second digit minor releases; and the third digit bug-fix or technical changes. If the version number is omitted, 0.00 is used.

CMHG automatically inserts the current date into the version string, as required by RISC OS convention.

A 'comment' of up to 34 characters can also be included after the version number. It will appear in the tail of the module's help string, after the date. A typical use is for annotating the help string in the following style:

```
SomeModule      0.91 (27 JUN 1989) Experimental version
```

CMHG refuses to generate a help string longer than 79 characters and warns if it has to truncate your input.

Help and command keyword table

CMHG description:

```
command-keyword-table: cmd_handler command-description+
```

(Here *command-description*+ denotes one or more command descriptions).

A command-description has the format:

```
star-command-name "("
        min-args:       unsigned-int    ; default 0
        max-args:       unsigned-int    ; default 0
        gstrans-map:    unsigned-int    ; default 0
        fs-command:                     ; flag bits in
        status:                         ; the flag byte
        configure:                      ; of the cmd table
        help:                           ; info word.
        invalid-syntax: text
        help-text:      text
        ")"
```

Each sub-argument is optional. A comma after any item allows continuation on the next line.

A ***text*** item follows the conventions of ANSI C string constants: it is a sequence of implicitly concatenated string segments enclosed in " and ".

Segments may be separated by white space or newlines (no continuation comma is needed following a string segment).

Within a string segment \ introduces an escape character. All the single character ASCII escapes are implemented, but hexadecimal and octal escape codes are not implemented. A \ immediately preceding a newline allows the string segment to be continued on the following line (but does **not** include a newline in the string; if a newline is required, it must be explicitly included as \n).

min-args and **max-args** record the minimum and maximum number of arguments the command may accept; **gstrans-map** records, in the least significant 8 bits, which of the first 8 arguments should be subject to expansion by OS_GSTrans before calling the command handler.

The keywords **fs-command**, **status**, **configure** and **help** set bits in the command's information word which mark the command as being of one of those classes.

invalid-syntax and **help-text** messages are (should be) self-explanatory.

Example CMHG description:

```
command-keyword-table: cmd_handler
tm0(    min-args: 0, max-args: 255,
        help-text: "Syntax\ttm1 <filenames>\n"),
tm1(    min-args:1, max-args:1,
        help-text: "Syntax\ttm2" " <integer>"
        "\n")
```

This describes two * commands, *tm0 and *tm1, which are to be handled by the C function **cmd_handler**. The handler function will be called with 0 as its third argument if it is being called to handle the first command (tm0, above), 1 as its third argument if it is being called to handle the second command (tm1, above), etc. The programmer must keep the CMHG description in step with the implementation of cmd_handler.

C interface:

```
_kernel_oserror *cmd_handler(char *arg_string, int argc, int cmd_no, void *pw);
/*
 * If cmd_no identifies a *HELP entry, then cmd_handler must return
 * arg_string or NULL (if arg_string is returned, the NUL-terminated
 * buffer will be printed).
 * Return NULL if if the command has been successfully handled;
 * otherwise return a pointer to an error block describing the failure
 * (in this case, the veneer code will set the 'V' bit).
 * *STATUS and *CONFIGURE handlers will need to cast 'arg_string' to
 * (possibly unsigned) long and ignore argc. See the RISC OS Programmer's
 * Reference Manual for details.
 * pw is the private word pointer ('r12') value passed into the entry veneer
 */
```

SWI chunk base number

CMHG description:

```
swi-chunk-base-number: number
```

You should use this entry if your module provides any SWI handlers. It denotes the base of a range of 64 values which may be passed to your SWI handler. SWI chunks are allocated by Acorn: read the documentation carefully to discover which chunks you may use safely. In some cases you may need to write to Acorn to get a chunk allocated uniquely to your product (though this should not be undertaken lightly and should only be done when all alternatives have been exhausted). See the chapter *An introduction to* SWIs in the RISC OS 3 *Programmer's Reference Manual* for more details.

SWI handler code

CMHG description:

```
swi-handler-code:  swi_handler  ; any valid C function name will do
```

C interface:

```
_kernel_oserror *swi_handler(int swi_no, _kernel_swi_regs *r, void *pw);
/*
 * Return: NULL if the SWI is handled successfully; otherwise return
 * a pointer to an error block which describes the error.
 * The veneer code sets the 'V' bit if the returned value is non-NULL.
 * The handler may update any of its input registers (r0-r9).
 * ps is the private word pointer ('r12') value passed into the
 * swi_handler entry veneer.
 */
```

If your module is to handle SWIs then it must include both **swi-handler-code** and **swi-chunk-base**.

Example CMHG description:

```
swi-chunk-base-number: 0x88000
swi-handler-code:      widget_swi
```

SWI decoding table

CMHG description:

```
swi-decoding-table: swi-base-name swi-name*
```

This table, if present, is used by OS_SWINumberTo/FromString.

Example CMHG description:

```
swi-chunk-base-number:  0x88000
swi-handler-code:       widget_swi
swi-decoding-table:     Widget,
                        Init  Read  Write  Close
```

This would be appropriate for the following name/number pairs:

```
Widget_Init             0x88000
Widget_Read             0x88001
Widget_Write            0x88002
Widget_Close            0x88003
```

SWI decoding code

CMHG description:

```
swi-decoding-code: swi_decoder          ; any valid C function name will do
```

C interface:

```
void swi_decode(int r[4], void *pw);
/*
 * On entry, r[0] < 0 means a request to convert from text to a number.
 * In this case r[1] points to the string to convert (terminated by a
 * control character, NOT necessarily by NUL).
 * Set r[0] to the offset (0..63) of the SWI within the SWI chunk if
 * you recognise its name; set r[0] < 0 if you don't recognise the name.
 *
 * On entry, r[0] >= 0 means a request to convert from a SWI number to
 * a SWI string:
 *   r[0] is the offset (0..63) of th SWI within the SWI chunk.
 *   r[1] is a pointer to a buffer;
 *   r[2] is the offset within the buffer at which to place the text;
 *   r[3] points to the byte beyond the end of the buffer.
 * You should write th SWI name into the buffer at th position given
 * by r[2] then update r[2] by the length of the text written (excluding
 * any terminating NUL, if you add one).
 *
 * pw is the private word pointer ('r12') passed into the swi_decode
 * entry veneer.
 */
```

If you omit a SWI decoding table then your SWI decoding code will be called instead. Of course, you don't have to provide either.

Turning interrupts on and off

The following (<kernel.h>) library functions support the control of the interrupt enable state:

```
int _irqs_disabled(void);
/*
 * Returns non-0 if IRQs are currently disabled.
 */

void _irqs_off(void);
/*
 * Disable IRQs.
 */

void _irqs_on(void);
/*
 * Enable IRQs.
 */
```

These functions suffice to allow saving, restoring and setting of the IRQ state. Ground rules for using these functions are beyond the scope of this document. However, general advice is to leave the IRQ state alone in SWI handlers which terminate quickly, but to enable it in long-running SWI handlers.

What a SWI handler does to the IRQ state is part of its interface contract with its clients: you, the implementor, control that interface contract.

IRQ handlers

CMHG description:

```
irq-handlers:  entry_name/handler_name ...
```

Any number of entry_name/handler_name pairs may be given. If you omit the / and the handler name, CMHG constructs a handler name by appending **_handler** to the entry name.

C interface:

```
extern int entry_name(_kernel_swi_regs *r, void *pw);
/*
 * This is name of the IRQ handler entry veneer compiled by CMHG.
 * Use this name as an argument to, for example, SWI OS_Claim, in
 * order to attach your handler to IrqV.
 */

int handler_name(_kernel_swi_regs *r, void *pw);
/*
 * This is the handler function you must write to handle the IRQ for
 * which entry_name is the veneer function.
 *
 * Return 0 if you handled the interrupt.
 * Return non-0 if you did NOT handle the interrupt (because,
 * for example, it wasn't for your handler, but for some other
 * handler further down the stack of handlers).
 *
 * 'r' points to a vector of words containing the values of r0-r9 on
 * entry to the veneer. Pure IRQ handlers do not require these, though
 * event handlers and filing system entry points do. If r is updated,
 * the updated values will be loaded into r0-r9 on return from the
 * handler.
 *
 * pw is the private word pointer ('r12') value with which
 * the IRQ entry veneer is called.
 */
```

Handlers must be installed from some part of the module which runs in SVC mode (eg initialisation code, a SWI handler, etc). The name to use at installation time is the **entry_name** (**not** the name of the handler function). This is because C functions cannot be entered directly from IRQ mode, but have to be entered and exited via a veneer which switches to SVC mode. Running in SVC mode gives your handler maximum flexibility.

IRQ handlers can also be used as filing system entry points. A full discussion of these topics is beyond the scope of this Guide; refer to the RISC OS 3 *Programmer's Reference Manual* for details and for information on how to install and remove handlers.

Event handler

CMHG description:

```
event-handler:  entry_name/handler_name event_no event_no ...
```

Only one entry_name/handler_name pair may be given.

