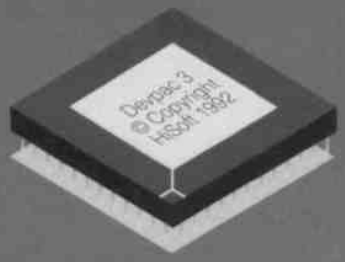

Devpac 3

for your Atari

User Manual

High quality software for all Atari 680x0 computers from

HiSoft

High Quality Software

Devpac 3 for the Atari ST/STE/TT/Falcon030

By HiSoft

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Program:

designed and programmed by HiSoft.

Manual:

written by Alex Kiernan, David Nutkins and Keith Wilson.

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Chapter I - Introduction

Introduction

HiSoft Devpac 3 (called simply HiSoft Devpac from now on) is a complete package for the production of fast, efficient assembly language programs on your Atari computer.

There is an *editor* for the creation and editing of your assembler source code, a *linker* for building your programs together with other object files, a *debugger* for helping you to stamp out those nasty bugs and, of course, an *assembler* to turn your source code into speedy, compact machine code.

This chapter is an introduction to this manual which aims to cover all aspects of installing and using HiSoft Devpac on your Atari computer - it does not attempt to teach you 680x0 programming although the accompanying 68000 pocket book and the examples should be of assistance in this regard. For further reading, you should consult the *Bibliography.*

Please spend some time and effort getting to know and learning how to use the manual so that you can gain the maximum benefit from HiSoft Devpac.

The rest of this section explains how to use the manual, whether you are a beginner or an expert, how to use your computer to best effect with HiSoft Devpac and, finally, we outline the different type styles that we have used throughout the manual to (hopefully) make it easy and enjoyable to use.

Devpac 3 Disk Contents

Devpac 3 is supplied on one *double-sided* 3.5" disk. Please note that the following list of files is intended as a guide only; subsequent versions of Devpac may contain extra files.

DEVINST.RSC,DEVINST.PRG,DEVINST.DIR,DEVINST.INF

The installation program and its support files.

DEVPAC.PRG — The multi-window editor and control program.

HISOFTED.INF — The editor preferences file.

READ.ME — A text file including latest details about Devpac 3; please read this file carefully before contacting our technical support department with any queries.

AMON \ — Auto-resident versions of Mon, the debugger.

BINXCUNK.TTP	Lattice C format linker.
BINXGEN.TTP	68000 version of Gen, the assembler.
BIN\MON.PRG	68000 version of Mon, the debugger
BINXSRSPLIT.TTP	A utility program for users of Motorola format S-records which splits an S-record file into its high and low byte components.
BINXSTRIP.TTP	Symbol table stripper.
BIN030N	68030 specific versions of Gen, the assembler, and Mon, the debugger.
EXAMPLES\	Some example programs including the short tutorial for this manual.
EXTRAS\ ,EXTRAS\ AESPATH,EXTRAS\ FSEL\	A number of 'freebies'; please see the text files within these subdirectories for more details.
EXTRAS\MENU2ASM\	Devpac 2 compatible menu compiler.
INCDIR\AESUB.S	AES library source.
INCDIR\BIOS.I	BIOS definitions include file.
INCDIRXGEMDOS.I	GEMDOS definitions include file.
INCDIRXGEMMACRO.I	macros for AES/VDI interface.
INCDIRWDIUB.S	VDI library source.
INCDIRXXBIOS.I	XBIOS definitions include file.
GST\	GST linker, librarian and library files.
RAMDISK\	Reset-proof ramdisk and associated files.

Making a Working Copy

Before using Devpac 3 you should make a back-up copy of the distribution disk and put the original away in a secure place; safe from extremes of temperature, magnetic fields, moisture and children! The disks can be backed-up using the Desktop or any backup utility - before making any backup always write-protect the master to prevent accidental erasure.

The disk is not copy-protected to allow easy back-up and to avoid inconvenience; remember though that the software and this manual are protected by international copyright laws and you are only permitted to copy the software for your own personal use. If this sounds officious, look at it another way - if you give away copies of Devpac 3 to your friends we will not receive enough revenue from the sale of the package to improve this and other products. We want to help you, please help us in return.

Registration Card

Enclosed with this manual is a registration card which you should fill in and return to us in order to register your purchase of Devpac 3. This will entitle you to a free period of technical support and will enable us to keep you informed of future developments to our software.

For details of our technical support services, please refer to *Appendix H* in this manual.

You will need to quote your serial number (to be found on the disk label) to obtain technical support and you may find it useful to make a note of it here:

Serial No.

The README File

As with all HiSoft products Devpac 3 is continually being improved and the latest details that cannot be included in this manual may be found in the READ.ME file on the disk. This file should be read at this point, by double-clicking on its icon from the Desktop. It will also contain last-minute details on the installation process.

Installation

Whether you are a beginner or expert you should now run the installation program from your back up copy of the distribution disk. The GEM-based installation program is designed to ease the building of various standard configurations for the HiSoft Devpac system.

For hard disk owners, the installation program will copy the files that you need to your hard disk. If you are the type of person who doesn't like installation programs that write things to your hard disk, you can view the files that would be copied, and copy them yourself. The installation takes note of your hardware configuration and only copies files that could be of use to you.

By default, the installation program (for floppy based installations) doesn't copy the tools for using the GST format as most people don't need this.

The installation program for hard disk users deliberately does not automatically install a ramdisk. This is because many users will already have their own preferred ramdisk.

For users of floppy disk based systems, the installation program will produce a work floppy which contains the essential tools for your machine configuration, this disk can also be used to keep small programs of your own.

If you are using a non-hard disk system and wish to use larger than normal capacity (e.g. 800K) floppy disks, you should format a floppy using your favourite extended formatter *prior* to running the installer; you *must* use the volume name DEVWORK for this disk. If you intend to use standard floppies then the installation program will format these for you.

We strongly suggest that you start by using the set-up recommended by the installation program until you are sufficiently familiar with the package to re-configure it to meet your unique requirements.

To run the installation program, double-click on DEVINST.PRG from your backup of disk 1 in Drive A. Note that the installer expects to find its subsidiary files in the current directory.

How to use the Manual

We have designed this manual to tell you about using HiSoft Devpac on the Atari computers. We have packed a great deal of information about the package into the manual and, in order to help you use it efficiently and easily, we will now plot recommended courses through the manual, whether you are a beginner to assembly language or a seasoned expert.

A Course for the Beginner

If you are a newcomer to assembly language then we recommend that you read one of the books in the *Bibliography* alongside this manual.

This chapter is an introduction to using Devpac and covers the contents of your master disk, making a back-up copy of it, installing Devpac and registering your purchase.

At the end of this chapter there is a simple tutorial which you should follow to familiarise yourself with the use of the main parts of the program suite; it is certainly worth working through.

Chapter 2 considers the editing environment with an overview of using the package and is well worth reading; much of *Chapter 3*, detailing the assembler, is liable to mean little until you become more experienced but should be used as a reference. The overview of the debugger in *Chapter 4* is recommended, though the detail of this package can be left for a while. *Chapters 5* and 6 can be omitted unless you are linking your programs together or using S-records. Looking at and running the supplied source code should be helpful.

The Appendices are mainly for reference and you will only need to dip into them occasionally.

We hope you find HiSoft Devpac easy and friendly to use, please do not hesitate to write to us with any suggestions for improvements and/or alterations.

A Course for Seasoned Assembler Programmers

If you are experienced in the use of 680x0 assembly language but have not used a member of the Devpac family before then here is a very quick way of assembling a source file:

Load DEVPAC.PRG, Press Alt-L and select your file which will load into the editor. Using the first four entries on the Options menu select the options you require. You should also select Format - ST RAM from the Assembler options - Control dialog.

Pressing Alt-A will start the assembler; any assembly errors will be remembered and on

return to the editor you will be placed on the first one. Subsequent errors may be found by pressing Alt-J.

To run your successfully-assembled program press Alt-X (note that the Run command this is available whether assembling to disk or memory).

As a quick introduction to the debugger the example at the end of this preface is recommended. If you have any problems *please* read the relevant section of the manual before contacting us for technical support.

The Appendices are for general reference and it is worth glancing through all of them to acquaint yourself with their contents.

Good luck, we hope you find HiSoft Devpac a powerful, flexible and easy-to-use development system. Of course, we welcome any written comments you may have on how we might improve both the program and the manual.

Devpac Version 2 Users

Turn to *Appendix F* and read the section summarising the new features, then read *Chapter 2* which covers the editor. The beginning of *Chapter 3* covers the new assembly options.

System Requirements

HiSoft Devpac will run on any Atari 680x0 computer (ST, STE, Mega, TT, Falcon etc.) with at least 512Kb of memory and a double-sided disk drive. You will undoubtedly find it useful for this and other programs to purchase a second disk drive or hard disk.

Users with only 512Kb of RAM may run out of memory when attempting to assemble larger programs or in other circumstances. The installation of a RAM-disk or other device on a 512Kb machine will restrict HiSoft Devpac.

If you are short of memory, remember that the least memory hungry thing is to assemble a one line program (consisting of an include statement) from a CLI. Upgrades to a megabyte of memory are available at very reasonable prices and we strongly recommend this, not just for HiSoft Devpac but for general use too.

Typography

In order to make the manual easy to read and to convey the maximum information as clearly as possible, we have adopted certain typefaces and type styles throughout the manual.

Typefaces

Palatino	General text.

Futura oblique	Chapter and sub-Chapter headings and
Monospace	Used to show something that is typed in at the keyboard or displayed on the screen. Predominantly used in program listings and references to function
	names, variables etc.
Avant Garde	Used for filenames, menu selections
	and button names. Also used to
	denote legends on single keys such as Alt (the Alternate key) and Control.

Type styles

The *italic* style is used mainly for *emphasis.*

Special Characters

[ ] Within syntax descriptions, information enclosed in [ ] is

optional.

Indicates repetition in syntax descriptions.

Vertically-spaced dots show that some part of a program has been omitted.

Acknowledgements

The trademarks (both registered and otherwise) of various companies are used throughout this manual. In particular:

HiSoft Devpac, Power BASIC, HiSoft BASIC, Gen and Mon are trademarks of HiSoft

Atari is a registered trademark of Atari Corp.

We acknowledge any other trademark used but not listed above.

We would like to thank the following people for their invaluable help in the production of HiSoft Devpac and this manual:

Andy Pennell for his hard work in programming the original Devpac, Julia for holding the fort when lesser people would have deserted, Marlynne for her tenaciousness and tact, Sallie for her database work and her jodhpurs, Pauline for getting it together and all the other unsung heroes and heroines that have kept us alive and smiling over the past 12 years!

A Quick Tutorial

This is deliberately a 'quick and dirty' tutorial so you can see how straightforward it is to create, edit, assemble and debug programs with Devpac.

In this tutorial we are going to assemble and run a simple program, which contains two errors and debug it. The program itself is intended to print a message.

To follow this tutorial you must already have installed Devpac and be in the editor. If you are not you should run the installation program (assuming you have not already done so), then double-click on the DEVPAC.PRG icon from your work disk.

You will then be presented with an empty window; to load the file you should move the mouse over the File menu and click on Load.... The standard GEM file selector will then appear and the file we want is called DEMO.S. You may either double-click on the name or type it in and press Return to load the file. Note that the file is in the EXAMPLES directory on your work disk.

When the file has loaded the window will show the top lines of the file. If you want to have a quick look at the program you may click on the scroll bar or use the cursor keys.

With most shorter programs it is best to have a trial assembly that doesn't produce a listing or binary file to check the syntax of the source and show up typing errors and so on. Move the mouse to the Program menu and select Check.

The assembler will report an error, instruction not recognised, pressing any key will return you to the editor. The cursor will be placed on the incorrect line and the error message displayed in the window title bar.

The program line should be changed from MOV. L to MOVE . L, so do this, then select Control... from the Options menu and change the setting of the Format popup menu to ST RAM. This is very much faster than assembling to disk and allows you to try things out immediately, which is exactly what we want.

If you are unsure of how any of the user interface elements work, you may like to read the section *A word about pop-up menus and dialogs* now.

The assembly worked this time, so click on Run from the Program menu, and what happens? Not a lot it would seem, except that some bombs appeared briefly on the screen - oh, there's a bug.

Some alternate desktops (e.g. NeoDesk™) and other programs (e.g. MiNT) replace the standard bomb handler; in this case you won't see bombs, but that program's 'bomb' handlers message...

The tool for finding bugs and checking programs is a debugger, so select Debug from the Program menu which will call the debugger. This is described more fully later, but for now we just want to run the program from the debugger to 'catch' any problems and find out what causes them, so press Control-R to run the program.

On a 68000 computer, the message Address Error will appear at the bottom of the display,

with the Disassembly window showing the current instruction

```
MOVE.W      1,-(A7)
```

This instruction causes an address error on a 68000 because the location 1 is at an odd address which cannot be accessed with the `MOVE.W` instruction.

This is not the case on 68020s upwards and, you will instead see the message Bus Error, but with the Disassembly window showing the same instruction. In this instance the problem is because location 1 is in protected memory which cannot be accessed in user mode.

However, for all processors, the problem is the same - there should a hash sign before the 1 to put the immediate value of 1 on the stack. To return to the editor press Control-C *twice* (once to terminate your program, once to terminate the debugger), so we can fix this bug in the source code.

Press Alt-T, to go to the top of the file, then click on Find from the Search menu. We are going to find the errant instruction so enter:

```
move.w
```

then press Return to start.the search. The first occurrence has a hash sign, so press Alt-N to find the next, which is the line:

```
move.w      c_conin,-(a7)
```

Ahah! - this is the one, so add a hash to change it to

```
move.w      #c_conin,-(a7)
```

then assemble it again. If you click on Run from the Program menu you should see the message, and pressing any key will return you to the editor.

However, did you notice how messy the screen was - the desktop pattern looked very untidy and you possibly got mouse 'droppings' left on the screen. This was because DEMO is a TOS program running with a GEM screen - to change this, click on Run with GEM from the Program menu - the check mark next to it should disappear. If you select Run again you can see the display is a lot neater, isn't it? If you run a GEM program you must ensure the check mark is there beforehand, otherwise nasty things can happen.

Although the program now works we shall use Mon, the debugger, to trace through the program, step by step. To do this select Debug from the Program menu, the debugger will appear with the message Breakpoint, showing your program.

There are various windows, the top one displaying the machine registers, the second a disassembly of the program, and the third some other memory.

If you look at window 2, the Disassembly window, you will see the current instruction, which in this case is

```
MOVE.L      #string,-(A7)
```

As the debug option was specified in the source code all program symbols will appear in the debugger.

Let's check the area around string. Press Alt-3 and you should see window 3's title inverted.

Next press Alt-A and a dialog box will appear, asking Window start address? - to this enter

```
string
```

and press Return. This will re-display window 3 at that address, showing the message in both hex and ASCII.