C interface:

```
extern int entry_name(_kernel_swi_regs *r, void *pw);
/*
 * This is name of the event handler entry veneer compiled by CMHG.
 * Use this name as an argument to, for example, SWI OS_Claim, in
 * order to attach your handler to EventV.
 */

int handler_name(_kernel_swi_regs *r, void *pw);
/*
 * This is the handler function you must write to handle the event for
 * which entry_name is the veneer function.
 *
 * Return 0 if you wish to claim the event.
 * Return non-0 if you do not wish to claim the event.
 *
 * 'r' points to a vector of words containing the values of r0-r9 on
 * entry to the veneer. If r is updated, the updated values will be
 * loaded into r0-r9 on return from the handler.
 *
 * pw is the private word pointer ('r12') value with which
 * the event entry veneer is called.
 */
```

The name to use at installation time is the **`entry_name`** (**not** the name of the handler function). Refer to the RISC OS 3 *Programmer's Reference Manual* for details and for information on how to install and remove event handlers. As an example, this is the skeleton of an event handler for key presses and mouse clicks:

```
/* the claim/free functions... */

#define EventV 16
#define EnableEvent 14
#define DisableEvent 13
#define MouseClick 10
#define Keypress 11

static void claim_release(int claim, void *pw)
{
        _kernel_swi_regs regs;
        regs.r[0] = EventV;
        regs.r[1] = (int) register_event;
        regs.r[2] = (int) pw;
        _kernel_swi(claim ? OS_Claim : OS_Release,&regs,&regs);
}
```

```
static void add_remove(int add)
{
        _kernel_swi_regs regs;
        regs.r[0] = add ? EnableEvent:DisableEvent;
        regs.r[1] = MouseClick;                 /* mouse */
        _kernel_swi(OS_Byte,&regs,&regs);
        regs.r[1] = Keypress;                   /* keyboard */
        _kernel_swi(OS_Byte,&regs,&regs);
}

static void claim_free_events(int claim,void *pw)
{
        if (claim) {
                claim_release(1,pw);
                add_remove(1);
        } else {
                add_remove(0);
                claim_release(0,pw);
        }
}

/* init... */
extern _kernel_oserror *events_init(char *cmd_tail, int podule_base, void *pw)
{
        IGNORE(cmd_tail);
        IGNORE(podule_base);
        claim_free_events(1,pw);
        return NULL;
}

/* finalise... */
extern _kernel_oserror *events_final (int fatal, int podule, void *pw)
{
        IGNORE(fatal);
        IGNORE(podule);
        /* handle low level events */
        claim_free_events(0,pw);
        return NULL;
}

/* the handler itself... */
extern int event_handler(_kernel_swi_regs *r,void *pw)
{
        IGNORE(pw);
        /* switch on the event code */
        switch (r->r[0]) {
        case MouseClick:
        case Keypress:
                break;
        default:
                break;
        }
        return 1;
}
```

Library initialisation code

CMHG description:

```
library-initialisation-code: xxxx
```

The code ***xxxx*** is called instead of **_clib_initialisemodule**. Because the C library has not been initialised at this point, and there is hence no C environment present, ***xxxx*** must be written in assembler. It should be a veneer around a call to **_clib_initialisemodule**.

19 Overlays

Overlays are a very old technique for squeezing quart-sized programs into pint-sized memories: a kind of poor man's paging.

In common with paged programs, an overlaid program is stored on some backing store medium such as a floppy disc or a hard disc and its components (called overlay segments) are loaded into memory only as required. In theory, this reduces the amount of memory required to run a program at the expense of increasing the time taken to load it and repeatedly re-load parts of it. It is a classic space-time trade-off. In practice, except in rather special circumstances, the saving in memory accruing from the use of overlays is rather modest and less than you might expect. Indeed, as discussed below, overlays have rather restricted applicability under RISC OS. Nonetheless, their use can occasionally be a 'life saver'.

Paging vs overlays

In a paged system, a program and its workspace is broken up into fixed size chunks called *pages*. A combination of special hardware and operating system support ensures that pages are loaded only when needed and that un-needed pages are soon discarded. In principle, the author of a paged program need not be aware that it will be paged (but this is often not true in practice if the author wishes the program to run at maximum speed). Both code and data are paged, automatically. In general, for single programs which re-use their workspace whenever possible, one sees a ratio of program size plus workspace size to occupied memory size in the region 1.5 to 3. One can always increase the ratio arbitrarily by integrating several sequentially used programs into a single image and by never re-using workspace. But, fundamentally, paging rarely squeezes more than a quart-sized program into a pint-sized memory. Of course, there are other benefits of paging, but these are beyond the scope of this section.

In contrast, an overlaid program is broken up into variable sized chunks (called overlay segments) by the user, who also determines which of these chunks may share the same area of memory. As the overlay system permits two code fragments which share the same area of memory to call one another and return successfully to the caller, this is merely a matter of performance. However, if data is included in an overlaid segment the situation becomes more complicated and the user has more work to do. For example, it must be ensured that all code which uses the data resides in the same segment as the data. Furthermore, it must be acceptable that the data is re-initialised every time the segment is re-loaded. Thus, in general, it is

possible to overlay two work areas each of which is private to two distinct sets of functions which are not simultaneously resident in memory. Overall, it would be unusual to overlay more than a quart-sized program into a pint-sized memory, much as with paging (you may achieve a factor as high as four for code, but non-overlaid data will usually dilute the overall factor substantially; it all depends on the details of your application).

A more detailed description of the low-level aspects of overlays is given in the section *Generating overlaid programs* on page 140 of the *Desktop Tools* guide. If you are especially interested in using overlays you may prefer to read that section next. Otherwise, if you are more interested in when to use overlays, please read on.

When to use overlays

Overlays work best when a program has several semi-independent parts. A good model for purposes of understanding is to think of a special-purpose command interpreter (the root segment) which can invoke separate commands (overlay segments) in response to user input. Consider, for example, a word processor which consists of a text editor and a collection of printer drivers. It is clear that each of the printer drivers can be overlaid (you are unlikely to have more than one printer); it may even be plausible to overlay each with the editor itself (you may not be able to edit while printing – depending on how fast the printer goes and on how much CPU time is required to drive it). Furthermore, if the time taken to load an overlay segment can be tacked on to an interaction with the user, it is probable that the program will feel little slower than if it were memory-resident. In summary: overlays work best if your program has many independent sub-functions.

On the other hand, if your program has many semi-independent parts, it may be better to structure it as several independent programs, each called from a control program. By using the shared C library, each program can be relatively small, and the Squeeze utility can be used to reduce the space taken by it on backing store by nearly a factor of 2. (See the chapter *Squeeze* on page 151 of the *Desktop Tools* guide for details). In contrast, overlay segments cannot be squeezed (though the root program can be). So, if you can structure your application as independent, squeezed programs it may take up less precious floppy disc space and load faster, especially from a floppy disc, than if you structure it using overlays.

If adopted, this strategy will force the independent programs to communicate via files. Provided the data to be communicated has a simple structure this causes no problems for the application; provided it is not too voluminous, use of the RAM filing system (RamFS) is suggested as this is fast and requires no special application code in order to use it.

So, overlays are most appropriate for applications which manipulate very large amounts of highly structured data – Computer Aided Design applications are archetypal here – whereas multiple independent programs are most appropriate for applications which manipulate relatively small amounts of simply structured data and are otherwise dominated by large amounts of code.

Naturally, if you are porting an existing application to RISC OS, your view will be coloured by whether or not it is already structured to use overlays. If it is, it will probably be best to stick to using overlays, rather than attempting to split the application up into semi-independent sub-applications.

On the other hand, if you are writing an application from scratch, you probably want to ponder this question in more depth. For example, to what other systems will the application be targeted? Using multiple semi-independent applications may work very nicely under UNIX or OS/2 where the output of one process can be piped into another, but less well under MS-DOS where use of overlays is much more the norm.

Part 5 – Appendixes

Appendix A: Changes to the C compiler

Acorn C/C++ is the fifth release of an Acorn C compiler product for RISC OS, and replaces the *Acorn Desktop* C product. The product has seen the following significant changes since the last release:

- The product has been merged with the Assembler.
- A C++ translator has been added to the product. This is a port of Release 3.0 of AT&T's CFront product.
- A C++ tool has been added to the product to provide an interface for C++ compilation that is similar to that provided by the CC tool for C compilation.
- The compiler now produces smaller programs that use less memory and run faster. This performance improvement is the result of many small improvements to the compiler, such as:
  - in-lining some commonly used small library functions
  - introducing conditionalised conditions
  - using variable lifetime analysis to improve the allocation of variables to registers.
- The Toolbox has been added to the product, to facilitate the design and coding of consistent user interfaces for RISC OS desktop applications. See the accompanying *User Interface Toolbox* guide.
- RISC_OSLib has been removed from the product, as the Toolbox now provides far superior facilities for writing RISC applications.

Appendix B: C errors and warnings

This appendix gives a brief description of the intended purposes of error and warning messages from the CC tool, along with some hints for interpreting them. It then lists most of the common errors in alphabetical order. It is not a complete list. Since the messages are designed as far as possible to be self-explanatory, some of the more simple common ones are not listed here.

Interpreting CC errors and warnings

The compiler can produce error and warning messages of several degrees of severity. They are as follows:

- **Warnings** indicating curious, but legal, program constructs, or constructs that are indicative of potential error;
- **Non-serious errors** that still allow code to be produced;
- **Serious errors** that may cause loss of code;
- **Fatal errors** that may stop the compiler from compiling;
- **System errors** that signal faults in the system itself.

Warnings from CC are intended to provide a helpful level of checking, in addition to the level required by the ANSI standard. On some other systems, such as UNIX, separate facilities (like lint) are provided to perform this checking. Warnings flag program constructs that may indicate potential errors, or those not recommended because they may function differently on other machines, and hence hinder the portability of code.