To execute this `MOVE` instruction press Control-Z. This will execute the instruction then the screen will be updated to reflect the new values of the program counter and register A7. If you press Control-Z again the `MOVE.W` instruction will be executed. If you look at the hex display next to A7 you should see a word of 9, which is what you would expect after that instruction.

The next instruction is `TRAP #1`, to call GEMDOS to print a string, but hang on - would we notice a string printed in the middle of the Mon display? Never fear, Mon has its own screen to avoid interference with your program's, to see this press the V key, which will show a blank screen, ready for your program. Pressing any other key will return you to Mon.

To execute this call press Control-Z, which will have printed the string. To prove it press V again, then any key to return to Mon.

Press Control-Z twice more until you reach the next trap. This one waits for a key press so hit Control-Z and the program display will automatically appear, waiting for a key. When you're ready, press the q key. You will return to Mon and if you look at the register window the low 8 bits of register DO should be $71, the ASCII code for q, and next to that it will be shown as q (unless in low-resolution).

The final trap quits the program, so to let it run its course press Control-R, you will then return to the debugger as the program has finished. Finally press Control-C to leave the debugger and return to the editor.

That completes our quick tutorial.

Chapter 2 - Using the Editor

Introduction

The editor supplied with HiSoft Devpac is fully integrated with the system which means that you can develop programs in an intuitive and interactive manner, creating and editing your programs in the same environment as running and debugging your finished masterpiece.

Moreover, those of you with strong preferences for your own editor can dispense with the HiSoft editor and use your own favourite package along with the command line version of HiSoft Devpac; although you will lose the benefits of interactive development.

The editor for HiSoft Devpac is a multi-window screen editor which allows you to enter and edit text and save and load from disk, as you would expect. It also lets you print some or all of your text, search and replace text patterns and use any of your computer's desk-accessories. It is GEM-based, which means it uses all the user-friendly features of GEM programs that you have become familiar with such as windows, menus and mice. However, if you're a diehard used to the hostile world of computers before the advent of WIMPs, you'll be pleased to know you can do practically everything you'll want to do from the keyboard without having to touch a mouse.

The editor is 'RAM-based', which means that the file you are editing stays in memory for the whole time, so you don't have to wait while your disk grinds away loading different sections of the file as you edit. As the ST/TT range of computers have so much memory, the size limitations often found in older computer editors do not exist with HiSoft Devpac. As all editing operations, including things like searching, are RAM-based they act extremely quickly.

When you have typed in your programs it is not much use if you are unable to save them to disk, so the editor has a comprehensive range of save and load options, allowing you to save all or part of the text and to load other files into the middle of the current one, for example.

To get things to happen in the editor, there are various methods available to you. Features may be accessed in one or more of the following ways:

Using a single key, such as a Function or cursor key;

Clicking on a menu item, such as Save;

Using a menu shortcut, by pressing the Alternate key (subsequently referred to as Alt) in conjunction with another, such as Alt - F for *Find;*

Using the Control key in conjunction with another, such as Control -A for *cursor word left,*

Clicking on the screen, such as in a scroll bar.

The menu shortcuts have been chosen to be, hopefully, easy to remember.

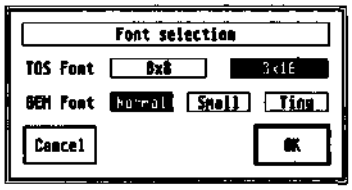
A word about pop-up menus and dialogs

The editor makes extensive use of dialog boxes and pop-up menus, so it is worth recalling

how to use them, particularly for entering text. The editor's dialog boxes contain buttons, radio buttons, and editable text.

Exit buttons may be clicked on with the mouse and cause the dialog box to go away. Usually there is a default button, shown by having a wider border than the others. Pressing Return on the keyboard is equivalent to clicking on the default button. Where there are non-default buttons, the editor allows these to be selected from the keyboard using the sequence Alt-first letter of the button name; obviously where several buttons have the same first letter only one may be selected!

Radio buttons are groups of buttons of which only one may be selected at a time - clicking on one automatically de-selects all the others.



A dialog with buttons (OK, Cancel) and radio buttons (Normal, Small etc.)

Editable text is shown with a dotted line, and a vertical bar marks the cursor position.

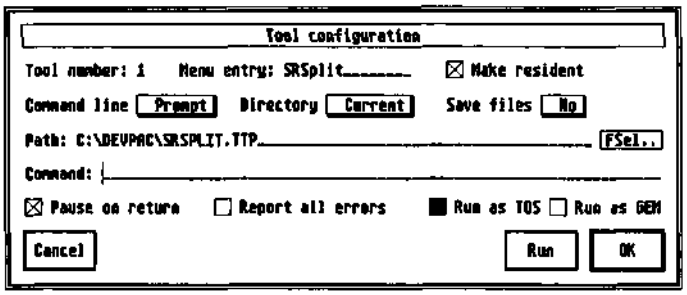
Editable text

Characters may be typed in and corrected using the Backspace, Delete and cursor keys. You can clear the whole edit field by pressing the Esc key. If there is more than one editable text field in a dialog box, you can move between them using the Tab key or the j and | keys or by clicking near them with the mouse.

More than one editable text field

Some dialog boxes allow only a limited range of characters to be typed into them - for example the Goto... dialog box only allows numeric characters (digits) to be entered.

As well as the conventional GEM user interface facilities, the editor also uses some extensions. To illustrate these, consider the dialog box shown below:



The Tool Configuration dialog box

Some options are accessed via 'pop-up' menus similar to those used by Atari's new control panel. Thus if you move the mouse over the As shown selection (by Command line) and press down on the left mouse button, a menu like this will pop up:

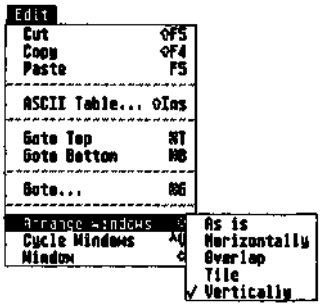
A pop-up menu

This indicates that the current setting for this option is As shown. The mouse will highlight the current selection that you are making and when you let go of the mouse this indicates that you have made your selection. If you let go outside the pop-up menu then this is taken as cancelling the selection.

The box beside Make resident has a cross in it, indicating that this option is selected; similarly Report all errors is *not* selected. Clicking in one of these boxes, or the associated text, will cause that option to be toggled on and off.

Run as TOS and Run as GEM are a pair of 'radio options'; the solid box indicates the currently selected item: clicking on Run as TOS will change both boxes.

Some of the menu items on the main 'drop-down' menus now have submenus; these are indicated by a o symbol. For example:

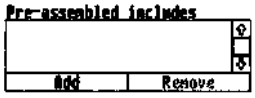


A sub menu

When you highlight a menu item (like Arrange Windows in the example above), the corresponding sub-menu will appear after a short delay. You can then move the mouse to the right to select the particular item that you want. To cancel the operation just click outside both boxes without selecting an item or move to another item from the main menu.

If the editor doesn't have enough room to display the sub-menu to the right of the main menu, it will do so on the left; the items are selected in the same way.

The editor also uses a number of list boxes; these allow a number of selections to be entered (e.g. multiple INCLUDE directories, EQU symbols etc.).



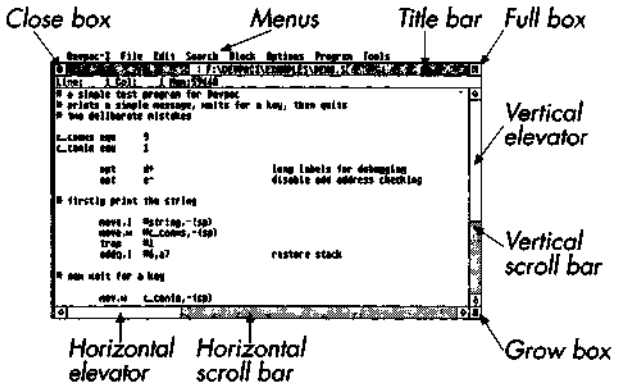
A list box

To add a new element to the list, click on the Add button, whilst an existing element may be removed by clicking on the item (which will become highlighted) and then clicking Remove. To edit an existing item, double-click on it. If at some point you need to reorder the entries in the list (e.g. the order in which INCLUDE directories are searched), this may be achieved by dragging an entry from its current position to a new position.

The Editor's windows

Having loaded HiSoft Devpac, you will be presented with an empty window with a status line at the top and a flashing black block, which is the *cursor*, in the top left-hand corner.

The window used by the editor works like all other GEM windows, so you can move it around by using the *title* bar on the top of it, you can change its size by dragging on the *grow* box, and make it full size (and back again) by clicking on the *full* box.



A GEM window

The status line contains information about the cursor position in the form of Line and Column offsets as well as the number of bytes of memory which are free to store your text. Initially this is displayed as 59980, as the default text size is 60000 bytes. You may change this default if you wish, together with various other options, by selecting Preferences, described later. The 'missing' 20 bytes are used by the editor for internal information. The rest of the status line area is used for error messages, which will usually be accompanied by a 'ping' noise to alert you. Any message that is printed will be removed when subsequently you press a key.

Switching Windows

The editor has support for up to seven windows, which can be selected by pressing Alt-1 to Alt-7 (on the top row of numbers, *not* on the numeric pad). The windows can be organised in a number of ways and you can select this using Arrange Windows on the Edit menu. Try this out for yourself to get the idea of how the different arrangements work.

If you have a preferred window arrangement, you can get the editor to remember your preference by holding down Control whilst selecting the layout. The layout will then become permanent and the editor will rearrange the windows as necessary to conform to your preference.

You can cycle through the open windows using the Cycle Windows command from the Edit menu (or use Control-V), by clicking on the appropriate window with the mouse or by selecting the appropriate sub-item from the Window item on the Edit menu.

To close a window and thus free the memory used by it, click on its close box or use the Control-W key combination.

To cut and paste between windows is just as simple as copying blocks in a single window, i.e.

mark the block and then use the Cut command, switch windows (as described above) and then Paste. See below for more detail on cut and paste.

Entering text and moving the cursor

To enter text, simply type on the keyboard and at the end of each line press the Return key (or the Enter key on the numeric pad) to start the next line. You can correct your mistakes by pressing the Backspace key, which deletes the character to the left of the cursor, or the Delete key, which removes the character on the cursor.

Cursor keys

To move the cursor around the text to correct errors or enter new

characters, you can use the cursor keys, labelled * » | and j or the

mouse; move the cursor to a specific position on the screen with the mouse pointer and click. If you position the cursor past the right-hand end of the line and type some text at that point the editor will automatically add the text to the real end of the line. If you type in long lines the window display will scroll sideways if required.

When you cursor up at the top of a window the display will either scroll down if there is a previous line, or print the message Top of file in the status line. Similarly if you cursor down off the bottom of the window the display will either scroll up if there is a following line, or print the message End of file.

You can move the cursor on a character basis by clicking on the arrow boxes at the end of the horizontal and vertical scroll bars.

To move immediately to the start of the current line, press Control *-, and to move to the end of the current line press Control -*.

To move the cursor a word to the left, press Shift«- and to move a word to the right press Shift -». You cannot move past the end of a line with Shift -». A word is defined as anything surrounded by a space, a tab or a start or end of line. The keys Control-A and Control - F also move the cursor left and right on a word basis.

To move the cursor a page up, you can click on the upper grey part of the vertical scroll bar, or press Shift f. To move the cursor a page down, you can click on the lower grey part of the scroll bar, or press Shiftj.

Tab key

The Tab key inserts a special character (ASCII code 9) into the buffer, which on the screen looks like a number of spaces, but is rather different. Pressing Tab aligns the cursor onto the next 'multiple of 8' column, so if you press it at the start of a line (column 1) the cursor moves to the next multiple of 8, +1, which is column 9. Tabs are very useful indeed for making items line up vertically such as the instructions in your program. When you delete a tab the line closes up as if a number of spaces had been removed. The advantage of tabs is that they take up only 1 byte of memory, but can show on screen as many more.

You can change the tab size using the Preferences command described shortly.

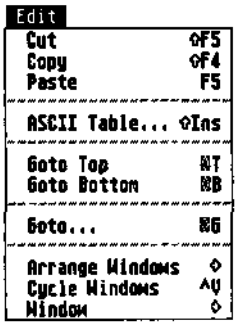
Backspace key

The Backspace key removes the character to the left of the cursor. If you backspace at the very beginning of a line it will remove the 'invisible' carriage return and join the line to the end of the previous line. Backspacing when the cursor is past the end of the line will delete the last character on the line, unless the line is empty in which case it will re-position the cursor on the left of the screen.

Delete key

The Delete key removes the character under the cursor and has no effect if the cursor is past the end of the current line.

The Edit menu



The commands on the top of the Edit menu may be used to perform the conventional Cut, Copy and Paste operations on marked blocks.

These are described under *Block commands,* below.

Go to top of file

To move to the top of the text, click on Goto Top from the Edit menu, or press Alt-T. The screen will be re-drawn if necessary starting from line 1.

Go to end of file

To move the cursor to the start of the very last line of the text, click on Goto Bottom, or press Alt-B.

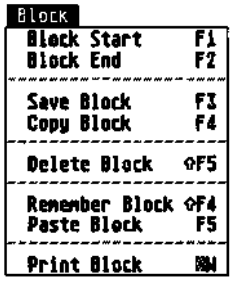
Goto line

To move the cursor to a specific line in the text, click on Goto... from the Edit menu, or press Alt-G. A dialog box will appear, allowing you to enter the required line number. Press Return or click on the OK button to go to the line or click on Cancel to abort the operation. After clicking on OK the cursor will move to the specified line, redisplaying if necessary, or give the error End of file if the line doesn't exist.

Another fast way of moving around the file is by dragging the slider on the vertical scroll bar,

which works in the usual GEM fashion.

Block Commands



A block is a marked section of text which may be copied to another section, deleted, printed or saved onto disk. Blocks may be marked using the mouse, via menu items or with function keys.

A marked block is highlighted by showing the text in reverse. While you are editing a line that is within a block this highlighting will not be shown but will be re-displayed when you leave that line or choose a command.

Marking a block

The simplest way to mark a block is to click on the first character in the block and drag the mouse to the end of the block. The block will be highlighted by showing the text in reverse as you drag the mouse. When you move the mouse to the bottom of the window, the window will scroll. Conversely, moving the mouse to the top of the window, will cause the window to scroll in the opposite direction. You may start marking a block, by clicking at the end if you wish.

Double-clicking will cause the word 'under' the mouse to be marked as the block. If you double-click and then drag, text will be highlighted a word at a time. Clicking in the left hand margin of the window causes dragging to occur a line at a time.

The start of a block may also be marked by moving the cursor to the required place and selecting Block Start or pressing key F1. The end of a block can be marked by moving the cursor and selecting Block End or pressing key F2. The start and end of a block do not have to be marked in a specific order - if it is more convenient you may mark the end of the block first.

The Clipboard: Copy, Cut & Paste

HiSoft Devpac provides conventional clipboard facilities, as popularised by the Apple Macintosh. Once you have marked a block you may copy it to the clipboard by selecting Copy from the Edit menu. The main text will remain as it is. The contents of the clipboard may then be inserted at another position by moving the cursor there and selecting Paste.