Some warnings point out the use of facilities provided in this ANSI C implementation which are above the minimum required by ANSI – for example, use of external identifiers that are identical in the first six characters, which may not be differentiated by other systems which conform to the ANSI standard.

Programs ported from other machines may cause large numbers of warning messages from CC, which you can disable with the **Suppress warnings** option (see page 34 for more information).

You can also enable additional checks with the CC and C++ **Features** option. This is best done in the final stages of a project, and will help you to produce high-quality software.

Errors and serious errors collectively respond to ANSI 'diagnostics'; whether an error is serious or not reflects the compiler's view, not yours, or that of the ANSI committee.

After issuing a warning, non-serious, or serious error, CC continues compiling, sometimes producing more such messages in the process. Compilation of C by CC can be thought of as a pipeline process, starting with preprocessing, syntax analysis, then semantic analysis (when the structure of a portion of code is analysed). When syntax errors in C are encountered by CC, the compiler can often guess what the error was, correct it, and continue. When semantic errors are found, portions of your code are often ignored before continuing, and serious error messages are reported.

Unfortunately, the compact and powerful nature of C leads to a high proportion of semantic errors. Ignoring portions of your code is likely to make subsequent portions incorrect, so one serious error can often start a cascade of error messages. Often, therefore, it is sensible to ignore a set of error messages following a serious error message.

If the compiler produces any message more serious than a warning, it will set a bad return code, usually terminating any 'make' of which it is a part in the process. Any serious error will cause the output object file to be deleted; fatal and system errors cause immediate termination of compilation, with loss of the object file and bad return code set.

Future releases of the compiler may distinguish further forms of error, or produce slightly different forms of wording.

In pcc mode, constructs that are erroneous in ANSI mode are reported, even though legal in pcc mode.

Warnings

Warning messages indicate legal but curious C programs, or possibly unintended constructs (unless warnings are suppressed). On detection of such a condition, the compiler issues a warning message, then continues compilation.

Warning messages

'&' unnecessary for function or array *xx*

This is a reminder that if xx is defined as `char` *xx*`[10]` then *xx* already has a pointer type. There is a similar reminder for function names too. Example:

```
static char mesg[] = "hello\n";
int main ()
{
        char *p = &mesg; /* mesg is already compatible with char * */
        ...
```

actual type '*xx*' mismatches format '%*x*'

A type error in a `printf` or `scanf` format string. Example:

```
{
        int i;
        printf("%s\n", i); /* %s need char* not int */
        ...
```

ANSI 'xx' trigraph for 'x' found — was this intended?

This helps to avoid inadvertent use of ANSI trigraphs. Example:

```
printf("Type ??/!!: "); /* "??/" is trigraph for "\" */
```

argument and old-style parameter mismatch : *xx*

A function with a non-ANSI declaration has been called using a parameter of a wrong data type. Example:

```
int fnl(a , b)
int a;
int b;
{
  return a * b;
{
...
int main()
{
  int l; float m;
  fnl(l , m);           /* m should be 'int' */
  ...
```

character sequence /* inside comment

You cannot nest comments in C. Example:

```
/* comment out func() for now...
/* func() returns a random number */
int func(void)
{
        ...
        return i;
}
*/
```

Dangling 'else' indicates possible error

This hints that you may have mismatched your **if**s and **else**s. Remember an **else** always refers to the most recent unmatched **if**. Use braces to avoid ambiguity. Example:

```
if (a)
         if (b)
         return 1;
         else if (c)
         return 2;
        else /* this belongs to the if (a). Or does it?*/
         return 3;
```

Deprecated declaration of *xx*() – give arg types

A feature of the ANSI standard is that argument types should be given in function declarations (prototypes). 'No arguments' is indicated by **void**. Example:

```
extern int func(); /* should have 'void' in the parentheses */
```

extern clash xx , xx clash (ANSI 6 char monocase)

Using compiler **Feature** option **e**, it was found that two external names were not distinct in the first six characters. Some linkers provide only six significant characters in their symbol table. Example:

```
extern double function1 (int i);
extern char * function2 (long l);
```

extern 'main' needs to be 'int' function

This is a reminder that `main()` is expected to return an integer. Example:

```
void main()
{
        ...
```

extern *xx* not declared in header

Compiling with **Feature** `h`, an external object was discovered which was not declared in any included header file.

floating point constant overflow

This is typically caused by a division by zero in a floating point constant expression evaluated at compile time. Example:

```
#define lim 1
#define eps 0.01
static float a = eps/(lim-1); /* lim-1 yields 0 */
```

floating to integral conversion failed

A cast (possibly implicit) of a floating point constant to an integer failed at compile time. Example:

```
static int i = (int) 1.0e20; /* INT_MAX is about 2e10 */
```

formal parameter '*xx*' not declared — 'int' assumed

The declaration of a function parameter is missing. Example:

```
int func(a)
/*a should be declared here or within the parentheses*/
{
        ...
```

Format requires *nn* parameters, but *mm* given

Mismatch between a `printf` or `scanf` format string and its other arguments. Example:

```
printf("%d, %d\n",1); /* should be two ints */
```

function *xx* declared but not used

When compiling with **Feature** `v`, the function *xx* was declared but not used within the source file.

`Illegal format conversion '%x'`

Indicates an illegal conversion implied by a `printf` or `scanf` format string. Example:

```
printf("%w\n",10); /* no such thing as %w */
```

`implicit narrowing cast : xx`

An arithmetic operation or bit manipulation is attempted involving assignment from one data type to another, where the size of the latter is naturally smaller than that of the assigned value. Example:

```
double d = 1.0; long l = 2L; int i = 3;
i = d * i;
i = l | 3;
i = l & ~1;
```

`implicit return in non-void function`

A non-void function may exit without using a return statement, but won't return a meaningful result. Example:

```
int func(int a)
{
        int b=a*10;
        .../* no return <expr> statement */
}
```

`incomplete format string`

A mistake in a `printf` or `scanf` format string. Example:

```
printf("Score was %d%",score); /* 2nd % should be %% */
```

`'int xx()' assumed – 'void' intended?`

If the definition of a function omits its return type – it defaults to `int`. You should be explicit about the type, using `void` if the function doesn't return a result. Example:

```
main()
{
        ...
```

inventing 'extern int *xx*();'

The declaration of a function is missing. Example:

```
printf("Type your name: ");
/* forgot to #include <stdio.h> */
```

lower precision in wider context: *xx*

An arithmetic operation or bit manipulation is attempted involving assignment from `int`, `short` or `char` to `long`. Example:

```
long l = 1L; int i = 2; short j = 3;
l = i & j;
l = i | 5;
l = i * j;
```

One circumstance in which this causes problems is when code like

```
long f(int x){return 1<<x;}
```

(which fails if `int` has 16 bits) is moved to machines such as the IBM PC.

No side effect in void context: '*op*'

An expression which does not yield any side effect was evaluated; it will have no effect at run-time. Example:

```
a+b;
```

no type checking of enum in this compiler

Compiling with **Feature** `x`, an `enum` declaration was found, and this message refers to the ANSI stipulation that enum values be integers, less strictly typed than in some earlier dialects of C.

Non-ANSI #include <xx>

A header file has been #included which is not defined in the ANSI standard. < > should be replaced by " ".

non-portable — not 1 char in '*xx*'

Assigning character constants containing more than one character to an `int` will produce non-portable results. Example:

```
static int exitCode = 'ABEX';
```

non-value return in a non-void function

The expression was omitted from a **return** statement in a function which was defined with a non-**void** return type. Example:

```
int func(int a)

{
        int b=a*10;
        ...
        return; /* no <expr> */
}
```

odd unsigned comparison with 0 : xx

An attempt has been made to determine whether an unsigned variable is negative. Example:

```
unsigned u , v;
if (u < 0) u = u * v;
if (u >= 0) u = u / v;
```

Old-style function: xx

Compiling with **Feature** o, it was noted that the code contains a non-ANSI function declaration. Example:

```
void fn2(a , b)
int a;
int b;
{ b = a; }
```

omitting trailing '\0' for char[*nn*]

The character array being equated to a string is one character too short for the whole string, so the trailing zero is being omitted. Example:

```
static char mesg[14] = "(C)1988 Acorn\n";/* needs 15 */
```

repeated definition of #define macro xx

When compiling with **Feature** h, a macro has been repeatedly #defined to take the same value.

shift by *nn* illegal in ANSI C

This is given for negative constant shifts or shifts greater than 31. On the ARM, the bottom byte of the number given is used, ie it is treated as `(unsigned char)` nn. NB: negative shifts are not treated as positive shifts in the other direction. Example:

```
printf("%d\n",1<<-2);
```

'short' slower than 'int' on this machine (see manual)

For speed you are advised to use `int`s rather than `short`s where possible. This is because of the overhead of performing implicit casts from `short` to `int` in expression evaluation. However, `short`s are half the size of `int`s, so arrays of `short`s can be useful. Example:

```
{
        short i,j; /* quicker to use ints */
        ...
```

spurious {} around scalar initialiser

Braces are only required around structure and array initialises. Example:

```
static int i = {INIT_I}; /* don't need braces */
```

static *xx* declared but not used

A static variable was declared in a file but never used in it. It is therefore redundant.