The current block may be deleted using Cut from the Edit menu; selecting Paste will then insert the block that was cut (unless you have used Copy in the mean time). Thus to move a block with this method, Cut the block from its original position and then Paste it into its new one.

The block menu also gives you the flexibility of the following commands.

Saving a block

Once a block has been marked, it can be saved by clicking on Save Block from the Block menu or by pressing key F3. If no block is marked, the message What blocks ! will appear. If the start of the block is textually after its end the message Invalid block! will appear. Both errors abort the command. Assuming a valid block has been marked, the GEM file selector will appear, allowing you to select a suitable disk and filename. If you save the block with a name that already exists the old version will be overwritten - no backups are made with this command.

Copying a block

A marked block may be copied, memory permitting, to another part of the text by moving the cursor to where you want the block copied and clicking on Copy Block or by pressing key F4. If you try to copy a block into a part of itself, the message Invalid block! will appear and the copy will be aborted.

Deleting a block

A marked block may be deleted from the text by clicking on Delete Block or by pressing Shift-F5. The shift key is deliberately required to prevent it being used accidentally. A deleted block is remembered, memory permitting, in the clipboard, for later use. This is equivalent to Cut on the Edit menu.

Copy block to block buffer

The current marked block may be copied to the block buffer, memory permitting, using Remember Block or by pressing Shift-F4. This can be very useful for moving blocks of text between different files by loading the first, marking a block, copying it to the block buffer then switching to another window or loading the other file and pasting the block buffer into it. This is equivalent to Copy on the Edit menu.

Pasting a block

A block in the clipboard may be pasted at the current cursor position by clicking on Paste Block or by pressing F5. This is equivalent to Paste on the Edit menu.

The contents of the clipboard is lost if the edit buffer size is changed and after an assembly.

Printing a block

A marked block may be sent to the printer by clicking on Print Block or by pressing Alt-W. An alert box will appear confirming the operation and clicking on OK will print the block.

The printer port used will depend on the port chosen with the Control Panel, or will default to the parallel port. Tab characters are sent to the printer as a suitable number of spaces, so the net result will normally look better than if you print the file from the Desktop.

If you try to print when no block is marked at all then the whole file will be printed.

Block markers remain during all editing commands, moving where necessary, and are only reset by the commands Delete block and Load.

Deleting text

Delete line

The current line can be deleted from the text by pressing Control - Y.

Delete to end of line

The text from the cursor position to the end of the current line can be deleted by pressing Control - Q.

UnDelete Line

When a line is deleted using either of the above commands it is preserved in an internal buffer, and can be re-inserted into the text by pressing Control - U, or the Undo key. This can be done as many times as required, particularly useful for repeating similar lines or swapping individual lines over.

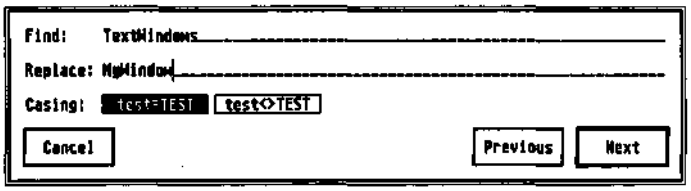
Delete block

A marked block may be deleted from the text by clicking on Delete Block or by pressing Shift-F5. The shift key is deliberately required to prevent it being used accidentally. A deleted block is remembered, memory permitting, in the clipboard, for later use. This is equivalent to Cut on the Edit menu.

Searching and Replacing Text

The commands on the Search menu may be used for finding and perhaps replacing existing text. The strings involved are set up by selecting Find or press Alt-F.

This allows you to enter the find and replace strings as shown in the following dialog box:



In the example above TextWindows has been entered as the find string and MyWindow as the replace string.

If you click on Cancel, no action will be taken; if you click Next (or press Return) the search will start forwards, while clicking on Previous will start the search backwards. If you do not wish to replace, leave the replace string empty.

If the search is successful, the screen will be re-drawn with the cursor positioned at the start of the string. If the string could not be found, the message Not found will appear in the status area and the cursor will remain unmoved.

Whether test is treated as the same as TEST or Test etc. depends on which Casing button is selected. In the example above the search would stop if TEXTWINDOWS was found; if testoTest was selected then the search would not find TEXTWINDOWS.

To find the next occurrence of the string click on Find Next from the Edit menu, or press Alt-N. The search starts at the position just past the cursor.

To search for the previous occurrence of the string click on Find Previous from the Search menu, or press Alt-P. The search starts at the position just before the cursor.

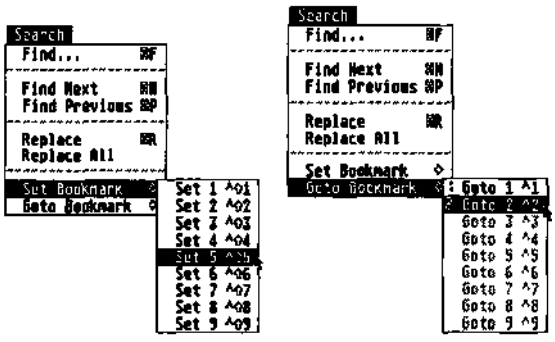
Having found an occurrence of the required text, it can be replaced with the replace string by clicking on Replace from the Search menu, or by pressing Alt-R. Having replaced it, the editor will then search for the next occurrence.

If you wish to replace every occurrence of the find string with the replace string from the cursor position onwards, click on Replace All from the Search menu. During the global replace the Esc key can be used to abort when the status area will show how many replacements were made. There is deliberately no keyboard equivalent for Replace All to prevent it being chosen accidentally.

To search and replace Tab characters press Control-1 when typing in the dialog box. Other control characters may be searched for in a similar manner except for the CR (Control-M) and LF (Control-J) characters. Alternatively, press Shift-Ins and this will display the character set from which you may pick the required character with the mouse.

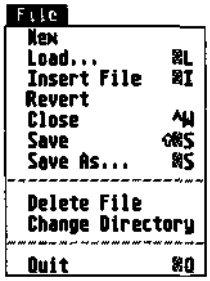
Bookmarks

A further way to navigate your source text is via the use of bookmarks. A bookmark is set by selecting the appropriate Set Bookmark item from the Search menu or by using Control-Shift and a digit key (not the numeric keypad). When you set a bookmark the corresponding item on the Goto Bookmark menu will become enabled. Then, selecting this item, or by pressing Control and the digit, will return you to the original position.



When you set a bookmark, the window number to which it refers is displayed in the menu. Going to a bookmark may cause you to switch windows. Note that bookmarks that are set in a given window are lost when you close that window.

Disk Operations



The File menu contains many operations that involve using the disk system; you can save and load your source file, insert text into your source, delete a file from a disk and more.

New

Select New to open an empty window, assuming that there is one available - you are allowed up to seven windows at once in HiSoft Devpac.

Assuming that there are no more than six windows open, New will create a window which is empty and has no title.

Loading Text

To load in a new text file, click on Load from the File menu, or press Alt-L. This will open a new window (or warn you if no more windows are available) or select an unused window and then a file selector will appear, allowing you to specify the disk and filename. Assuming you do not Cancel, the editor will attempt to load the file. If it will fit, the file is loaded into memory and the new window is re-drawn. If it will not fit an alert box will appear warning you, and you should use Preferences to make the edit buffer size larger, then try to load it again.

If the file can't be found a dialog box will appear, asking you if you wish to create that file. You may do so, or alternatively modify the filename and try again.

When loading HiSoft Devpac from a CLI, you may include up to seven filenames. The corresponding files will then be loaded automatically. If a file cannot be found you will be asked if you wish to create it or may change the filename if you wish. If you use the new Atari desktop (TOS 2.00 and above) and install HiSoft Devpac as a *GEM takes parameters* (GTP) program then you may also enter up to seven file names to be loaded.

Revert

Revert will warn you that you are about to lose the text in the selected window and, assuming

that you choose to continue, it will then re-load the last saved version of the file that you were editing in this window.

Revert will do nothing if you try to use it on a file that has not been saved previously.

Save As...

To save the text you are editing, click on Save As... from the File menu, or press Alt-S. The file selector will appear, allowing you to select a suitable disk and filename. Clicking OK or pressing Return will then save the file onto the disk.

If you click on Cancel the text will not be saved. Normally if a file exists with the same name it will be deleted and replaced with the new version, but if Make backups is selected from Preferences then any existing file will be renamed with the extension .BAK (deleting any existing .BAK file) before the new version is saved.

Save

If you have already done a Save As (or a Load), the editor will remember the name of the file and display it in the title bar of the window. If you want to save it without having to bother with the file selector, you can click on Save on the File menu, or press Shift-Alt-S, and it will use the old name and save it as above. If you try to Save without having previously specified a filename you will be presented with the file selector, as in Save As.

Inserting Text

To read a file from disk and insert it at the current position in your text, click on Insert File from the File menu, or press Alt-I. The file selector will appear and assuming that you do not cancel, the file will be read from the disk and inserted, memory permitting.

Delete File

You may want to delete a file from disk (if for instance you have run out of disk space whilst trying to save); click on Delete File. The file selector will appear, allowing you to select a suitable disk and filename. Clicking OK or pressing Return will then delete the file from the disk. If you click on Cancel the file will *not* be deleted.

Close

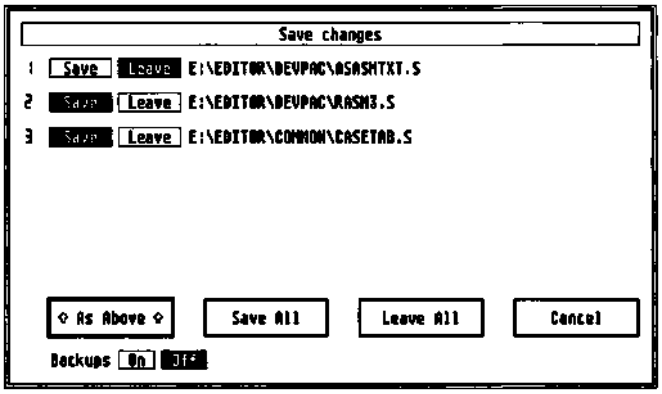
This is the same as pressing Control-W and will close the currently selected window. If the file that is being edited in this window has been changed since it was loaded or is a new file, you will be warned before the window is closed. You can choose to continue and lose your changes, cancel the action or save the changes.

Change Directory

This option allows you to move the current directory path; this can be useful when running programs which expect all of their files to be in the same place as the program itself. After clicking on Change Directory the file selector will appear, allowing you to select a suitable disk and folder name. Clicking OK or pressing Return will then change the directory. If you click on Cancel the directory path will not be changed.

Quitting HiSoft Devpac

To leave HiSoft Devpac, click on Quit from the File menu, or press Alt-Q. If changes have been made to the text which have not been saved to disk, an alert box will appear asking for confirmation.



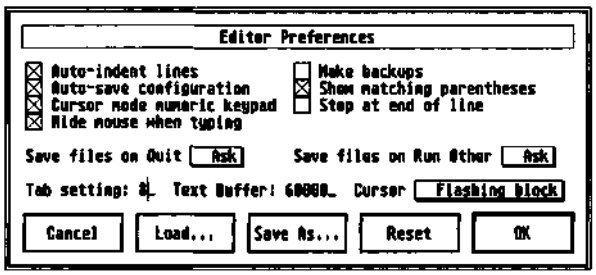
This example shows that two files have changed. Clicking on Save All, As Above or pressing Return will exit the editor saving the changes. Clicking on Cancel will return to the editor. Leave All will ignore all the changes you have made.

If you wish to save some files but not others click on the appropriate Leave buttons. For example if you clicked on the Leave button by ASASMTXT.S in the above example and then pressed Return, only RASM3.S and CASETAB.S would be saved.

You can also enable and disable backups from this dialog box. This is useful if you normally use backups, but decide that you don't require a backup of a one line change.

Configuring the editor

Selecting Preferences… from the Options menu will produce a dialog box like this:



The editor preferences box

This box allows you to set up the editor as you would like to use it; you can then save your customisation to disk so that the editor will always behave the same way. Here are the different settings that you can change.

Auto-indent lines

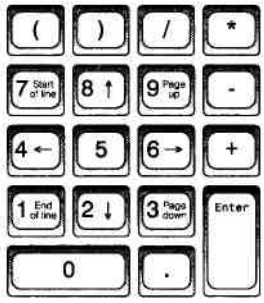
Selecting this option sets auto-indent mode. When active, an indent is added to the start of each new line created when you press Return. The contents of the indent of the new line is taken from the white space (i.e. tabs and/or spaces) at the start of the previous line. This allows you to lay out your program neatly, by simply pressing Return.

Auto-save configuration

When this option is selected, the current preferences will automatically be saved when you exit the editor. So when you load the editor again, the preferences will be just the same as when you last used it.

Cursor mode numeric pad

The Cursor Mode Numeric Pad option allows the use of the numeric keypad in an IBM-PC-like way allowing single key presses for cursor functions, and defaults to Cursor pad mode. The keypad works as shown in diagram below:



When this option is not selected the keyboard reverts to returning the digits etc.

Hide mouse when typing

Selecting Hide mouse when typing causes the mouse pointer to disappear when you start entering text with the keyboard. As soon as you move the mouse, or use a command that displays a dialog box, the mouse will re-appear. This option may be disabled if you prefer to always see the mouse on the screen.

Make backups

Selecting this option causes the editor to make a backup (with the extension .BAK) when saving files.

Show matching parentheses

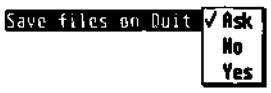
This facility lets you check that your parentheses match. With this option enables, when you press) the cursor will quickly move to any matching (character and then back to the current position, thus you can ensure that you have closed the correct number of brackets in a complex expression. If you find this cursor movement distracting then disable the option.

Stop at end of line

When this option is selected, if you press cursor left at the beginning of a line or cursor right at the end of line, the cursor does not move. Disabling this option, causes the cursor to move to the previous line if you press cursor left at the beginning, and to the next line if you press cursor right at the end.

The best way to find out which you prefer is to try using each setting.

Save files on Quit



By default the editor will prompt you, if you are about to quit without having saved all the files, you have changed.

The saving of these files can be made automatic by selecting Yes or disabled by selecting No (but don't blame us if you forget to save your files!).

Save files on run other

This enables you to choose whether files are saved before using the Run Other and Run with Shell commands, in the same way as that for Save files on Quit.

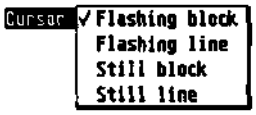
Tab setting

By default, the tab setting is 8, but this may be changed to any value from 2 to 16.

Text Buffer

By default the text buffer size is 60000 bytes, but this can be changed from 4000 to 999000 bytes. This determines the largest file size that can be loaded and edited. This amount of memory is allocated for each window in use. Care should be taken to leave sufficient room in memory for assemblies - pressing the Help key displays free system memory, and for assemblies this should always be at least 100k bytes. Changing the editor workspace size will cause any text you are currently editing to be lost, so a confirmation is required if it has not been saved.

Cursor



By default the editor cursor is a flashing block, but this can be changed as required.

Load...

This button lets you load a settings file. The editor settings are normally stored in a file called HISOFTED.INF in the current directory, but the editor will 'look down' both the AES and GEMDOS paths. If you want to use more than one set of preferences, then you can explicitly load a settings file.

Saving preferences

To save the settings file you can either choose Save as... from the Preferences box or choose Save preferences from the Options menu.

This latter command, on the Options menu, saves the current editor, assembler and Tools menu preferences under the name HISOFTED.INF. If you want to call your settings file a different name you should use Save as... in the Preferences... box, as described below.

When the editor is loaded, it looks for the HISOFTED.INF configuration file firstly in the current directory (which is the folder where you double-clicked on the data file), then using the system path. Saving the editor preferences this way will put the .INF file in the same place it was loaded from or, if it was not found, it will be placed in the current directory path.

In addition to saving the editor configuration the current program buffer size, the options from within the assembler options dialog boxes, are also saved.

Use Save as... from the Preferences box to save a settings file with a name other than HISOFTED.INF; an extension of .INF is still usual.

With this option you can save a number of different settings files under different names; however the editor always loads the settings file called HISOFTED.INF when it starts up so that, if you want to make a particular settings file the default, you will need to re-name it to HISOFTED.INF.

Reset

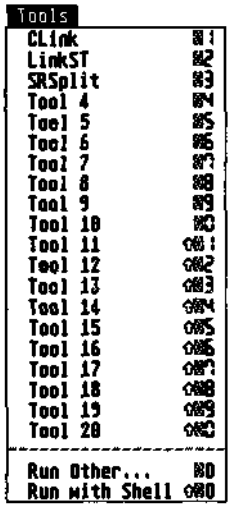
Clicking on this box causes the settings to be reset to their default values; useful if you have made a complete mess of your options.

Running other programs

There are three ways that you can execute other programs from within the editor; Run Other..., Run with Shell... and by a selection from the Tools menu. These different methods will

now be described.

Tools Menu



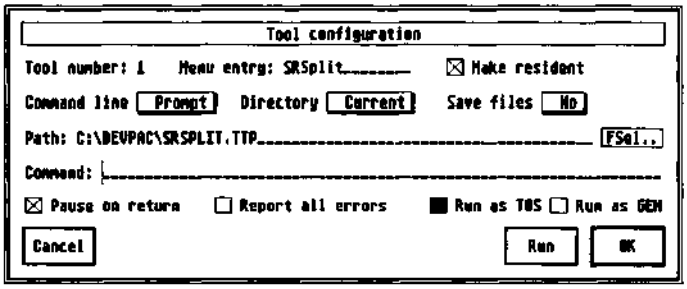
The Tools menu lets you run programs of your choice from within the editor using a single keystroke or click of the mouse.

The configuration can be saved in the preferences file, ensuring that the same facilities can be used again, the next time that you run the editor.

The preferences file that we supply is already set up to run the tools supplied with HiSoft Devpac.

Before you can use this facility you will need to configure each tool so that the editor can find the appropriate file. To configure a tool, hold down the Control key and select the appropriate menu item or press Control-Alt and the appropriate key *on the numeric keypad.*

This will produce a dialog box like this:



If you just want to use the default settings, you need only change the Path item so that the file can be found; either amend this item or click on FSel and use the file selector to select the appropriate file.

Once you have made the required changes you should press Return (or click on OK) to make your changes permanent; alternatively pressing Cancel will ignore any changes you have made. The other options in this box are:

Menu entry

The name typed in this field gives the name of the tool as placed on the Tools menu. Hence in the above example the name SRSplit appears on the menu.

Command line

These options configure the way the command line is obtained for a program which is about to be run.

If None is selected then a program will be run as a plain GEM or TOS program with no command line. If Prompt has been selected you will be prompted for a command line in the same way as occurs when using Run Other.

Finally As shown allows the command line on the line below to be used. This command line is specified in the same way as that used by Run with Shell and may have the same meta-characters in it, as in the example above.

Directory

This sets up which directory will be the current one when the tool is run. Current will leave the directory as that of the editor itself.

Tool's switches to the directory of the tool being run, whereas Top window switches to where the file in the current window is stored on disk.

Save files

This option changes which files will be saved before running the tool. If you select No then no files will be saved, selecting Yes (the default) will save *all* files (not just the current window), whilst Ask... will prompt you using the Save/Leave dialog described under Quitting HiSoft Devpac.

Path

This option specifies which program is actually to be run. If you give a full pathname, or select one by clicking on the FSel.. button then that specific file is run. If you just use a name then this will be treated as if you had used it as an argument to the Run with Shell command described above.

Pause on return

This option controls whether the editor pauses after running the tool. Typically you will select this when funning a TOS program but disable it when running a GEM program.

Report all errors

This option allows you to specify which errors the editor will bring to your attention when returning. If this option is not selected then you will only be alerted to negative return codes from programs, i.e. those normally indicating GEMDOS errors. Selecting it will also force positive program error returns to be flagged.

Run as TOS & Run as GEM

These buttons select how the program is run, either as a GEM program or as a TOS program.

Running a TOS program in GEM mode will look messy but work, but running a GEM program in TOS mode can crash the machine.

Make resident

If this item is selected then when the editor next loads it will attempt to load this tool into memory and make it resident, i.e. merely execute the tool from memory rather than load it

from disk each time. This is particularly useful with substantial programs like WERCS.

As well as the obvious disadvantage of permanently tying up your memory, not all programs can be made resident.

We do not recommend running third party programs in this way. They may crash immediately, or the second time they are run or may simple not quite work correctly possibly destroying your valuable files in the process.

Running Tools

Running a configured tool is simple, just select the appropriate menu item or press Alt and the appropriate key *on the numeric keypad* and the program will be run using the settings described above.

Run Other...

This command, on the Tools menu (also reached by Alt-O), lets you run other programs from within the editor, then return to it when they finish.

When you select Run Other... you will first be warned if you have not saved your source code (unless you have modified the setting of the Save files on Run Other option in Preferences). Then the GEM file selector will appear, from which you should select the program you wish to run. If it is a JOS or .TTP program you will be prompted for a command line, and then the screen will be initialised suitably.

This is the command to use for 'one-off execution of a program within the editor. If you are likely to want to run the same program a number of times, then use the facilities of the Tools menu. If you would prefer to specify the program to run via a command line, rather than using the file selector then use the Run with Shell command described below.

If you include the character sequence %. (i.e. per cent followed by full stop) in the command line (remember, you are prompted for a command line) these characters will be replaced by the full name of the file that you are currently editing. To pass the name without its extension, use %?.

If you need a true % to be passed type %%.

Run with Shell...

This command also lets you run other programs from within the editor, then return to it when they finish. The keyboard shortcut for this command is Shift-Alt-O.

It differs from Run Other in that you enter the file to run as a command line. If the editor finds that the _shell_p vector has been set up then this will be called to execute the command. This works well with the Craft, PKS and Gulam shells as the shell can be used to run batch files and expand file wildcards etc.

If the `_shell_p` vector has not been set up then the editor will look for the file to run using the PATH environment variable, which can be set using the Environment command from the Options menu.

The same expansion of the current filename as used by Run Other can be used by this command. If you wish to use the same command more than once you will probably save time

by using the Tools menu.

Setting the Path

The editor maintains a number of directory paths to make the operation of the integrated environment natural and seamless.

Paths are routes to files. Normally you keep all files of a similar type or usage in one folder or you may have a number of related folders all within one outer folder. For example if you have a hard disk, you probably have a DEVPAC3 folder containing the HiSoft Devpac program, its tools and its libraries.

In order that a program that uses these files can find them without having to ask the user for help, both the operating system and the HiSoft Devpac editor maintain a number of directory paths, some of which you can alter.

Here is a summary of the paths used by the integrated environment, how they are set and what uses them:

Current directory - this is a path that is set up (initially) by the program which ran the current program. For example, for the HiSoft Devpac editor this path will have been set up by the Desktop, assuming of course you ran HiSoft Devpac from the Desktop. However, since the editor allows this to be changed (via the Change Directory command on the File menu), it is normally reset to whatever was last stored in the HISOFTED.INF file, to save you having to change it every time you run the editor.

Most of the disk-related functions within the editor will search this path first.

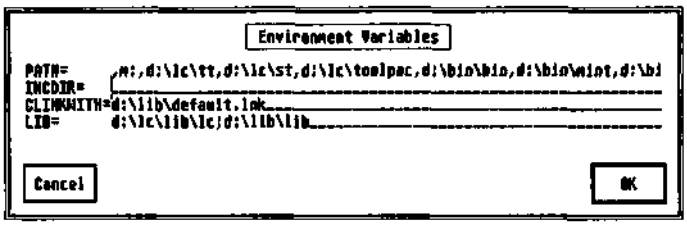
GEMDOS path - this path is that contained in the PATH environment variable. It is used by shells (e.g. Craft, PKS Shell, Gulam) to locate programs to run. It is specified as a list of , or ; separated folder names, each of which specify a folder which should be searched when trying to locate a file.

Within the editor it is used by Run with Shell, and to locate the named program. Other tools, like WERCS, may use it for locating subsidiary files, such as WERCS.RSC and WERCS.INF.

AES path - this is the path used by the AES when the user calls one of the AES routines which search for a file (shel_find and rsrc_load). Internally the format of this variable is identical to the GEMDOS path (in fact it *is* the GEMDOS PATH for the AES program!), although the AES provides no way of altering it and merely sets it to A:\ for a floppy based machine or C:\ for a hard disk machine.

Environment...

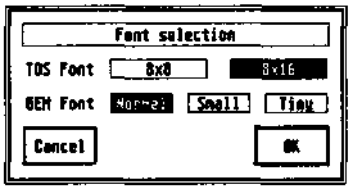
The Environment... option allows the environment variables used by the tools which are run to be altered. Only the variables which are needed are shown:



Miscellaneous Commands

Fonts...

The Fonts command is used to select different GEM or TOS fonts for use in the editor; it can be selected either by clicking on Fonts... from the Options menu, or by pressing Control-G. It displays a dialog box like this:



The GEM Font is the font that will be used by the editor to display text. In ST high resolution and the TT resolutions, there are three fonts available as above. Changing to Small will double the number of line displayed on the screen. With the Tiny font the characters are only 6 pixels by 6 pixels wide but this does mean that even in ST high resolution, there are over 100 characters per line and 54 lines!

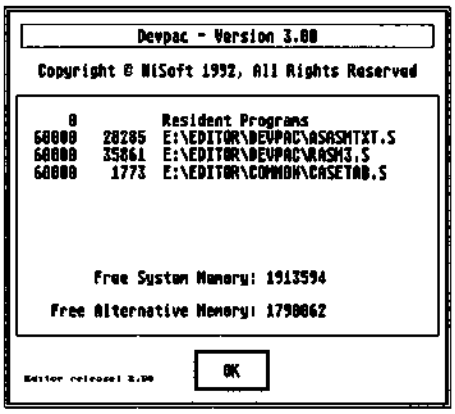
In ST medium resolution, there are only two fonts; Normal and Small. Small is 6 by 6 pixels and thus the characters are difficult to read but this does give an extra 7 lines of text and over 100 characters per line.

TOS font is used by non-GEM programs. In ST high resolution, using 8x8 will give 50 lines instead of 25.

You should be aware that any change of font that you make here will also be effective outside the editor, after you leave it.

About Devpac-3...

It you select About Devpac-3... from the Desk menu, a dialog box will appear giving various details about HiSoft Devpac, including its version number. You will also be told the amount of free memory that is available to you and how much is used by the resident programs including the text in the open windows.



Pressing Return or clicking on OK will return you to the editor.

ASCII Table...

To be found on the Edit menu, this displays a pop-up dialog box at the current mouse position, showing all the ASCII characters:

You may click on an individual character and it will be added to the text that you are editing at the current cursor position. You can bring up this display from the keyboard using Shift-Insert. This short cut can also be used in the editor's dialog boxes.

Note that the characters that would confuse the editor are 'greyed out' and may not be selected. Remember that characters other than those in the standard 7 bit ASCII set are not necessarily the same on other computers.

Help Screen

The key equivalents for the commands not found in menus can be seen by pressing the Help key, or Alt- H. A dialog box will appear showing the cursor and function keys, as well as the free memory left for the system.

Desk Accessories

If your system has any desk accessories, you will find them in the Desk menu. If they use their own window, as Control Panel does, you will find that you can control which window is at the front by clicking on the one you require.

For example, if you have selected the Control Panel it will appear in the middle of the screen, on top of the editor window. You can then move it around and, if you wish it to lie 'behind' the editor window, you can do it by clicking on an editor window, which brings the editor window to the front; you can then re-size it so you can see some part of the control panel's

window behind it. When you want to bring the control panel back to the front just click on it and the editor window will go behind. The editor's cursor only flashes and the menus only work when an editor window is at the front.

Automatic Launching

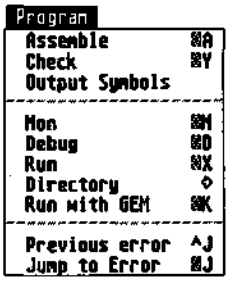
You may configure HiSoft Devpac to be loaded automatically whenever a source file is double-clicked from the Desktop, using the *Install Application* option.

To do this you first have to decide on the extension you are going to use for your files, which we recommend to be .S for assembly language files. Having done this, go to the Desktop, and click once on DEVPAC.PRG to highlight it. Next click on Install Application from the Options menu and a dialog box will appear. You should set the Document Type to be S (or whatever you require), and leave the GEM radio button selected. Finally click on the OK button (if you press Return it will be taken as Cancel).

Having done this, you will return to the Desktop. To test the installation, double-click on a file with the chosen extension which must be on the same disk and in the same folder as HiSoft Devpac and the Desktop will load HiSoft Devpac, which will in turn load in the file of your choice ready for editing or compilation.

Note: To make the configuration permanent, you have to use the Save Desktop option.

The Program Menu



The Program menu contains commands for assembling and running your program. The commands on it are used to communicate with the other parts of the package, the assembler, the debugger and, not least, the program that you are developing.

Assemble

This command will assemble the file that is currently being edited using that have been set up using the Assembler Options dialogs, which are described in detail at the beginning of the next section.

If you are compiling to memory and get a *program buffer full* error when you assemble something you should change the number given by Buffer size... on the Format popup menu. There is of course a penalty for this - the bigger the program buffer size the smaller the amount of memory left for the assembler itself to use while assembling your program. If the assembler itself aborts with *Out of memory* it means there is not enough left for a complete assembly - you should reduce the buffer size, or if this still fails you will have to assemble to disk.

When you assemble to disk the program buffer size number is ignored, giving maximum

room in memory for the assembler itself. If you haven't saved your program source code yet the file will be based on the name NONAME.

If there were any errors the editor will go to the first erroneous line and display the error message in the status bar. Subsequent errors (and warnings) may be investigated by pressing Alt-J.