Unrecognised #pragma (no '-' or unknown word)

#pragma directives are of the form

```
#pragma -xd
```
or
```
#pragma long_spelling
```

where *x* is a letter and *d* is an optional digit. These messages warn against unknown letters and missing minus signs.

use of '*op*' in condition context

Warns of such possible errors as = and not == in an `if` or looping statement. Example:

```
if (a=b) {
        ...
```

variable *xx* declared but not used

This refers to an automatic variable which was declared at the start of a block but never used within that block. It is therefore redundant. Example:

```
int func(int p)
{
        int a;  /* this is never used */
        return p*100;
}
```

***xx* may be used before being set**

Compiling with **Feature a**, an automatic variable is found to have been used before any value has been assigned to it.

***xx* treated as *xx*ul in 32-bit implementation**

This message warns of two's complement arithmetic's dependence on assigning negative constants to `unsigned ints`, and it explains that `int`s and `long int`s are both 32 bits.

Non-serious errors

These are errors which will allow 'working' code to be produced – they will not produce loss of code. On detection of such an error the compiler issues an error message, if enabled, then continues compilation.

',' (not ';') separates formal parameters

Incorrect punctuation between function parameters. Example:

```
extern int func(int a;int b);
```

ANSI C does not support 'long float'

This used to be a synonym for `double`, but is not allowed in ANSI C.

ancient form of initialisation, use '='

An obsolete syntax for initialisation was used, or incorrectly nested brackets have been found. Example:

```
int i{1};       /* use int i=1; */
```

array [0] found

The minimum subscript count allowed is 1. (Remember that the subscripts go from 0 - n–1.) Example:

```
static int a[0];
```

array of xx illegal – assuming pointer

Illegal objects have been declared to occupy an array. Examples:

```
int fn2[5]();           /* array of functions */
void v[10];             /* array of voids */
```

assignment to 'const' object 'xx'

You can't assign to objects declared as **const**. Example:

```
{
        const int ic = 42; /* initialisation ok */
        ic = 69; /* can't change it now */
        ...
```

comparison '*op*' of pointer and int: literal 0 (for == and !=) is the only legal case

You cannot use the comparison operators between an integer and a pointer type. As the message implies, you can only check for a pointer being (not) equal to **NULL** (**int** 0). Example:

```
{
        int i,j,*ip;
        j = i>ip; /* can't compare an int and an int * */
        ...
```

declaration with no effect

The compiler detected what appeared to be a declaration statement, but which resulted in no store being allocated. This may imply that a data type name was omitted.

differing pointer types: 'xx'

An illegal implicit type cast was detected in a comparison operation between two pointers of different types. Example:

```
{
        int     *ip;
        char    *cp;
        printf("%d\n", ip==cp); /* can't compare these */
        ...
```

differing redefinition of #define macro xx

#define gives a definition contradicting that already assigned to the named macro.

ellipsis (...) cannot be only parameter

Although C allows variable length argument lists, the '...' parameter cannot stand alone in this function declaration. Example:

```
void fnl(...) { }
```

expected 'xx' or 'x' - inserted 'x' before 'yy'

Often caused by omitting a terminating symbol in a statement when the compiler is able to insert this symbol for you, and then to recover. Example:

```
int f(int j)
{
  return j;
}
int main()
{
  int i=f(10;     /* ')' omitted here */
  return i;
}
```

formal name missing in function definition

This error occurs when a comma in a function definition led the compiler to suspect a further formal parameter was going to follow, but none did. Example:

```
int a(int b,) /* missing parameter */
{
        ...
```

function prototype formal 'xx' needs type or class – 'int' assumed

A formal parameter in a function prototype was not given a type or class. It needs at least one of these (**register** being the only allowed class). Example:

```
void func(a); /* I mean int a or perhaps register a */
```

function returning xx illegal – assuming pointer

A function apparently intends to return an illegal object. Example:

```
int fn3()[]             /* hoping to return an array */
{
  int list[3] = {1,2,3};
  return list;
}
```

function *xx* may not be initialised – assuming function pointer

A function is not a variable, so cannot be initialised. As an attempt to initialise *xx* has been made, ***xx*** is treated as of type function *. Example:

```
extern int func(void);
static int fn() = func; /* the compiler will use
         static int (*fn)() = func; instead */
```

<int> *op* <pointer> treated as <int> *op* (int)<pointer>

Warns of an illegal implicit cast within an expression. Typically *op* is an operator which has no business being used on pointers anyway, such as | or dyadic *. Example:

```
{
        int i, *ip;
        i = i | ip; /* bitwise-or on a pointer?! */
        ...
```

junk at end of #*xx* line – ignored

The *xx* is either **else** or **endif**. These directives should not have anything following them on the line. Example:

```
/* text after the #else should be a comment */
#else if it isn't defined
...
```

L'...' needs exactly 1 wide character

The `wchar_t` declaration of a wide character names an identifier comprising other than one character. Example:

```
wchar_t wc = L'abc';
```

linkage disagreement for 'xx' — treated as 'xx'

There was a linkage type disagreement for declarations, eg a function was declared as `extern` then defined later in the file as `static`. Example:

```
int func(int a); /* compiler assumes extern here */
...
static func(int a) /* but told static here */
{
        ...
```

more than 4 chars in character constant

A character constant of more than four characters cannot be assigned to a 32 bit `int`. Example:

```
{
        int i = '12345'; /* more than four chars */
        ...
```

no chars in character constant ''

At least one character should appear in a character constant. The empty constant is taken as zero. Example:

```
{
        int i = ''; /* less than one char == '\0' */
        ...
```

objects that have been cast are not l-values

The programmer tried to use a cast expression as an l-value. Example:

```
char *p;
*((int *)p)=10; /* (int *)p is NOT an l-value */
```

omitted <type> before formal declarator — 'int' assumed

This is given in a formal parameter declaration where a type modifier is given but no base type. Example:

```
int func(*a); /* a is a pointer, but to what? */
```

'*op*': cast between function pointer and non-function object

Casts between function and object pointers can be very dangerous! One possibly valid (but still very suspect) use is in casting an array of **int** into which machine code has been loaded into a function pointer. Example:

```
static int mcArray[100];
/*pointer to function returning void*/
typedef void (*pfv)(void);
        ...
    ((pfv)mcArray)(); /* convert to fn type and apply */
```

'*op*': implicit cast of non-0 int to pointer

Zero, equal to a **NULL** pointer, is the only **int** which can be legally implicitly cast to a pointer type. Example:

```
{
        int i, *ip;
        ip = i;          /* only the constant int 0 can be implicitly
                            cast to a pointer type */
        ...
```

'*op*': implicit cast of pointer to non-equal pointer

An illegal implicit cast has been detected between two different pointer types. The type casting must be made explicit to escape this error. Example:

```
{
        int     *ip;
        char    *cp;
        ip = cp; /* differing pointer types */
        ...
```

'*op*': implicit cast of pointer to 'int'

An illegal implicit cast has been detected between an integer and a pointer. Such casts must be made explicitly. Example:

```
{
        int i, *ip;
        i = ip; /* pointer must be cast explicitly */
        ...
```

overlarge escape '\\xxxx' treated as '\\xxx'

A hexadecimal escape sequence is too large. Example:

```
int novalue()
{
  if (seize) return '\xfff';            /* \xfff' too large */
  else return '\xff';
}
```

overlarge escape '\\x' treated as '\\x'

An octal escape sequence is too large. Example:

```
int novalue()
{
  if (huit) return '\777';              /* \777 too large */
  else return '\77';
}
```

<pointer> *op* <int> treated as (int)<pointer> *op* <int>

The only legal operators allowed in this context are + and -.

prototype and old-style parameters mixed

Use has been made of both the ANSI style function/definition (including a type name for formal parameters in a function's heading) and pcc style parameters lists. Example:

```
void fn4(a, int b)
int a;
{
  a = b;
}
```

'register' attribute for '*xx*' ignored when address taken

Addresses of register variables cannot be calculated, so an address being taken of a variable with a **register** storage class causes that attribute to be dropped. Example:

```
{
        register int i, *ip;
        ip = &i; /* & forces i to lose its register attribute */
        ...
```

return <expr> illegal for void function

A function declared as void must not return with an expression. Example:

```
void a(void)
{
        ...
        return 0;
}
```

size of 'void' required – treated as 1

This indicates an attempt to do pointer arithmetic on a `void *`, probably indicating an error. Example:

```
{
        void    *vp;
        vp++; /* how many bytes to increment by ? */
        ...
```

size of a [] array required – treated as [1]

If an array is declared as having an empty first subscript size, the compiler cannot calculate the array's size. It therefore assumes the first subscript limit to be 1 if necessary. This is unlikely to be helpful.

```
extern int array[][10];
static int s = sizeof(array); /*can't determine this*/
```

sizeof <bit field> illegal – sizeof(int) assumed

Bitfields do not necessarily occupy an integral number of bytes but they are always parts of an `int`, so an attempt to take the size of a bitfield will return `sizeof(int)`. Example:

```
struct s {
        int exp : 8;
        int mant : 23;
        int s : 1;
};
int main(void)
{
        struct s st;
        int i = sizeof(st.exp); /* can't obtain this in bytes */
        ...
```

Small (single precision) floating value converted to 0.0
Small floating point value converted to 0.0

A floating point constant was so small that it had to be converted to 0.0. Example:

```
static float f = 1.0001e-38 - 1.0e-38; /* 1e-42 too small for float */
```