If you have any include files loaded in other windows, these will be read directly from memory; there is no need to save them to memory before saving them. If the first error occurs in such an include file, then the editor will automatically switch to the appropriate window to show the error.

Check

Check or Alt-Y is just like assemble except that it does not produce output to memory or disk. If you know that your file contains errors this operation is slightly quicker than a normal assembly, even than an assemble to memory.

Output Symbols

This is used to produce a .GS file from an include file. The pre-assembled symbol table that is produced will then be loaded when you assemble a file that includes this file. Pre-assembly is described in detail in the next chapter.

Running Programs

If you click on Run from the Program menu or press Alt-X you can then run a program previously assembled into memory. When your program finishes it will return you to the editor. If the assembly didn't complete normally for any reason then it is not possible to run the program.

If your program crashes badly you may never return to the editor, so if in doubt save your source code before using this, or the Debug command.

If only non-fatal errors occurred during assembly (e.g. undefined symbols) you will still be permitted to run your program at your own risk.

Please Note

When issuing a Run command from the editor the machine may seem to 'hang up' and not run the program. This occurs if the mouse is in the menu bar area of the screen and can be corrected by moving the mouse. Similarly when a program has finished running, the machine may not return to the editor. Again, moving the mouse will cure the problem. This is due to a feature of GEM beyond our control.

Run with GEM

Normally when the commands Run, Debug or Mon are used the screen is initialised to the normal GEM type, with a blank menu bar and patterned desktop. However if running a TOS

program this can be changed to a blank screen with flashing cursor, by clicking on Run with GEM. A check-mark next to the menu item means GEM mode, no check mark means TOS mode. The current setting of this option is remembered if you save the editor preferences.

Running a TOS program in GEM mode will look messy but work, but running a GEM program in TOS mode can crash the machine.

Run Directory

Selecting Directory on the Program menu lets you choose the directory path that will be passed to any programs that you run in memory. If you select Current then the editor's current directory will be used; when Top Window is select the directory corresponding to the top most window will be used.

This can be useful if your program needs to load subsidiary files as it can find them immediately even if you have loaded the editor from another folder. Remember that you can change the editor's current directory using the Change Directory command from the File menu.

Debug

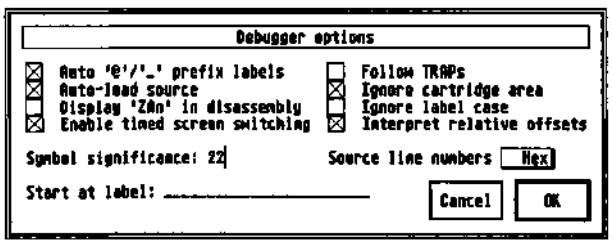
If you wish to debug a program previously assembled click on Debug from the Program menu. This will invoke Mon to debug your program, included any debugging information specified. The screen type selected is determined by the Run with GEM option, described above.

Mon

This item will invoke Mon in a similar way to if it was invoked by double-clicking on the program icon from the desktop, but instantly, as it is already in memory. You will return to the editor on termination of the debugger. The screen type selected is determined by the Run with GEM option, described above.

Debugger options

The integrated assembler makes available the debugger, Mon. The options for the debugger (set via Control-P inside Mon) may also be set up within the integrated environment:



If you wish to use an alternative debugger (e.g. DB from Atari) this can be done by

naming a copy of the debugger MON.

The integrated assembler will notice such uses and not pass the debugger strange options! Note that you should only make Mon resident (using the Resident... option), attempting to make other debuggers resident will almost certainly crash the machine.

Auto '©'/'_' prefix labels

With this option set Mon will try prefixing symbols by _ and @ if it cannot find a label, so that if you enter main and there is no label called main, then Mon will try _main or if this doesn't exist then it will try @main.

Auto-load source

Using the default settings, Mon will automatically load a source file and run your program until the label specified in the Start at label field, (i.e. the beginning of your main program), ready for you to set a breakpoint in the code. Mon loads the source file corresponding to the first module with debug information in the file that you are debugging.

Display 'ZAn' in disassembly

This option allows advanced programmers to enable the display of the normally hidden Z registers used by some 680x0 instructions.

Note that the Display 'ZAn' in disassembly option will be disabled if running on an ST.

Enable timed screen switching

Defaulting to On, this causes the display to switch to that of your program only after 20 milliseconds. It should be switched off when a program is about to change a screen's address or resolution and then turned back on afterwards.

Follow TRAPs

By default, single-stepping and the various forms of the Run command treat TRAPs, Line-A and Line-F calls as single instructions. However by turning this option On the relevant routines will be entered allowing ROM code to be investigated.

Ignore cartridge area

When this option is selected the Find command will not search the ROM cartridge area of the memory map. You should select this is you have hardware other than a ROM in this slot.

Ignore label case

This option defaults to On. If it is set to On then if you enter fred in an expression the subsequent search will give the value of the first symbol that matches this, ignoring case, thus finding FRED, fred or Fred. This option is useful for lazy typists who use the same name with different casing.

Interpret relative offsets

This option defaults to On and affects the disassembly of the address register indirect with

offset addressing modes, i.e. `xxx(An)`. With the option on, the current value of the given address register is added to the offset and then searched for in the symbol table. If found it is disassembled as symbol `(An)`. This option is required to show the addresses of your global variables if they are accessed via an address register.

Symbol significance: *sig*

This option specifies the number of characters the debugger treats as significant for identifiers. This can be useful if less than the default of 22 is required.

Source line numbers

Mon can either show line numbers in your source window in decimal, hex or not at all.

Start at label: *label*

When an executable file is loaded normally Mon stops at the first location in the program. If a different label is specified using this option (e.g. `main` for C, `REF0001` for HiSoft BASIC), then the program will instead be stopped at that point; this means you can start debugging at the start of your code, rather than the going through the compiler's startup code.

Assembly Errors

When the assembler detects an error or something that may be an error (a warning) it generates a message; these errors are remembered, and can be recalled from the editor; the message is followed by the line and file in which the error was detected.

When you return to be editor you can use Alt-J to move to the next error with the error message displayed in the status line. If you have a large number of errors the editor may not be able to remember them all. Alt-J goes to the next error regardless of the position of the cursor; it will switch windows is required. To go to a previous error use Control-J. The editor takes account of any insertions or deletions automatically so that unless one error (like a mistake in a definition) has caused multiple errors you should only need to compile once.

There's also the Shift-Alt-J command which finds the next error after the cursor in the current window. It is the appropriate one to use if you have got a number of include files and want to fix all the errors in one file before going on to the next one. You can also use it to find the first error in a file by typing Alt-T (to go to the top) and then Shift-Alt-J.

Occasionally the assembler will spot errors somewhat later than you might expect. This is usually because the text up to the point it has read is allowed in a certain context. If you have missed something out at the end of a line, then the error may be detected at the beginning of the next line.

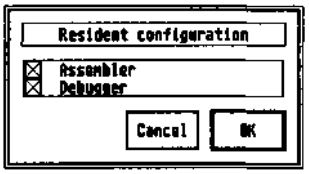
On occasions the assembler will generate more than one error message as a result of a single error in your program; do not be put off by this. If you get confused, just re-assemble.

Incidentally, if you start a assembly of a large program you can break out and returned to the editor using the key combination Shift-Shift when using the integrated assembler.

See the *Appendix B - Devpac error messages* for details of all the error messages produced.

Resident Tools

This command, on the Options menu, lets you control how the Devpac programs are loaded into memory.



There are two different ways that the editor can load a tool which it needs. Firstly, by default, the tools (assembler and debugger) will be read into memory when the editor starts up. If, however, you are low on memory, unchecking the boxes will only load the tool when necessary.

A tool will be loaded by the editor when needed and then removed after use; you do not have to have the tool permanently resident in order to use it.

To pre-load non-program files (such as include files or pre-assembled symbol files) we recommend copying them into a RAM disk.

Chapter 3 - The Assembler

Introduction

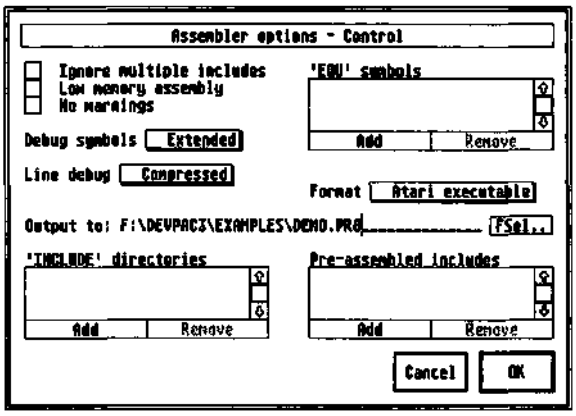
Gen is a powerful, fast, full specification 680x0/6888x/68851 assembler, available instantly from within the editor or as a standalone program. It converts the text typed or loaded into the editor, optionally together with files read from disk, into a binary file suitable for immediate execution or linking. It can also produce a memory image for immediate execution from the editor.

Invoking the Assembler

From the Editor

Before using the assembler you will probably need to set up the assembler's options to reflect your preferences. This is achieved via the first four entries on the Options menu.

The Control dialog



The control dialog

This dialog is used to control the assembly process.

Ignore multiple includes causes the assembler only to assemble an include file the first time that it is included. This leads to slightly faster assembly times and is most useful when using the operating system include files which may be called more than once. However you should not use this option if the multiple includes are each intended to generate code.

Low memory assembly lets you reduce the memory requirements of the assembler by causing it never to cache include files in memory. Under normal circumstances you should leave this button unchecked, and select it only if the assembler runs out of memory.

The No warnings option suppresses the generation of assembler warnings.

The Debug symbols popup lets you choose which symbols to include in the executable.

You normally include symbols in a file so that you can see them when using the debugger. The choices correspond to the following OPTs:

None	NODEBUG
Normal	DEBUG
Exports	XDEBUG

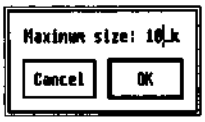
Note that the different options have different effects depending on the format of code being generated; you should refer to the *Output File Directives* section.

Choosing Line debug includes information about the code addresses corresponding to the line numbers in your program.

Two formats are available: Standard which uses LINE debug hunks that are compatible with Lattice C. Compressed uses HCLN hunks which need approximately one quarter of the space of LINE hunks but are not supported by Lattice C. Beware that even using the compressed format increases the size of your program substantially. Mon understands both formats.

The Format popup lets you select the output format produced by the assembler; Atari Executable, Linkable (GST, DRI or Lattice), S-records or to RAM. The differences between these are detailed later.

Normally you will want to use Atari Executable or one of the RAM options. The final option on this menu is Buffer size... which brings up the following dialog:



This sets the size of the buffer that is used when assembling to memory. You will need to change this if you get a Program buffer full error message from the assembler.

The 'EQU' symbols list box enables you to initialise the values of labels; each label has the form: `label=value`, e.g.

```
FALCON030=1
```

would set the label `FALCON030` to have the value 1. Note that omitting value causes the label to be set to the value 1.

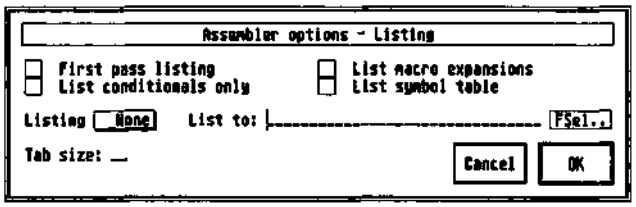
The 'INCLUDE' directories list allows you to set up a list of directories that will be searched for include files. Typically you will set this up to point to the main directory for your operating system include files.

The Pre-assembled includes list allows you to set up any pre-assembled header files that will be loaded before assembly begins. Such header files contain the symbol table information for macros and absolute labels and are produced using the Output Symbols command from the Program menu. These files are described in detail later.

Output is used to override the default name for the assembler's output file which is the same as the main file but with a .PRG extension if executable, with a .O or .BIN extension if linkable or a .MX extension if S-records are being produced. Even if you have specified an output filename with this option you will still need to ensure that you have selected one of the disk

based formats.

The Listing dialog



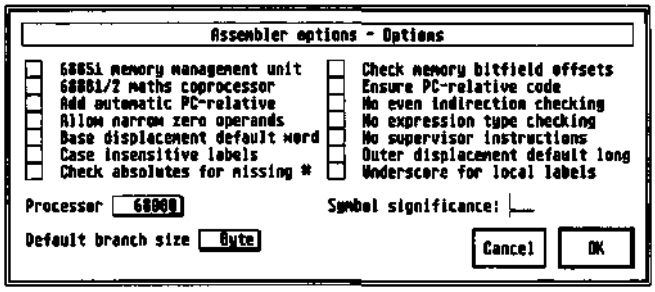
The Listing dialog

The List symbol table, List macro expansions, List conditionals only and First pass listing options should be self explanatory. Generating a listing on pass one is only normally useful when debugging complex usage of conditional assembly.

The Listing popup enables you to select an assembly listing. None will suppress the listing, Screen and Printer will direct it to the appropriate device.

Disk will send the listing to a file based on the source filename but with the extension .LST. You may set your own file or device for the listing file using the List to item.

Tab size sets the size of tabs in listing files.



The Options dialog

The Processor popup lets you select for which main processor the assembler will generate code. If you are writing a program that is to run on all Atari TOS computers leave this as 68000.

If you are writing a program specifically for the TT or Falcon030 then you should select 68030.

The 68881/2 maths coprocessor and 68851 memory management unit check boxes enable the instructions for these coprocessors. Note that the 68851 should only be selected if you are generated code for a 68020/68851 combination; the 68030 and 68040 processor options automatically enable the MMU instructions for those particular chips. Equally it is not necessary to select the maths co-processor when using the 68040.

Use Case insensitive labels to select whether labels are case dependent or not; if checked, then Test and test would be treated as the same label, when not checked they are treated as different.

Symbol significance lets you define the number of characters that will be considered when labels are compared. The default value is 127 characters, the maximum. The minimum value is 8.

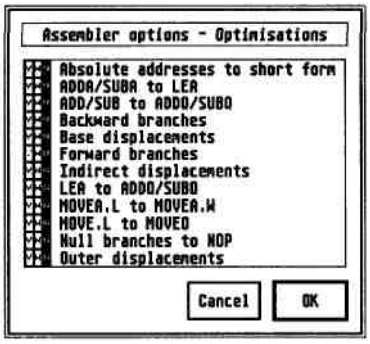
The Default branch size popup sets the default size for branch instructions.

Using Word (the default) gives the same code as produced by 68000-only assemblers.

The remaining options correspond to the following OPT directives; these are described in detail below.