Spurious #elif ignored
Spurious #else ignored
Spurious #endif ignored

One of these three directives was encountered outside any `#if` or `#ifdef` scope. Example:

```
#if defined sym
...
#endif
#else /* this one is spurious */
...
```

static function xx not defined - treated as extern

A prototype declares the function to be static, but the function itself is absent from this compilation unit.

string initialiser longer than char [nn]

An attempt was made to initialise a character array with a string longer than the array. Example:

```
static char str[10] = "1234567891234";
```

struct component *xx* may not be function - assuming function pointer

A variable such as a structure component cannot be declared to have type `function`, only `function *`. Example:

```
struct s {
        int fn();/* compiler will use int (*fn)(); */
        char c;
};
```

type or class needed (except in function definition) – int assumed

You can't declare a function or variable with neither a return type nor a storage class. One of these must be present. Examples:

```
func(void); /* need, eg, int or static */
x;
```

Undeclared name, inventing 'extern int xx'

The name xx was undeclared, so the default type **extern int** was used. This may produce later spurious errors, but compilation continues. Example:

```
int main(void) {
        int i = j; /*j has not been previously declared*/
        ...
```

unprintable character *xx* found – ignored

An unrecognised character was found embedded in your source – this could be file corruption, so back up your sources! Note that 'unprintable character' means any non-whitespace, non-printable character.

variable xx may not be function – assuming function pointer

A variable cannot be declared to have type **function**, only **function ***. Example:

```
int main(void)
{
        auto void fn(void); /* treated as void (*fn)(void);*/
        ...
```

xx may not have whitespace in it

Tokens such as the compound assignment operators (+= etc) may not have embedded whitespace characters in them. Example:

```
{
        int i;
        ...
        i + = 4; /* space not allowed between + and = */
        ...
```

Serious errors

These are errors which will cause loss of generated code. On detection of such an error, the compiler will attempt to continue and produce further diagnostic messages, which are sometimes useful, but will delete the partly produced object file.

'...' must have exactly 3 dots

This is caused by a mistake in a function prototype where a variable number of arguments is specified. Example:

```
extern int printf(const char *format,....); /*one . too many*/
```

'{' of function body expected – found 'xx'

This is produced when the first character after the formal parameter declarations of a function is not the { of the function body. Example:

```
int func(a)
int a;
        if (a) ... /* omitted the { */
```

'{' or <identifier> expected after 'xx', but found 'yy'

xx is typically **struct** or **union**, which must be followed either by the tag identifier or the open brace of the field list. Example:

```
struct *fred; /* Missed out the tag id */
```

'xx' variables may not be initialised

A variable is of an inappropriate class for initialisation. Example:

```
int main()
{
  extern int n=1;
  return 1;
}
```

'*op*': cast to non-equal 'xx' illegal
'*op*': illegal cast of 'xx' to pointer
'*op*': illegal cast to 'xx'

These errors report various illegal casting operations. Examples:

```
struct s {
        int a,b;
};
struct t {
        float ab;
};
int main(void)
{
        int i;
        struct s s1;
        struct t s2;
/* '=': illegal cast to 'int' */
        i = s1;
/* '=': illegal cast to non-equal 'struct' */
        s1 = s2;
/* <cast>: illegal cast of 'struct' to pointer */
        i = *(int *) s1;
/* <cast>: illegal cast to 'int' */
        i = (int) s2;
        ...
```

'*op*': illegal use in pointer initialiser

(Static) pointer initialisers must evaluate to a pointer or a pointer constant plus or minus an integer constant. This error is often accompanied by others. Example:

```
extern int count;
static int *ip = &count*2;
```

{} must have 1 element to initialise scalar

When a scalar (integer or floating type) is initialised, the expression does not have to be enclosed in braces, but if they are present, only one expression may be put between them. Example:

```
static int i = {1,2}; /* which one to use? */
```

Array size *nn* illegal – 1 assumed

Arrays have a maximum dimension of `0xffffff`. Example:

```
static char dict[0x1000000]; /* Too big */
```

attempt to apply a non-function

The function call operator `( )` was used after an expression which did not yield a pointer to function type. Example:

```
{
        int i;
        i();
        ...
```

Bit fields do not have addresses

Bitfields do not necessarily lie on addressable byte boundaries, so the `&` operator cannot be used with them. Example:

```
struct s {
        int h1,h2 : 13;
};
int main(void)
{
        struct s s1;
        short *sp = &s1.h2; /* can't take & of bit field */
        ...
```

Bit size *nn* illegal — 1 assumed

Bitfields have a maximum permitted width of 32 bits as they must fit in a single integer. Example:

```
struct s {
        int f1 : 40; /* This one is too big */
        int f2 : 8;
};
```

'break' not in loop or switch — ignored

A break statement was found which was not inside a **for**, **while** or **do** loop or **switch**. This might be caused by an extra }, closing the statement prematurely. Example:

```
int main(int argc)
{
        if (argc == 1)
                break;
        ...
```

'case' not in switch — ignored

A **case** label was found which was not inside a **switch** statement. This might be caused by an extra }, closing the **switch** statement prematurely. Example:

```
void fn(void)
{
        case '*': return;
        ...
```

<command> expected but found a 'op'

This error occurs when a (binary) operator is found where a statement or side-effect expression would be expected. Example:

```
        if (a) /10; /* mis-placed ) perhaps? */
        ...
```

'continue' not in loop — ignored

A **continue** statement was found which was not inside a **for**, **while** or **do** loop. This might be caused by an extra }, closing the **loop** statement prematurely. Example:

```
        while (cc) {
        if (dd)                 /* intended a { here */
                        error();
                }                       /*this closes the while */
                if (ee)
                        continue;
        }
```

'default' not in switch — ignored

A **default** label was found which was not inside a **switch** statement. This might be caused by an extra }, closing the **switch** statement prematurely. Example:

```
        switch (n) {
                case 0:
                        return fn(n);
                case 1: if (cc)
                        return -1;
                 else
                         break;
                } /* spurious } closes the switch */
                default:
                        error();
        }
```

duplicated case constant: *nn*

The case label whose value is *nn* was found more than once in a **switch** statement. Note that *nn* is printed as a decimal integer regardless of the form the expression took in the source. Example:

```
switch (n) {
        case ' ':
        ...
        case ' ':
        ...
}
```

duplicate 'default' case ignored

Two cases in a single **switch** statement were labelled **default**. Example:

```
switch (n) {
        default:
        ...
        default:
        ...
}
```

duplicate definition of 'struct' tag '*xx*'

There are duplicate definitions of the type **struct** *xx* **{...} ;**. Example:

```
struct s { int i,j;};
struct s {float a,b;};
```

duplicate definition of 'union' tag '*xx*'

There are duplicate definitions of the type **union** *xx* **{...} ;**. Example:

```
union u {int i; char c[4];};
union u {double d; char c[8];};
```

duplicate type specification of formal parameter '*xx*'

A formal function parameter had its type declared twice, once in the argument list and once after it. Example:

```
void fn(int i)
int i;          /* this one is redundant */
{
        ...
```

EOF in comment
EOF in string
EOF in string escape

These all refer to unexpected occurrences of the end of the source file.

Expected <identifier> after 'xx' but found 'xx'
expected 'xx' – inserted before 'yy'

This typically occurs when a terminating semi-colon has been omitted before a }. (Common amongst Pascal programmers) Another case is the omission of a closing bracket of a parenthesised expression. Examples:

```
int fn(int a, int b, int c)
{
        int d = a*(b+c;                 /* missing ) */
        return d                        /* missing ; */
}
```

Expecting <declarator> or <type>, but found '*xx*'

xx is typically a punctuation character found where a variable or function declaration or definition would be expected (at the top level). Example:

```
static int i = MAX;+1;          /* spurious ; ends expression */
```

<expression> expected but found '*op*'

Similar to above. An operator was found where an operand might reasonably be expected. Example:

```
        func(>>10); /* missing left hand side of >> */
```

grossly over-long floating point number

Only a certain number of decimal digits are needed to specify a floating point number to the accuracy that it can be stored to. This number of digits was exceeded by an unreasonable amount.

grossly over-long number

A constant has an excessive number of leading zeros, not affecting its value.

hex digit needed after 0x or 0X

Hexadecimal constants must have at least one digit from the set `0-9`, `a-f`, `A-F` following the `0x`. Example:

```
int i = 0xg; /* illegal hex char */
```

<identifier> expected but found 'xx' in 'enum' definition

An unexpected token was found in the list of identifiers within the braces of an enum definition. Example:

```
enum colour {red, green, blue,;}; /* spurious ; */
```

identifier (xx) found in <abstract declarator> - ignored

The `sizeof()` function and cast expressions require abstract declarators, ie types without an identifier name. This error is given when an identifier is found in such a situation. Examples:

```
i = (int j) ip; /* trying to cast to integer */
l = sizeof(char str[10]); /* probably just mean sizeof(str) */
```

illegal bit field type 'xx' – 'int' assumed

Int (signed or unsigned) is the only valid bitfield type in ANSI-conforming implementations. Example:

```
struct s { char a : 4; char b : 4;};
```

illegal in case expression (ignored): xx
illegal in constant expression: xx
illegal in floating type initialiser: xx

All of these errors occur when a constant is needed at compile time but a variable expression was found.

illegal in l-value: 'enum' constant 'xx'

An incorrect attempt was made to assign to an `enum` constant. This could be caused by misspelling an `enum` or variable identifier. Example:

```
enum col {red, green, blue};
int fn()
{
        int read;
        red = 10;
        ...
```

illegal in the context of an l-value: '*xx*'
illegal in lvalue: function or array '*xx*'

An incorrect attempt was made to assign to *xx*, where the object in question is not assignable (an l-value). You can't, for example, assign to an array name or a function name. Examples:

```
{
        int a,b,c;
        a ? b : c = 10;          /* ?: can't yield l-values. */
        if (a)                   /* use this instead */
                b = 10;
        else
                c = 10;
        ...
```

or, in the same context,

```
        *(a ? &b: &c) = 10;
```

illegal in static integral type initialiser: *xx*

A constant was needed at compile time but a suitable expression wasn't found.

illegal types for operands : '*op*'

An operation was attempted using operands which are unsuitable for the operator in question. Examples:

```
{
        struct {int a,b;} s;
        int i;
        i = *s;          /* can't indirect through a struct */
        s = s+s;         /* can't add structs */
        ...
```

incomplete type at tentative declaration of 'xx'

An incomplete non-static tentative definition has not been completed by the end of the compilation unit. Example:

```
int incomplete[];
...
/* should be completed with a declaration like: */
/* int incomplete[SOMESIZE];                    */
```

junk after #if <expression>
junk after #include "*xx*"
junk after #include <*xx*>

None of these directives should have any other non-whitespace characters following the expression/filename. Example:

```
#include <stdio.h> this isn't allowed
```

label '*xx*' has not been set

An attempt has been made to use a label that has not been declared in the current scope, after having been referenced in a `goto` statement. Example:

```
int main(void)
{
        goto end;
}
```

misplaced '{' at top level — ignoring block

{ } blocks can only occur within function definitions. Example:

```
/* need a function name here */
{
        int i;
        ...
```

misplaced 'else' ignored

An `else` with no matching `if` was found. Example:

```
        if (cc)          /* should have used { } */
                i = 1;
                j =2;
        else
                k = 3;
        ...
```

misplaced preprocessor character 'xx'

Usually a typing error; one of the characters used by the preprocessor was detected out of context. Example:

```
char #str[] = "string";                 /* should be char *str[] */
```

missing #endif at EOF

A `#if` or `#ifdef` was still active at end of the source file. These directives must always be matched with a `#endif`.

missing '"' in pre-processor command line

A line such as `#include "name has the second "` missing.

missing ')' after xx(... on line nn

The closing bracket (or comma separating the arguments) of a macro call was omitted. Example:

```
#define rdch(p) {ch=*p++;}
...
{
        rdch(p                  /* missing ) */
        ...
```

missing ',' or ')' after #define xx(...

One of the above characters was omitted after an identifier in the macro parameter list. Example:

```
#define rdch(p {ch = *p++;}
```

missing '<' or '"' after #include

A `#include` filename should be within either double quotes or angled brackets.

missing hex digit(s) after \x

The string escape `\x` is intended to be used to insert characters in a string using their hexadecimal values, but was incorrectly used here. It should be followed by between one and three hexadecimal digits. Example:

```
        printf("\xxx/"); /* probably meant "\\xxx/" */
```

missing identifier after #define
missing identifier after #ifdef
missing identifier after #undef

Each of these directives should be followed by a valid C identifier. Example:

```
#define @ at
```

missing parameter name in #define xx(...

No identifier was found after a `,` in a macro parameter list. Example:

```
#define rdch(p,) {ch=*p++;}
```

no ')' after #if defined (...

The **defined** operator expects an identifier, optionally enclosed within brackets. Example:

```
#if defined(debug
```

no identifier after #if defined

See above.

non static address '*xx*' in pointer initialiser

An attempt was made to take the address of an automatic variable in an expression used to initialise a **static** pointer. Such addresses are not known at compile-time. Example:

```
{
        int i;
        static int *ip = &i; /*&i not known to compiler*/
        ...
```

non-formal '*xx*' in parameter-type-specifier

A parameter name used to declare the parameter types did not actually occur in the parameter list of the function. Example:

```
void fn(a)
int a,b;
{
        ...
```

number *nn* too large for 32-bit implementation

An integer constant was found which was too large to fit in a 32 bit **int**. Example:

```
static int mask = 0x800000000; /*0x80000000 intended?*/
```

objects or arrays of type void are illegal

void is not a valid data type.

overlarge floating point value found
overlarge (single precision) floating point value found

A floating point constant has been found which is so large that it will not fit in a floating point variable. Examples:

```
float f = 1e40; /* largest is approx 1e38 for float */
double d = 1e310; /* and 1e308 for double */
```

quote (" or ') inserted before newline

Strings and character constants are not allowed to contain unescaped newline characters. Use \<nl> to allow strings to span lines. Example:

```
        printf("Total =
```

re-using 'struct' tag 'xx' as 'union' tag

There are conflicting definitions of the type `struct xx {...} ;` and `union` xx `{...} ;`. Structure and union tags currently share the same name-space in C. Example:

```
struct s {int a,b;};
...
union s (int a; double d;};
```

re-using 'union' tag 'xx' as 'struct' tag

As above.

size of struct 'xx' needed but not yet defined

An operation requires knowledge of the size of the struct, but this was not defined. This error is likely to accompany others. Example:

```
{
        struct s;               /* forward declaration */
        struct s *sp;           /* pointer to s */
        sp++;                   /* need size for inc operation */
        ...
```

size of union 'xx' needed but not yet defined

See above.

storage class 'xx' incompatible with 'xx' – ignored

An attempt was made to declare a variable with conflicting storage classes. Example:

```
{
        static auto int i; /* contradiction in terms */
        ...
```

storage class 'xx' not permitted in context xx – ignored

An attempt was made to declare a variable whose storage class conflicted with its position in the program. Examples:

```
register int i;          /* can't have top-level regs */
void fn(a)
static int a;            /* or static parameters */
{
        ...
```

struct 'xx' must be defined for (static) variable declaration

Before you can declare a static structure variable, that structure type must have been defined. This is so the compiler knows how much storage to reserve for it. Examples:

```
static struct s s1;              /* s not defined */
struct t;
static struct t t1;              /* t not defined */
```

struct/union 'xx' not yet defined – cannot be selected from

The structure or union type used as the left operand of a . or → operator has not yet been defined so the field names are not known. Example:

```
{
        struct s s1;             /* forward reference          */
        s1.a = 12;               /* don't know field names yet */
        ...
```

too few arguments to macro *xx*(... on line *nn*
too many arguments to macro *xx*(... on line *nn*

The number of arguments used in the invocation of a macro must match exactly the number used when it was defined. Example:

```
#define rdch(ch,p) while((ch = *p++)==' ');
...
        rdch(ptr);/* need ptr and ch */
        ...
```

too many initialisers in {} for aggregate

The list of constants in a static array or structure initialiser exceeded the number of elements/fields for the type involved. Example:

```
static int powers[8] = {0,1,2,4,8,16,32,64,128};
```

type '*xx*' inconsistent with '*xx*'
type disagreement for '*xx*'

Conflicting types were encountered in function declaration (prototype) and its definition. Example:

```
void fn(int);
...
int fn(int a)
{
        ...
```

A pernicious error of this type is caused by mixing ANSI and old-style function declarations. Example:

```
int f(char x);
int f(x)char x;
{
      ...
```

typedef name '*xx*' used in expression context

A **typedef** name was used as a variable name. Example:

```
typedef char flag;
...
{
        int i = flag;
```

undefined struct/union 'xx' cannot be member

A **struct/union** not already defined cannot be a member of another **struct/union**. In particular this means that a **struct/union** cannot be a member of itself: use pointers for this. Example:

```
struct s1 {
        struct s2 type; /* s2 not defined yet */
        int count;
};
```

unknown preprocessor directive : #xx

The identifier following a # did not correspond to any of the recognised pre-processor directives. Example:

```
#asm            /* not an ANSI directive */
```

uninitialised static [] arrays illegal

Static [ ] arrays must be initialised to allow the compiler to determine their size. Example:

```
static char str[];              /* needs {} initialiser */
```

union 'xx' must be defined for (static) variable declaration

Before you can declare a static union variable, that union type must have been defined. Example:

```
static union u u1; /* compiler can't ascertain size */
```

'while' expected after 'do' – found 'xx'

The syntax of the **do** statement is **do** statement **while (expression)**. Example:

```
        do      /* should put these statements in {} */
                l = inputLine();
                err = processLine(l);/*finds err, not while */
        while (!err);
```

Fatal errors

These are causes for the compiler to give up compilation. Error messages are issued and the compiler stops.

`couldn't create object file 'file'`

The compiler was unable to open or write to the specified output code file, perhaps because it was locked or the `o` directory does not exist.

`macro args too long`

Grossly over-long macro arguments, possibly as a result of some other error.

`macro expansion buffer overflow`

Grossly over-complicated macros were used, possibly as a result of some other error.

`no store left`
`out of store (in cc_alloc)`

The compiler has run out of memory – either shorten your source programs, or free some RAM by, for example, quitting some other applications.

If running under the desktop, you can use the Task Manager to increase your `wimpslot` size.

`too many errors`

More than 100 serious errors were detected.

`too many file names`

An attempt was made to compile too many files at once. 25 is the maximum that will be accepted.