Add automatic PC-relative	AUTOPC
Allow narrow zero operands	ALLOWZERO
Base displacement default word	BDW
Check absolutes for missing #	CHKIMM
Check memory bitfield offsets	CHKBIT
Ensure PC-relative code	CHKPC
No even indirection checking	NOEVEN
No expression type checking	NOTYPE
No supervisor instructions	USER
Outer displacement default long	ODL
Underscore for local labels	LOCALU

The Optimisations dialog



This dialog controls the optimisations that will be made automatically by the assembler. Most of these can be set to one of Yes (Y), Warn (W) or Off (N); when W is selected the assembler makes the optimisation and issues a warning so that you can see where it is modifying your code. Switching an optimisation on (Y) causes it to be made without any warning.

The exact code transformations that these options perform are detailed below.

Running the assembler

Having selected your required options you should select the Assemble menu item from the Program menu or press Alt-A to start the assembly. At the end of assembly if any errors occurred the cursor will be positioned on the first offending line.

If you wish to check the syntax of a program rather than actually assembling it to memory or disk, you can use the Check item from the Program menu - this is exactly like a normal

assembly but it does not output any code; the keyboard shortcut for this is Alt-Y.

The final form of assembly is to produce a pre-assembled header file so that you can use it via the Pre-assembled includes item on the Assembler options - Control dialog. To produce a pre-assembled file select Output Symbols. Note that files that are used in this context may not contain code - only definitions of macros and constants.

Assembly to Memory

To reduce development time Gen can assemble programs to memory, reducing disk access time. Such programs may self-modify if required as a re-executed program will be in its original state.

You should be careful when running from memory under the 68020 processor and above; these chips have an instruction cache and, if you modify an address that is already in the instruction cache, your new code will not be executed!

Stand-Alone Assembler

You can invoke the assembler from within the editor or from the Shell or CLI using the standalone assembler.

The standalone version of the assembler is called GEN.TTP and, if it is called without a command line, you will be prompted for one conforming to the rules below; enter the options you want and press Return or press Return immediately to abort.

At the end of an assembly invoked from the editor, Gen will automatically return to the editor. If a command line has been supplied manually the assembler will not wait for a key at the end of the assembly as it assumes it has been run from a CLI or batch file.

Command Line Format

The Gen command line consists of a series of options and the name of the main file that you wish to assemble. There may be options before and/or after the filename. You can use any of the long forms of OPT option names directly by preceding them with the + character. These are described in detail later.

The additional options that can be used from the command line are as follows; the corresponding OPT directive is shown in parentheses, where relevant. The latter options may be used on the command line with a leading +.

-B no binary file will be created.

-C case insensitive labels (+NOCASE).

-D debug (+DEBUG).

-E allows labels to be set; assignments must be separated by commas; see below for further details.

-H specify the pre-assembled header files that are to be loaded before assembly starts. Multiple files may be separated with a comma.

-I specify include directories to be searched (follow *immediately* with path). These directories will be searched when the assembler is opening include files; they should

normally be terminated with a slash.

-L GST linkable code (+GST).

-L2 DRI linkable code (+DRI).

-L6 output Motorola S-records (+SREC).

-L7 Lattice linkable code (+LATTICE).

-M use low memory (slower) assembly mode. See the section on integrated options in the previous chapter. *Not* the same as OPT M+.

-O specify output filename (which should follow *immediately* after O).

-P specify listing filename (which should follow *immediately* after P), defaults to source filename with extension of .LST. This may be any device.

-Q pause for key press after assembly.

-S include a symbol table at the end of the listing.

-T specifies the tab setting for listing. For example -T10 uses a tab setting of 10.

-V specify options as if they were specified using OPT on the second line of the main source file; note it is normally easier to us the +*option* format.

-X use extended format symbols in executable (+XDEBUG).

-W specify a file that contains a list of options to be used (which should follow *immediately* after W). There may only be one -W file per assembly and this option may only be used on the command line.

-Z enable listing on pass 1. The information in the code field may be incorrect but this can be used to find mistakes when omitting an ENDC (+LIST1). This is provided for backward compatibility; +TRACEIF can normally be used to find such errors more quickly.

The default is to create a executable binary file with a name based on the source file and output file type, no listing, with case sensitive labels.

Some examples of command lines:

```
gen test -b
```

assembles test..S with no binary output file.

```
gen test -oc:\test.prg -p
```

assembles test.s into a binary file c:\test.prg and sends a listing file to test. 1st.

```
gen test  -l1dpprn:
```

assembles test.s into GST linkable code with debug and a listing to the parallel port; a listing to the serial port can be obtained by specifying aux: as the listing name.

```
gen test +GST +DEBUG -pprn:
```

achieves the same effect.

```
gen test -wtest.opt
```

assembles the file test.s using the options contained in the file test.opt.

Defining Labels on the Command-Line

The -E option allows symbols to be defined at assembly time without having to change the source file. This option can be followed by one or more assignments of the form

symbol=expression

where `symbol` and `expression` follow the normal rules of the assembler and may contain values that have been defined previously. Multiple assignments must be separated by commas. If you omit the `=expression`, then the symbol will be assigned the absolute value 1.

Assembly Process

Gen is a two-pass assembler; during the first pass it scans all the text in memory and from disk if required, building up a symbol table. If syntax errors are found on the first pass these will be reported and assembly will stop at the end of the first pass, otherwise, during the second pass the instructions are converted into bytes, a listing may be produced if required and a binary file can be created on the disk. During the second pass any further errors and warnings will be shown, together with a full listing and symbol table if required.

If started from the command line assembly may be aborted by pressing Control-C, although doing so will make any binary file being created invalid as it will be incomplete and should not be executed.

Assemblies started from the editor may be aborted by holding down both Shift keys.

Return Codes

If using the comand line version of the assembler from batch- or make-files, you may exploit the codes the program returns. These are:

100+	initialisation failure
20	fatal error
10	error(s)
5	warning(s)
0	OK

Binary file types

There are five main types of binary files which may be produced by Devpac, for different types of applications. They are Atari executable, DRI linkable, GST linkable, Lattice linkable and Motorola S-records.

Devpac can also assemble executable code directly to memory when using the integrated version allowing very fast edit-assemble-debug-run times.

When producing linkable code, Devpac does not produce an executable file, but a file that needs to be processed by a linker to produce an executable file. An advantage of using this format is that your program can be linked with the output of a high level language compiler such as HiSoft BASIC. You can also use linkable code to split your assembly program into a number of modules.

Motorola S-records are the industry standard method of programming EPROMs and for standalone systems that use the 680x0 family of processors. The code produced is an ASCII file that runs at a particular address. As a result S-records are not suitable for executing directly under TOS but are ready for downloading to an EPROM programmer or stand-alone system.

The type of executable file may be specified using the assembly options box, by using - L on the command like or `OPT` and then the format name within the source code. Such a directive must be placed *before* any code is generated and to avoid any confusion should be before any module or section directives.

The different possibilities are summarised in the table below:

Lx	OPT name	Result	Extension
0	`ATARI`	Atari executable	.PRG
1	`GST`	GST linkable	.BIN
2	`DRI`	DRI linkable	.o
6	`SREC`	Motorola S-records	.MX
7	`LATTICE`	Lattice C linkable code	O

Thus you can select Lattice C linkable code from the assembler options box or by using a command line like:

```
test  -17
```

or by including

```
      opt   LATTICE
```

at the start of the file.

For the curious, L values of 3,4 and 5 are used by other products in the Devpac family - ensuring source code compatibility across the range.

Output Filename

Gen has certain rules regarding the calculation of the output filename, using a combination of that specified at assembly time (either in the Output to: field in the assembler control options box or using the - 0 option on the command line) and the OUTPUT directive:

If an output filename is explicitly given at assembly time then

name=explicit filename

else if the OUTPUT directive has not been used then

name=source filename + .PRG, .BIN, .O or .MX

else if the OUTPUT directive specifies an extension then

name=source filename + extension in OUTPUT

else

name=name in OUTPUT

Types of code

Unlike most 8-bit operating systems, but like most 16-bit systems, an executable program under TOS will not be loaded at a particular address but, instead, be loaded at an address depending on the exact free memory configuration at that time.

To get around the problem of absolute addressing the TOS file format includes *relocation information* allowing TOS to relocate the program after it has loaded it but before running it. For example, the following program segment

```
        move.l      #string,a0
        .
        .
        .
string      dc.b  'Press any key',0
```

places the absolute address of `string` into a register, even though at assembly time the real address of `string` cannot possibly be known. Generally the programmer may treat addresses as absolute even though the real addresses will not be known to him, while the assembler (or linker) will look after the necessary relocation information.

For certain programs, normally games or for S-record production an absolute start address may be required, for this reason the ORG directive is supported.

The syntax of the language accepted by the assembler will now be described.

Assembler Statement Format

Each line that is to be processed by the assembler should have the following format:

Label	Mnemonic	Operand(s)	Comment
start	move.l	d0,(a0)+	store the result

Exceptions to this are comment lines, which are lines starting with an asterisk or semicolon,

and blank lines, which are ignored. Each field has to be separated from the others by *white space* - any number or mixture of space and tab characters.

Label field

The label should normally start at column 1, but if a label is required to start at another position then it should be followed immediately by a colon (:). Labels are allowed on all instructions, but are prohibited on some assembler directives, and absolutely required on others. A label may start with the characters A-Z, a-z, @ or underline (_), and may continue with a similar set together with the addition of the digits 0-9 and the period (.). Note that the @ character is allowed as the first character *except* when followed by a digit from 0-7 when it is taken as the start of an octal number.

Labels starting with a period are *local labels,* described later. Sequences of digits terminated by a $ are also local labels. Macro names and register equate symbols may not have periods in them, though macro names may start with a period. By default the first 127 characters of labels are significant, though this can be reduced if required. Labels should not be the same as register names, or the reserved words SR,CCR,USP or any of the other special registers described under *Special Addressing Modes* below.

By default labels are case-sensitive though this may be changed.

Some example legal labels are:

```
test, TEST, _test, _test.end, tests, _5test, @test
```

Some example illegal labels are:

```
5test,_&e, test>,
```

There are three reserved symbols in Devpac, all starting with two underline characters. These are `__LK`, `__RS` and `__G2`.

Mnemonic Field

The mnemonic (or opcode) field comes after the label field and can consist of 680x0 assembler instructions, assembler directives or macro calls. Some instructions and directives allow a size specifier) separated from the mnemonic by a period. Allowed sizes are .B for byte, .W for word, .L for long and .S for short. In addition floating point instructions may also have sizes of .X for extended, .D for double, .P for packed decimal and .S for short floating point. Some of the MMU instructions have a size of .D indicating a double long word (64-bits).

The specifiers which are allowed depend on the particular instruction or directive. Gen is case-insensitive to mnemonic and directive names, so `Move` is the same as move and the same as `mOvE`, for example.

Operand Field

For those instructions or directives which require operands, this field contains one or more parameters, separated by commas. Devpac is case-insensitive regarding register names so they may be in either, or mixed, case.

Comment Field

Any white space not within quotation marks found after the expected operand(s) is treated as a delimiter for a start of the comment and will be ignored by the assembler.

Examples of valid lines

```
      move.l      d0,(a0)+    comment is here

loop  TST.W d0

lonely.label

 rts

* this is a complete line of comment

;  and so is this

      indented: link a6,#-10 make room

a_string:   dc.b   'spaces allowed in quotes'   a string
```

Expressions

Gen allows complex expressions and supports full operator precedence, parenthesis and logical operators.

Expressions are of two main types - *absolute* and *relative* - and the distinction is important. Absolute expressions are constant values which are known at assembly-time.

Relative expressions are program addresses which are not known at assembly-time as the TOS loader can put the program where it likes in memory. Some instructions and directives place restrictions on which types are allowed and some operators cannot be used with certain type-combinations.

Symbols used in expressions will be either relative or absolute, depending on how they were defined. Labels within the source will be relative, while those defined using the `EQU` directive will be the same type as the expression to which they are equated.

The use of an asterisk (*) denotes the value of the program counter at the start of the instruction or directive and is always a relative quantity.

Operators

The operators available, in decreasing order of precedence, are:

unary minus (-) and plus (+)

bitwise not (~)

shift left (<<) and shift right (>>)

bitwise And (&), Or (!) and Xor (^)

multiply (*) and divide (/)

addition (+) and subtraction (-)

equality (=), less than (<), greater than (>), inequality (<>), less than or equals (<=), greater than or equals (>=)

The comparison operators are signed and return 0 if false or -1 ($FFFFFFFF) if true. The shift operators take the left hand operand and shift it the number of bits specified in the right hand operand; vacated bits are filled with zeroes.

This precedence can be over-ridden by the use of parentheses (and). With operators of equal precedence, expressions are evaluated from left-to-right. Spaces in expressions (other than those within quotes as ASCII constants) are not allowed as they are taken as the separator to the comment.

All expression evaluation is done using 32-bit signed-integer arithmetic, with no checking of overflow.

Note that | (vertical bar) may be used as a synonym for ! (or) and that ! = may be used as a synonym for <> (inequality).

Numbers

Absolute numbers may be in various forms:

decimal constants, e.g. `1029`

hexadecimal constants, e.g. `$12f`

octal constants, e.g. `@730`

binary constants, e.g. `%1100010`

character constants, e.g. `'X'`

$ is used to denote hexadecimal numbers, % for binary numbers, § for octal numbers and single ' or double quotes " for character constants.

The default base for numbers may be changed using the `RADIX` directive.

Character Constants

Whichever quote is used to mark the start of a string must also be used to denote its end and quotes themselves may be used in strings delimited with the same quote character by having it occur twice. Character constants can be up to 4 characters in length and evaluate to right-justified longs with null-padding if required. For example, here are some character constants and their ASCII and hex values:

```
"Q"     Q       $00000051
'hi'    hi      $00006869
"Test"  test    $54657374
"it's"  it's    $69742770
'it''s' it's    $69742770
```

Strings used in DC.B statements follow slightly different justification rules, detailed with the directive later.

Floating point constants

Floating point constants are only allowed as arguments for floating point instructions and FEQU directives. Such constants may either be expressed in hexadecimal or conventional decimal notation. Hexadecimal floating point constants should be preceded by : or $; the colon is the Motorola standard. When using hexadecimal the way in which the value is interpreted depends on the size used in the instruction. Thus

```
fmove.x     #$4000000080000000000000000,fp0

fmove.s     #$40000000,fp0

fmove.d     #:4000000000000000,fp0

fmove.p     #$000000020000000000000000,fp0

fmove.s     #2.0,fp0
```

all load the floating point, register FP0 with the value 2.0.

For a description of the floating point formats see *Appendix E.*

Decimal numbers consist of one or more decimal digits followed by an optional fractional part consisting of a full stop (period) and an arbitrary number of decimal digits, optionally followed by an exponent consisting of the letter E or e and a signed decimal exponent. The maximum values allowed depend on the size of the appropriate instruction.

```
fmove.s     #2,fp0

fmove.x     #2E1,fp0

fmove.x     #12345.678e-789,fp1

fmove.x     #0.001,fp2

fmove.x     #-1.2345E1234,fp3
```

The only operator that is allowed in floating point expression is the unary minus (-) operator.

Allowed Type Combinations

The table below summarises for each operator the results of the various type combinations of parameter and which combinations are not allowed. An R denotes a Relative result, an A denotes absolute and a * denotes that the combination is not allowed and will produce an error message if attempted.