System errors

There are some additional error messages that can be generated by the compiler if it detects errors in the compiler itself. It is very unusual to encounter this type of error. If you do, note the circumstances under which the error was caused and contact your Acorn supplier.

These error messages all look like this:

```
*****************************************************************************
* The compiler has detected an internal inconsistency. This can occur       *
* because it has run out of a vital resource such as memory or disk         *
* space or because there is a fault in it. If you cannot easily alter       *
* your program to avoid causing this rare failure, please contact your      *
* Acorn dealer. The dealer may be able to help you immediately and will     *
* be able to report a suspected compiler fault to Acorn Computers.          *
*****************************************************************************
```

Appendix C: C++ errors and warnings

This appendix contains the text and explanation for all 'not implemented' messages produced by the C++ Language System Release 3.0. They are listed here in alphabetical order.

Each message is preceded by a file name, a line number, and the text 'not implemented'. A complete error has this syntax:

```
"file", line n: not implemented: message
```

where the *message* is as used in the headings below. The line number is usually the line on which a problem has been diagnosed.

A 'not implemented' message is issued when Release 3.0 encounters a **legal** construct for which it cannot generate code. Because code is not generated, 'not implemented' messages cause the CC command to fail, and the program is not linked. Release 3.0 does, however, attempt to examine the rest of your program for other errors.

'Not implemented' messages

actual parameter expression of type string literal

A template is instantiated with a sting literal actual argument:

```
template <char* s> struct S {/*...*/};

S<"hello world"> svar;

"file", line 3: not implemented: actual parameter expression of type string
literal
```

address of bound member as actual template argument

A template is instantiated with the address of a class member bound to an actual class object:

```
template <int *pi> class x {};
class y { public: int i; } b;

x< &b.i > xi;

"file", line 4: not implemented: address of bound member (& ::b . y::i) as
actual template argument
```

& of *op*

This message should not be produced.

1st operand of .* too complicated

The first operand of a function call expression involves a pointer to a member function and is an expression that may have side effects or may require a temporary.

```
struct S { virtual int f(); };
int (S::*pmf)() = &S::f;
S *f();
int i = (f()->*pmf)();
```

```
"file", line 5: not implemented: 1st operand of .* too complicated
```

2nd operand of .* too complicated

The second operand of a pointer to member operator is an expression that has side effects.

```
struct S { int f(); };
int (S::*pmf)() = &S::f;
S *sp = new S;
int i = 5;
int j = (sp->*(i+=5, pmf))();
```

```
"file", line 5: not implemented: 2nd operand of .* too complicated
```

call of virtual function *function* before class has been completely declared

```
class x {
public:
        virtual x& f();
        int foo(x t = pt->f());
private:
        static x* pt;
        int i;
};
```

```
"file", line 6: not implemented: call of virtual function x::f() before
class x has been completely declared - try moving call from argument list into
function body or make function non-virtual
```

cannot expand inline function *function* with for statement in inline

A `for` statement appears in the definition of an inline function.

```
struct S {
        int s[100];
        S() { for (int i = 0; i < 100; i++) s[i] = i; }
};
```

```
"file", line 1: not implemented: cannot expand inline function S::S() with for
statement in inline
```

cannot expand inline function *function* with statement after "return"

A value-returning inline function contains a statement following a `return` statement.

```
inline int f(int i) {
        if (i) return i;
        return 0;
}
```

```
"file", line 4: not implemented: cannot expand inline function f() with
statement after "return"
```

cannot expand inline function *function* with two local variables with the same name (*name*)

Two variables with the same name and different types are declared within the body of a value-returning inline function.

```
inline int f(int i) {
        { int x = i; }
        { double x = i; }
        return 0;
}
```

```
"file", line 5: not implemented: cannot expand inline function f() with two
local variables with the same name (x)
```

cannot expand inline function needing temporary variable of array type

An inline function that contains a local declaration of an array object is called.

```
inline int f(int i) {
        int a[1];
        a[0] = i;
        return i;
}
int v = f(0);
```

```
"file", line 6: not implemented: cannot expand inline function needing
temporary variable of array type
```

cannot expand inline function with return in if statement

This message should not be produced.

cannot expand inline function with static *name*

An inline function contains the declaration of a static object.

```
inline void f() {
        static int i = 5;
}
```

```
"file", line 2: not implemented: cannot expand inline function with static i
```

cast of non-integer constant

A cast of a non-integer constant as an actual parameter to a template class.

```
template <int i> class x;
int yy;

x< (int)&yy > xi;
```

```
"file", line 4: not implemented: cast of non-integer constant
```

cannot expand inline void *function* called in comma expression

A call of an `inline void` function that cannot be translated into an expression (that is, one that includes a loop, a `goto`, or a `switch` statement) appears as the first operand of a comma operator.

```
int i;
inline void f() { for (;;) ; }
void g() { for (f(), i = 0; i < 10; i++) ; }
```

```
"file", line 3: not implemented: cannot expand inline void f() called in comma
expression
```

cannot expand inline void *function* called in for expression

A call of an **inline void** function that cannot be translated into an expression (that is, one that includes a loop, a **goto**, or a **switch** statement) appears in the second expression of a **for** statement.

```
void inline f() { for (;;) ; } void g() { for (;; f()) ; }
```

```
"file", line 2: not implemented: cannot expand inline void f() called in for
expression
```

cannot expand value-returning inline *function* with call of ...

A value-returning inline function is defined, and it contains a call to another inline function that is not value-returning.

```
inline void f() { for(;;) ; }
inline int g() { f(); return 0; }
```

```
"file", line 2: not implemented: cannot expand value-returning inline g() with
call of non-value-returning inline f()
```

cannot merge lists of conversion functions

A derived class with multiple bases is declared and there are conversion operators declared in more than one of the base classes.

```
struct B1 {
        operator int();
};
struct B2 {
        operator float();
};
struct D : public B1, public B2 { };
```

```
"file", line 7: not implemented: cannot merge lists of conversion functions
```

catch

The keyword **catch** appears; **catch** is reserved for future use.

```
int catch;
```

```
"file", line 1: not implemented: catch
"file", line 1: warning: name expected in declaration list
```

class defined within sizeof

A class or union definition appears as the type name in a **sizeof** expression.

```
int i = sizeof (struct S { int i; });
```

```
"file", line 1: not implemented: class defined within sizeof
"file", line 1: error: S undefined, size not known
```

class hierarchy too complicated

This message should not be produced.

conditional expression with *type*

The second and third operands of a conditional expression are member functions or pointers to members.

```
struct S { int i, j; };
void f(int i) {
        int S::*pmi = i ? &S::i : &S::j;
}
```

```
"file", line 3: not implemented: conditional expression with int S::*
```

constructor needed for argument initializer

The default value for an argument is a constructor or is an expression that invokes a constructor.

```
struct S { S(int); };
int f(S = S(1));
int g(S = 5);
```

```
"file", line 2: not implemented: constructor as default argument
"file", line 3: not implemented: constructor needed for argument initializer
```

copy of *member*[], no memberwise copy for *class*

An implementation-generated copy operation for a class *X* is required, but the operation cannot be generated because *X* has an array member whose type is a class with either a virtual base class or its own defined copy operation. The workaround is to add a memberwise copy operator to *X*.

```
struct S1 {};
struct S2 : S1 { S2& operator=(const S2&); };
struct X { S2 m[1]; };
X var1;
X var2 = var1;
```

```
"file", line 5: not implemented: copy of S2[], no memberwise copy for S2
```

default argument too complicated

A default argument in a declaration not at file scope requires the generation of a temporary.

```
struct S {
        S();
        int f(const int &r = 1);
};
```

```
"file", line 3: not implemented: default argument too complicated
"file", line 3: not implemented: needs temporary variable to evaluate argument
initializer
```

ellipsis (...) in argument list of template function *name*

An ellipsis is used in a template function declaration:

```
template <class T> f(T, ...);
```

```
"file", line 1: not implemented: ellipsis (...) in argument list of template
function f()
```

explicit template parameter list for destructor of specialized template class *name*

Explicit template parameters are included in declaration of a specialised class' destructor:

```
template <class T> struct S { /*...*/ };

struct S<int> {
        ~S<int>();
};
```

```
"file", line 4: not implemented: explicit template parameter list for
destructor of specialized template class S <> -- please drop the parameter
list
```

Instead, declare the specialised destructor as follows:

```
template <class T> struct S { /*...*/ };

struct S<int> {
        ~S();
};
```

formal type parameter *name* used as base class of template

The formal type parameter is used as the base class of a template class:

```
template <class T> struct S : public T {/*...*/};
```

```
"file", line 1: not implemented: formal type parameter T used as base class of
template
```

forward declaration of a specialized version of template *name*

A forward declaration of a specialised, rather than generalised template:

```
template <class T> struct S; struct S<int>;
```

```
"file", line 2: not implemented: forward declaration of a specialized
version of template S <int >
```

general initializer in initializer list

The initialiser list in a declaration contains an expression that cannot easily be evaluated at compile time or that requires runtime evaluation.

```
int f();
int i[1] = { f() };
```

```
"file", line 2: not implemented: general initializer in initializer list
```

initialization of *name* (automatic aggregate)