	A op A	A op R	R op A	R op R
Shift	A	*	*	*
operators		*	*	*
Bitwise	A	*	*	*
operators		*	*	*

Multiply	A	*	*	*
Divide	A	*	*	*
Add	A	R	R	*
Subtract	A	*	R	A
Comparisons	A	*	*	A

Addressing Modes

The available *68000* addressing modes are shown in the table below. Please note that Gen is case-insensitive when scanning addressing modes, so `d0` and `A3` are both valid registers.

Form	Meaning	Example
`dn`	data register direct	`d3`
`An`	address register direct	`a5`
`(An)`	address register indirect	`(a1)`
`(An)+`	address register indirect with post-increment	`(a5)+`
`-(An)`	address register indirect with pre-decrement	`-(a0)`
`d(An)`	address register indirect with displacement	`20(a7)`
`d(An,Rn.s)`	address register indirect with index	`4(a6,d4.L)`
`d.W`	absolute short address	`$0410.W`
`d.L`	absolute long address	`$12000.L`
`d(PC)`	program counter relative with offset	`NEXT(PC)`
`d(PC,Rn.s)`	program counter relative with index	`NEXT(PC,a2.W)`
`#d`	immediate data	`#26`
`n`	denotes register number from 0 to 7	
`d`	denotes a number	
`R`	denotes index register, either aord	
`s`	denotes size, either W or U when omitted defaults to W	

When using address register indirect with index the displacement may be omitted, for example

```
move.l      (a3,d2.1),d0
```

will assemble to the same as

```
move.l      0(a3,d2.1),d0
```

The modes discussed above can be used regardless of the processor type. The following are additional modes that are only available when using a 68020 or later processor.

Extended Index Registers for 68020

Certain existing modes have been extended to support a scale on the index register as follows:

```
exp(An,Xn<.size><*scale>)

exp(PC,Xn<.size><*scale>)
```

If the above syntax is used then the expression must fit into 8 bits; if it is larger then the new modes (`bd`, `an` , `Xn`) / (`bd`, `PC`, `Xn`) should be used. Suppressed (Z) registers cannot be used with this syntax. See below.

New 68020 Modes

The new modes in their most basic form are:

`(bd.An.Xn)`	address register indirect with index (base displacement)
`([bd,An],Xn,od)`	memory indirect post-indexed
`([bd.An.Xn] ,od)`	memory indirect pre-indexed
`(bd.PC.Xn) ,od)`	program counter indirect with index (base displacement)
`([bd,PC],Xn,od)`	program counter indirect post-indexed
`([bd,PC,Xn],od)`	program counter indirect pre-indexed

Every item in the above is optional and within each set of brackets the item list may be in any order. In general the meaning of the syntax is that the processor takes the sum of any items in brackets and then performs an indirection (memory access) for each set of brackets.

For example, consider,

```
move.w          ([$12.w,a1,d1],$24.w),d0
```

and let us assume that `a1` has the value $1230002 and `d1` has the value $1234. Then this will cause the processor to calculate `a1+d1+$12` (giving $1231248) and fetch the long word value from that address. Assuming $1231248 contains $12345678 then $24 will be added to this (giving $1234569C) and finally the word contents of $1234569C will be loaded into the least significant word of `d0`.

Depending on which items have been omitted, the assembler may change the choice of addressing mode to be more optimal. If you wish to have a particular mode with missing items then the item may be suppressed using Z-notation, i.e. specifying ZAn, or ZPC, as required. The elements described above are further detailed below:

bd - Base Displacement

This is an expression which may be relative or absolute, word or longword in size. The default size is *long*, but word may be forced by adding .W after the expression. The default size itself may be changed with the `BDW` and `BDL` options. If the base displacement is known on pass 1 the size can be optimised automatically by Gen using `opt O8+`.

Xn - Index Register, with optional size and scale

This item has the general form `Xn<.size><*scale>` where the size may be .W (the default) or .L. The scale must evaluate to 1, 2, 4 or 8.

od - Outer Displacement

This is an expression which may be word or longword in size but must be absolute. The default size is word, but long may be forced by adding .L after the expression. The default size itself may be changed with the ODW and ODL options. If the outer displacement is known on pass 1 the size can be optimised automatically by Gen using **opt 09+.**

New 68020 Syntax for Old Modes

The new syntax for the old modes is:

(d16,An)	equivalent to exp (An)
(d8,An,Xn)	equivalent to exp(An,Xn), though Xn may be scaled
(d16,PC)	equivalent to exp(PC)
(d8,PC,Xn)	equivalent to exp(PC,Xn), though Xn may be scaled

If any items are explicitly suppressed then a suitable new 68020 addressing mode will be used.

Ordering Rules

Any set of items within brackets may be ordered arbitrarily, though care should be taken if two address registers are specified; the leftmost register will be used as the base register, the rightmost as the index register. For example the mode:

```
(a3,isize,a2)
```

is specified the assembler will assume a3 is the base register and a2 will be sign-extended from 16-bits, as .W is the default index size.

Data Register Indirect

The 68020 allows data register indirection, by suppressing suitable items, but take care; the default size for index registers is word, so the line

```
move.l      (d3),d0
```

will actually be coded as

```
move.l      (0,za0,d3.w),d0   the (bd,An,Xn) form
```

which will indirect via the sign-extended value of d3; the likely correct line is

```
move.l      (d3.l),d0
```

Special Addressing Modes

CCR	condition code register
SR	status register

USP	user stack pointer

In addition to the above, SP can be used in place of A7 in any addressing mode, e.g. 4(SP,d3.W)

The data and address registers can also be denoted by use of the reserved symbols R0 through R15. R0 to R7 are equivalent to d0 to d7; R8 to R15 are equivalent to A0 to A7. In general we recommend sticking to the standard register names, but this option can be useful when porting code from other assemblers or to simplify tools which generate assembly language.

The registers above are available on all 68000 family processors. The following registers are only available on higher processors and in the 68851 MMU. The use of some of these registers varies from chip to chip.

AC	access control register
BAC0-7	breakpoint acknowledge control register
BAD0-7	breakpoint acknowledge data register
CAAR	cache address register
CACR	cache control register
CAL	current access level
CRP	CPU root pointer
DRP	DMA root pointer register
DTT0,	data transparent translation registers
ISP	interrupt stack pointer
ITT0,	instruction transparent translation registers
MMUSR	MMU status register
MSP	master stack pointer
PCSR	MMU cache status register
PSR	MMU status register
SCC	stack change control register
SFC, DFC	alternate function code registers
SRP	supervisor root pointer
TC	MMU translation control register
TT0, TT1	translation control registers
URP	user root pointer
VAL	validate access level register
VBR	vector base register

In general, user programs running under TOS should not use these registers since they are reserved for use by the operating system; some low level programs may find it necessary to manipulate the cache control register if using self-modifying code.

Floating point registers

FP0-FP7	general purpose floating point registers
FPCR	floating point control register

FPSR	floating point status register
FPIAR	floating point instruction address register

The addressing modes used in conjunction with the floating point instructions are the same as those for the 'ordinary' instructions, although you should note that the floating point instructions always use at least one floating point register.

Local Labels

Gen supports local labels, that is labels which are local to a particular area of the source code. These are denoted by starting with a period and are attached to the last non-local label, for example:

```
len1  move.l      4(sp),a0

.loop tst.b (a0)+

      bne.s .loop

      rts

len2  move.l      4(sp),a0

.loop tst.b -(a0)

      bne.s .loop

      rts
```

There are two labels called `.loop` in this code segment but the first is attached to `len1`, the second to `len2`.

As the local labels are attached in this way, you must have at least one real label before the first local one.

If you wish to use global labels starting with a dot you may use `OPT LOCALU` to allow this an make the underline character introduce local labels.

The local labels .W and .L are not allowed to avoid confusion with the absolute addressing syntax.

You may also use strings of decimal digits terminated by a $ sign as local labels. This facility has been provided for compatibility with other assemblers; we recommend the use of form shown above as this makes programs much more readable.

Symbols and Periods

Symbols which include the period character can cause problems with Gen due to absolute short addressing.

The Motorola standard way of denoting absolute short addresses causes problems as periods are considered to be part of a label, best illustrated by an example:

```
      move.l      vector.w,d0
```

where `vector` is an absolute value, such as a system variable. This would generate an undefined label error, as the label would be scanned as vector `.w`.

To work around this, the expression, in this case a symbol, may be enclosed in brackets, e.g.

```
        move.l      (vector).w,d0
```

though the period may still be used after numeric expressions, e.g.

```
        move.l      402.w,d0
```

Devpac 1 supported the use of \ instead of a period to denote short word addressing and this is still supported in this version, but is not recommended due to the potential for \W and \L to be mistaken for macro parameters.

Instruction Set

Word Alignment

All instructions with the exception of `DC.B` and `DS.B` are always assembled on a word boundary. Should you require a `DC.B` explicitly on a word boundary, use the `EVEN` directive before it. Although all instructions that require it are word-aligned, labels with nothing following them are not word-aligned and can have odd values. This is best illustrated by an example:

```
        nop     will always be word aligned

        dc.b    'odd'

start

        tst.l (a0)+

        bne.s start
```

The above code would not produce the required result as start would have an odd value. To help in finding such instructions the assembler will produce an error if it finds an odd destination in a `BSR` or `BRA` operand. Note that such checks are not made on any other instructions, so it is recommended that you precede such labels with an `EVEN` directive if you require them to be word-aligned. A common error is deliberately not to do this, as you know that the preceding string is an even number of bytes long. All will be well until the day you change the string...

Instruction Set Extensions

The complete 68000-68040 instruction set is supported (depending on the processor selected) together with the 68881/68882 and 68551 coprocessors. A number of standard shorthands are automatically accepted as detailed below. A complete description of the 68000 instruction set can be found in the supplied pocket guide. Full details of the instructions for the other chips including syntax and addressing modes can be found in the M68000 Family Programmer's

Reference Manual which is available from HiSoft.

Condition Codes

The alternate condition codes HS and LO are supported in Bcc, DBcc and Scc instructions, equivalent to CC and CS, respectively.

Branch instructions

To force a short branch use Bcc.B or Bcc.S, to force a word branch use Bcc .W or to leave to the optimiser use Bcc. To use a 32 bit branch when 68020 or above code generation is in effect then use Bcc.L.

When 68000/68008/68010 code generation is selected Bcc.L is interpreted as a Bcc.W with a warning for compatibility with Devpac 1. To cause Bcc.L to be converted to Bcc.W regardless of the processor selected then use OPT OLD as described elsewhere.

A BRA.S to the immediately following instruction is not allowed but may be converted, with a warning, to a NOP using OPT O7+ (see the options sub-section for details). A BSR.S to the immediately following instruction is not allowed and will produce an error.

DBRA Instruction

DBRA is accepted as an equivalent to DBF.

ILLEGAL Instruction

This generates the op-code word $4AFC.

LINK Instruction

If the displacement is positive or not even a warning will be given.

MOVE from CCR Instruction

This is a 68010 and upwards instruction, converted with a warning to MOVE from SR when 68000 only code is selected.

MOVEQ Instruction

It the data is in the range 128-255 inclusive a warning will be given. It may be disabled by specifying a long size on the instruction.

Assembler Directives

Certain pseudo-mnemonics are recognised by Gen. These *assembler directives*, as they are called, are not (normally) translated into opcodes, but instead direct the assembler to take certain actions at assembly time. These actions have the effect of changing the object code produced or the format of the listing. Directives are scanned exactly like executable instructions and some may be preceded by a label (for some it is obligatory) and may be followed by a comment. If you put a label on a directive for which it not relevant, the result is undefined but will usually result in the label being ignored.

Each directive will now be described in turn. Please note that the case of a directive name is not important, though they generally are shown in upper case. The use of brackets ([ ]) in

descriptions denote optional items, ellipses (...) denote repeated items.

Assembly Control

END

This directive signals that no more text is to be examined on the current pass of the assembler. It is not required.

INCLUDE filename

This directive will cause source code to be taken from a file on disk and assembled exactly as though it were present in the text. The directive must be followed by a filename in normal TOS format.

A drive specifier, directory and extension may be included as required, e.g.

```
include   c:\devpac\includes\header.i
```

Include directives may be nested as deeply as memory allows and if any error occurs when trying to open the file or read it, assembly will be aborted with a fatal error. When using the integrated editor if an include file is loaded then this will be read direct from memory; there is no need to save it to disk before assembly.

If you have checked the Ignore multiple includes item in the *Assembler Options - Control* dialog or used the `OPT INCONCE` option, then attempts to include a file a second time will be ignored.

If no drive is specified, that of the main source file will be used when trying to open the file.

For maximum flexibility, Gen allows a two ways of specifying where include files may be found without the need to specify the full pathname as in the example above.

First, the Assembler Options - Control dialog 'INCLUDE' directories list (and its command line equivalent the `-I` option) lets you set directories that will be searched to find the include files. Second you can use the `INCDIR` directive itself to add to this path list.

Thus typically you use the assembler dialog to set up the directory for the system includes and use the `INCDIR` directive for any files that are specific to this particular program.

The more memory the better, Gen will read the whole of the file in one go if it can and not bother to re-read the file during pass 2.

Pre-assembled files

When searching for include files Gen also looks for a file with the same name as the include file but with any extension replaced with .GS. This is assumed to be a pre-assembled symbol table file corresponding to that file name.

Such a file is produced using the Output Symbols option from the Program menu or by using

the `OPT GENSYM` option. The .GS file that this produces contains the symbol table definitions for the absolute labels and macros that are defined by the include file. It also lists the files that the include file has included itself.

When the assembler loads a .GS file the labels and macros contained within it are added to the symbol table for the new assembly. If a definition is already present then it is ignored. Any subsequent references to this include file and the files that it includes will be ignored.

Thus if you Output Symbols from the Devpac include file GEMMACRO.I this will generate GEMMACRO.GS. Your programs that use this include file will then load the .GS file and will assemble more quickly. You can even delete the original include file if you wish (make sure you have a copy of the source first, though!).

If you know that your program is going to include a particular pre-assembled file you can load it before assembly starts using the Pre-assembled includes dialog from the Assembler Control dialog or via the command line `-H` option.

Note that you cannot pre-assemble files that generate code, i.e. files such as AESLIB.S *may not* be pre-assembled.

INCDIR *pathnamelisf*

The `INCDIR` directive lets you specify directories that will be searched for include files as well as those specified via the `-I` command line flag or Include list in the assembler control dialog.

The format for `pathnamelist` is a list of items separated by commas or semicolons and the directories should be terminated by a backslash. Pathnames that contain spaces should be enclosed in quotes.

INCBIN *filename*

This takes a binary file and includes it, verbatim, into the output file. Suggested uses include screen data, sprite data and ASCII files. The `INCBIN` directive uses the same method for finding files as the `INCLUDE` directive above.

The included data *is* forced to an even boundary, however the section counter is *not* forced to an even boundary after the include if the file is an odd number of bytes in length.