An aggregate at local scope is initialised. This message is not issued if the `+a1` option (produces declarations acceptable to an ANSI C compiler) is specified.

```
void f() {
        int i[1] = {1};
}
```

```
"file", line 2: not implemented: initialization of i (automatic aggregate)
```

initialization of union with initializer list

An object of union type is initialised with an initialiser list. This message is not issued if the `+a1` option (produces declarations acceptable to an ANSI C compiler) is specified.

```
union U { int i; float f; };
U u = {1};
```

```
"file", line 2: not implemented: initialization of union with initializer list
```

initializer for class member array with constructor

This message should always be accompanied by an error message. The 'not implemented' message is inappropriate and should not be reported.

initializer for local static too complicated

This message should not be produced.

initializer for multi-dimensional array of objects of class *class* with constructor *name*

A multi-dimensional array of a class with a constructor has an explicit initialiser.

```
struct S { S(int); };
S s[2][2] = {1,2,3,4};
```

```
"file", line 2: not implemented: initializer for multi-dimensional array of
objects of class S with constructor ::s
```

implicit static initializer for multi-dimensional array of objects of class with constructor

```
class x {
public:
        x() ;
};

main() {
static x xx[10][20];
}
```

```
"file", line 7: not implemented: implicit static initializer for multi-
dimensional array of objects of class x with constructor
```

initializer list for local variable *name*

This message should not be produced.

label in block with destructors

A labelled statement appears in a block in which an object with a destructor exists.

```
struct S { S(int); ~S(); };
void f() {
        S s(5);
xyz:    ;
}
```

```
"file", line 5: not implemented: label in block with destructors
```

local class *name* within template function

A local class is defined inside a template function. A similar message is issued for `local` enums and `local` typedefs defined inside a template function:

```
template <class T> f() {
        class l {/*...*/};
        enum E {/*...*/};
        typedef int* ip;
};
```

```
"file", line 2: not implemented: local class l (local to f()) within
template function
"file", line 3: not implemented: local enum E(local to f()) within template
function
"file", line 4: not implemented: local typedef ip within template function
```

local static class *name* (*type*)

A static array of objects of a class with a constructor is declared at local scope.

```
class S {
public:
        S();
};
void f() {
        static S s[9];
}
```

```
"file", line 2: not implemented: local static class s ( S [9])
```

local static *name* has *class*::~*class*() but no constructor (add *class*:: *class*())

A static class object with a destructor, but no constructor, appears at local scope.

```
struct S { ~S(); };
void f() { static S s; }
```

```
"file", line 1: warning: S has S::~S() but no constructor
"file", line 2: not implemented: local static s has S::~S() but no constructor
(add S:: S())
```

lvalue *op* too complicated

This message should not be produced.

needs temporary variable to evaluate argument initializer

A default argument requires a temporary variable.

```
void f() {
        int g(const int& = 5);
}
```

```
"file", line 2: not implemented: needs temporary variable to evaluate argument
initializer
```

nested class *type* as parameter type to template class *name*

A nested class is used as the actual parameter for a template class instantiation:

```
template <class T> struct S;

struct outer {
        struct inner {};
};

S<outer::inner> svar;
```

```
"file", line 7: not implemented: nested class outer::inner as parameter type
to template class S
```

nested class *name* within nested class *name* within template class *name*

Classes may only be nested directly within template classes, classes within nested classes within template classes are not implemented:

```
template <class T> class S {
class nest1 {
        class nest2 {/*...*/};
        };
};
```

```
"file", line 3: not implemented: nested class S::nest1::nest2 within nested
class S::nest1 within template class S
```

nested depth class beyond 9 unsupported

Classes are nested more than nine levels deep.

```
struct S1 {
 struct S2 {
  struct S3 {
   struct S4 {
    struct S5 {
     struct S6 {
      struct S7 {
       struct S8 {
        struct S9 {
         struct S10 { enum { e }; };
};};};};};};};};};
```

```
"file", line 20: not implemented: nested depth class beyond 9 unsupported
```

non-trivial declaration in switch statement

A 'non-trivial' declaration appears within a switch statement. Such a declaration might declare an object of reference type, a static object, a **const** object, an object of a class type with constructor or destructor, an object with an initialiser list, or an object initialised with a string literal.

```
void f(int i) {
        switch (i) {
        default:
                int& j = i;
        }
}
```

```
"file", line 2: not implemented: non-trivial declaration in switch statement
(try enclosing it in a block)
```

Note that since it is illegal to jump past a declaration with an explicit or implicit initialiser unless the declaration is in an inner block that is not entered, most declarations in **switch** statements and not contained in inner blocks will be errors.

out-of-line definition of member function of class nested within template class

The member functions of a class nested within a template function must be defined within the definition of the nested class.

```
template <class t> struct x {
        struct y { void foo(); };
        // ...
};

template <class t>
        void x<t>::y::foo(){}
```

```
"file", line 7: not implemented: out-of-line definition of member function
of class nested within template class ( x::y:: foo())
```

overly complex *op* of *op*

This message should not be produced.

parameter expression of type float, double or long double

A template taking a non-type argument is declared taking a float, double or long double argument:

```
template <double d> struct S { /*...*/};
```

```
"file", line 1: not implemented: parameter expression of type float, double,
or long double
```

postfix template function operator ++(): please make a class member function

The postfix implementation of a template increment or decrement operator must be a member function.

```
template <class t> struct x {
        int operator++(int); // ok
};

template <class t>
        int operator++(x<t>&,int); // sorry

x<int> xi;
```

```
"file", "", line 6: not implemented: postfix template function operator
++(): please make a class member function
```

pointer to member function *type* too complicated

This message should not be produced.

public specification of overloaded *function*

The base class member in an access declaration refers to an overloaded function. A similar message is issued for **private** and **protected** access declarations.

```
struct B { int f(); int f(int); };
class D : private B {
public:
        B::f;
};
```

```
"file", line 2: not implemented: public specification of overloaded B::f()
```

reuse of formal template parameter *name*

A template formal parameter name is reused within the template declaration:

```
template <class T> struct S {
        int T;
};
```

```
"file", line 2: not implemented: reuse of formal template parameter T
```

specialized template *name* not at global scope

A specialised template is declared at other than global scope:

```
template <class T> struct S {
        T var;
};

void f() {
        struct S <int > {
                int var;
        };
};
```

```
"file", line 6: not implemented: specialized template S not at global scope
```

static member anonymous union

A static class member is declared as an anonymous union.

```
class C {
        static union {
                int i;
                double d;
        };
};
```

```
"file, line 5: not implemented: static member anonymous union
```

struct *name* member *name*

This message should not be produced.

template function actuals too complicated (please simplify)

```
#include <iostream.h>

template <class i> struct x { x(); };

template <class t>
ostream& operator<<(ostream &os, x<t>&) { return os; }

x<int> z;

main() {
/*
 * ok: simplified invocation of actual template function:
 *      cout << "hello"; cout << z << endl;
 */

// generates sorry message: actuals too complicated
cout << "hello" << z << endl;
}
```

```
"file", line 17: not implemented: template function operator <<(): actuals too
complicated (please simplify)
```

template function instantiated with local class *name*

```
template <class T> int f(T);

f2() {
        struct local {/*...*/};
        local lvar;
        f(lvar);
}
```

```
"file", line 6: not implemented: template function f() instantiated with local
class local
```

temporary of class *name* with destructor needed in *expr* expression

An expression containing a `?:`, `||`, or `&&` operator requires a temporary object of a class that has a destructor.

```
struct S { S(int); ~S(); };
S f(int i) {
        return i ? S(1) : S(2) ;
}
```

```
"file", line 3: not implemented: temporary of class S with destructor needed
in ?: expression
```

too few initializers for *name*

The initialiser list for an array of class objects has fewer initialisers than the number of elements in the array.

```
struct S { S(int); S(); };
S a[2] = {1};
```

```
"file", line 2: not implemented: too few initializers for ::a
```

type1 assigned to *type2* (too complicated)

A pointer is initialised or assigned with an expression whose type is too complicated.

```
struct S1 {};
struct S2 { int i; };
struct S3 : S1, S2 {};
int S3::*pmi = &S2::i;
```

```
"file", line 4: not implemented: int S2::* assigned to int S3::* (too
complicated)
```

use of *member* with formal template parameter

An attempt to use a member of a formal parameter type, such as `T::type`, is not currently supported. For example,

```
template <class T> class U {
        typedef T TU;
        // ...
};

template <class Type> class V {
        Type::TU t;
        // ...
};
```

```
"file", line 9: not implemented: use of Type::TU with formal template type
parameter
"file", line 9: cannot recover from earlier errors
```

visibility declaration for conversion operator

An access declaration is specified for a conversion operator.

```
struct B { operator int(); };
class D : private B {
public:
        B::operator int;
};
```

```
"file", line 1: not implemented: visibility declaration for conversion
operator
```

volatile functions

A member function is specified as `volatile`.

```
struct S {
        int f() volatile;
};
```

```
"file", line 2: not implemented: volatile functions
```

wide character constant
wide character string

A wide character constant or a wide character string is used.

```
int wc = L'ab';
char *ws = L"abcd";
```

```
"file", line 1: not implemented: wide character constant
"file", line 2: not implemented: wide character string
```

C function index

Main entries are printed in bold type.

Symbols

A

B

C

D

E

F

G

I

L

M

P

W

X

C++ class index

Main entries are printed in bold type.

C

F

I

M

O

S

Index

Symbols

A

B

C

D

E

F

G

H

I

K

L

M

O

P

R

S

T

U

V

W

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