OPT option[,option ...]

There are a very wide range of options controlling all aspects of the assembly process; some may be set with their own option letter on the command-line, all may be set with an `OPT` directive within the source file, and most may also be set on the command-line using either a leading +, or the - v option.

Devpac 2 and below only supported options denoted with an alphabetic character followed by + or -; however owing to the large number of options, these have been supplemented with keywords. The old format options are still accepted.

Note that options specified on the command line override options specified on line 1 of the source; this *does not* apply to the integrated environment.

The options are as follows:

Processor selection

P=*type* allows selection of processor type; type may be one of 68000, 68008, 68010, 68020, 68030, 68040 or 68332. Optional co-processors may be specified, separated by a / and may be any combination of 68881, 68882 or 68851. Specifying a main processor will de-select any current co-processor.

68020 Default Displacement Sizes

BDW makes any unsized base displacements used in 68020 addressing modes word-sized; this will cause errors if you have any relocatable references as they cannot fit into a word.

BDL makes any unsized base displacements long-sized.

ODW makes any unsized outer displacements word-sized.

ODL makes any unsized outer displacements long-sized.

All of the above can be overridden on an individual basis by specifying .W or .L after the expression. In general we recommend the use of such explicit specifiers as it makes code more portable.

See below for automatic optimisation of long displacements into short ones.

Branch Control

OLD ordinarily a BRA.L is converted into a BRA.W with a warning, unless you selected a 68020 or higher processor in which case it will generate a BRA.L, a 32-bit PC-relative branch. The use of this option will force BRA.Ls to always be converted to BRA.Ws, regardless of the processor type selected. Note that this option is not available in the integrated environment.

BRW unsized branch instructions will default to BRA.W, unless optimisation type 1 is selected when it may be promoted to BRA.S.

BRB unsized branch instructions will default to BRA.S; errors will be generated if the branch is out of range.

BRS as above; included for Motorola compatibility.

BRL unsized branch instructions will default to BRA.L; P=68020 or P=68030 mode must be selected for this option to be valid.

The default option is BRW.

Symbol Case Sensitivity

By default all symbols are case-sensitive, though this can be overridden on the command-line. The default length of symbol significance is 127 characters, the maximum.

CASE symbols are case sensitive.

NOCASE symbols are case-insensitive.

Cx treat x characters as significant (x=8 -127).

`Cx+` symbols are case-sensitive to x characters.

`Cx-` symbols are case-insensitive to X characters.

Although it is unlikely to be useful, it is possible to use these options at any time in a source file and an unlimited number of times.

Listing Control

By default an assembly listing will show macro calls in the same form as those in the source.

`MEX` expand macro calls in the listing.

`NOMEX` don't expand macro calls.

By default there will be no symbol table listing, unless `-S` is specified on the command-line, or the option below is used:

`SYMTAB` select a symbol table listing.

`NOSYMTAB` disable a symbol table listing.

`LIST1` enable assembly listing on pass one.

`NOLIST1` disable listing on pass one (default).

Pass one listing is not useful generally, because the data for the instructions may be wrong. It can be useful when tracking down mistakes with conditional assembly and macros.

`TRACEIF` enable tracing of conditional assembly on pass one.

`NOTRACEIF` disable this tracing (default).

The `TRACEIF` option is designed for finding mistakes in complex use of conditional assembly and as such is only for experienced assembly language users. Conditional assembly is described in a later section in this chapter. `TRACEIF` gives a list of only the `IFxx`, `ELSE/ELSEIF` and `ENDC` directives together with a display of the conditional assembly counter.

Output File Format

`ATARI,GST,DRI,SREC,LATTICE`

These select the output file format and must be before the first line of the source file that generates code; for further details please see the beginning of this chapter.

`GENSYM` This causes Gen to output a symbol table (or pre-assembled) file with extension .gs rather than a conventional output file. As such this command can only be used for include files that do not generate any code. See the section above on *Pre-assembled files.*

Optimisation

Gen is capable of optimising certain statements to faster and smaller versions. By default all optimising is off but each type can be enabled and disabled as required. This option has several forms:

O1+ will optimise backward branches to short if within range, can be disabled with O1-.

O2+ will optimise address register indirect with displacement addressing modes to address register indirect, if the displacement evaluates to zero. It can be disabled with O2-. For example:

```
move.l      next(a0),d3
```

will be optimised to:

```
move.l      (a0),d3
```

if the value of next is zero.

O3+ will optimise absolute addresses to short-word addressing if in the signed 32 bit range $FFFF8000 to $7FFF inclusive.

O4+ will optimise instructions of the form MOVE.L #x,dn to MOVEQ if x is in the range -128 to 127 inclusive.

O5+ ADD #x and SUB #x instructions will be optimised to quick forms if x is in the range 1-8 inclusive.

O6+ not strictly an optimisation; a warning will be issued for each forward branch that could be made short; this must be used in conjunction with option type 1.

O7+ convert BRA.S to next instruction to NOP; note that this instruction is not possible, so an error will be issued if this attempted without this optimisation.

O8+ will optimise 68020 base displacements to the short form addressing if in the signed 32 bit range $FFFF8000 to $7FFF inclusive.

O9+ will optimise 68020 outer displacements to the short form addressing if in the signed 32 bit range $FFFF8000 to $7FFF inclusive.

O10+ will optimise ADD#x,An and SUB #x,An instructions to LEA x(An),An or LEA -x(An),An if this is possible but not in the case when an ADDQ/SUBQ instruction is preferable. This option is normally used in conjunction with 05+.

O11+ will optimise LEA x(An),An or LEA -x(An),An instructions to ADDQ.W #x,An and SUBQ.W #x,An if this is possible.

O12+ will optimise MOVE.L #x,An to MOVE.W #x,An if possible and if another optimisation has not been performed. This also optimises the corresponding ADD, SUB and CMP instructions.

O+ will turn all optimising on.

O- will turn all optimising off.

O1-,O2- etc. will disable the relevant optimisation.

OW- will disable the warning messages generated by each optimisation, OW+ will enable them. OWn+/- (where n is 1 -12) may be used to enable/disable a particular warning message.

If any optimising has been done during an assembly the number of optimisations made and bytes saved will be shown at the end of assembly.

Source Checking

The assembler has various ways of detecting possible programming errors, using these options:

ALLOWZERO allow the use of 0 to specify a bitfield of width 32 or in place of 8 within ADDQ/SUBQ for compatibility with some Motorola assemblers.

NOALLOWZERO disables the above (default).

CHKBIT will give errors if a memory bit field access attempts to reference a bit number out of the range 0 to 7 (default).

NOCHKBIT disables the above.

WARNBIT generates warnings for the above.

CHKIMM will give errors if an absolute value is used in such a way that the assembler thinks it should be an immediate value, for example:

```
and.b $df,dl
```

will generate the error # probably missing. Can be overridden on an individual basis by specifying .W or .L after the expression.

NOCHKIMM disables the above (default).

CHKPC will force errors if any attempt is made to generate non-position-independent code.

NOCHKPC disables the above (default).

EVEN causes the assembler to check that the value of an indirection is not odd on non-byte sized instructions to avoid address errors (default), for example

```
      move.l      data2,d0
data1 ds.b        1
data2 ds.b        1
```

Do not confuse this option with the EVEN directive itself.

NOEVEN disables the above, useful if you are writing code to run only on a 68030.

Miscellaneous

AUTOPC forces automatic PC addressing where possible; this is done on a lexical basis, not a value basis, and can be overridden individually by specifying .L, for example

```
move.l      test,a3
```

will be changed to `test (pc),a3`. Use of this option can significantly reduce program size and running time without a lot of extra typing. Please note however that it does not guarantee that the code generated will be position independent. We discourage the use of this option since it can easily cause confusion, particularly when using complex expressions.

If you need to override the automatic use of PC mode then use the form (expression) `.L` in a similar manner to that for short word addressing as described above under labels and periods.

So the example above could be forced to use absolute addressing by using the following:

```
MOVE.L      (int_in).L,dO
```

`NOAUTOPC` disables the above (default).

`INCONCE` causes multiple includes of the same file to be ignored, i.e. included only once. Whilst this speeds up the assembly of files that are 'protected' against multiple includes, this will cause problems with some files that need to be processed more than once. For example, rather than using a macro you might include a file a number of times to obtain two copies of the same routine or data.

`NOINCONCE` causes include files to be re-scanned each time they re included (default).

`LOCALU` changes the lead-in character for local symbols to be an underscore (_) instead of period; useful if you need to specify periods in external names.

`LOCALDOT` changes the lead-in character for local symbols to be a period (`.`) (default).

`NOTYPE` Disables the type-checking of the expression evaluator which is capable of detecting incorrect type mixing; if you get an error absolute not allowed or relative not allowed and you are sure you know that you want to do what you're trying to do, then this will disable the checks.

`TYPE` restores the type checking referred to above.

`NOWARN` disables all warning messages.

`WARN` enables warning messages (default).

`USER` any privileged instructions used after this option will generate an error; useful for system programmers wishing to separate user and supervisor code spaces.

`SUPER` permits privileged instructions to be used without errors (default).

Option Summary

Name	Default	Action	Old form
`ALLOWZERO`		allow narrow zero operands	
`ATARI`	✓	TOS executable output	`ID`
`AUTOPC`		use PC relative addressing	`A+`
`BDW`		default base displacement to word	
`BDL`	✓	defaults base displacement to long	
`BRB`		default branches to short	

BRL		default branches to long	
BRS		default branches to short	
BRW	✓	default branches to word	
CASE	✓	case-sensitive symbols	C+
Cx+	✓	case-sensitive symbols	Cx+
Cx-		case-insensitive symbols	Cx-
CHKBIT	✓	check bit fields	
CHKIMM		check immediate operands	1+
CHKPC		disallow non-PC addressing	P+
D		debug	D+
DEBUG		debug	D+
DRI		DRI format linkable	L2
EVEN	✓	ensure indirections are even	E+
GENSYM		generate Gen symbol table file	
GST		GST format linkable	L1
HCLN		generate compressed line numbers	
INCONCE		process multiple includes only once	
LATTICE	✓	Lattice format linkable	L7
LINE		generate standard line numbers	
LIST1		generate pass 1 listing	Z+
LOCALDOT	✓	use periods for local labels	U-
LOCALU		use underscores for local labels	U+
MEX		expand macro calls	M+
NOALLOWZERO	✓	disable narrow zero operands	
NOAUTOPC		disable automatic PC	A-
NOCASE		case-insensitive symbols	C-
NOCHKBIT		disable bit field checks	
NOCHKIMM	✓	disable immediate checks	I-
NOCHKPC		disable PC-only checks	P-
NODEBUG	✓	disable debug	D-
NOEVEN		disable indirection checks	E-
NOINCONCE	✓	re-process multiple includes	
NOHCLN	✓	no output of line numbers	
NOLINE	✓	no output of line numbers	
NOLIST1	✓	no pass 1 listing	Z-
NOMEX	✓	don't expand macro calls	M-
NOSYMTAB	✓	no symbol table listing	S-
NOTRACEIF	✓	don't trace conditionals	
NOTYPE		no type-checking	T-
NOWARN		no warning messages	W-
O+		enable all optimisations	O+
O-	✓	disable all optimisations	O-
ODW	✓	default outer displacement to word	
ODL		default outer displacement to long	

OLD		obsolete - treat BRA. L as BRA.W	
OW-		disable all optimisation warnings	ow-
OWx+		enable an optimisation warning	OWx+
OWx-		disable an optimisation warning	OWx-
Ox+		enable an optimisation	Ox+
Ox-		disable a specific optimisation	Ox-
P=	68000	specify processor	
SREC		S-record output	
SUPER	✓	privileged op-codes allowed	
SYMTAB		enable a symbol table listing	s+
TRACEIF		trace conditionals	
TYPE	✓	enable type checking	T+
USER		privileged op-codes disallowed	
WARN	✓	enables warning messages	
WARNBIT		warnings for bit field checks	
XDEBUG		specify extended debug	X+

Assembler Directives

[label] ***EVEN***

This directive forces the program counter to be even, i.e. word-aligned. As Gen automatically word-aligns all instructions (except DC.Bs and DS.Bs) it should not be required very often, but can be useful for ensuring buffers and strings are word-aligned when required.

CNOP *offset,alignment*

This directive aligns the program counter using the given offset and alignment. An alignment of 2 means word-aligned, an alignment of 4 means long-word-aligned and so on. The alignment is relative to the start of the current section. For example,

```
cnop  1,4
```

aligns the program counter a byte past the next long-word boundary.

[label] ***DC.B*** *expression[,expression ...]*

[label] ***DC.W*** *expression[,expression ...]*

[label] ***DC.L*** *expression[,expression ...]*

[label] ***DC.X*** *fp-const[,fp-const...]*

[label] ***DC.D*** *tp-const[,fp-const...]*

[label] ***DC.S*** *fp-const[,fp-const...]*

These directives define constants in memory. They may have one or more operands, separated by commas. The constants will be aligned on word boundaries for DC.W and DC.L. No more than 128 bytes can be generated with a single DC directive.

DC.B treats strings slightly differently to those in normal expressions. While the rules described previously about quotation marks still apply, no padding of the bytes will occur and the length of any string can be up to 128 bytes.

Be very careful about spaces in DC directives, as a space is the delimiter before a comment.

For example, the line

```
dc.b  1,2,3  ,4
```

will only generate 3 bytes - the , 4 will be taken as a comment.

The DC.X, DC.D and DC.S directives generate floating point constants and are only available if you have selected a maths coprocessor.

[label] ***DS.B*** *expression*

[label] ***DS.W*** *expression*

[label] ***DS.L*** *expression*

These directives will reserve memory locations and the contents will be initialised to zeros. If there is a label then it will be set to the start of the area defined, which will be on a word boundary for DS.W and DS.L directives. There is no restriction on the size, though the larger the area the longer it will take to save to disk (except in the case of true BSS sections).

For example, all of these lines will reserve 8 bytes of space, in different ways:

```
ds.b  8
ds.w  4
ds.l  2
```

[label] ***DCB.B*** *number[,value]*

[label] ***DCB.W*** *number[,value]*

[label] ***DCB.L*** *number[,value]*

This directive allows constant blocks of data to be generated of the size specified, number specifies how many times the value should be repeated. If value is omitted then the default value, zero is used.

FAIL

This directive will produce the error user error. It can be used for such things as warning the programmer if an incorrect number of parameters have been passed to a macro.

MACHINE *number*

This directive sets the processor for which code is generated and should be one of:

MC68000 MC68008 MC68010

MC68020 MC68030 MC68040

MC68332 CPU32

The last two items are equivalent. Note that you can also use the `OPT p=` option which also allows co-processors to be selected.

OUTPUT *filename*

This directive sets the normal output filename though can be overridden by specifying a filename from the command line or using the Output to: item in the *Assembler Options - Control* dialog. If filename starts with a period then it is used as an extension and the output name is built up as described previously.

RADIX *radix*

This directive sets the default base for numeric literals, `radix` may be one of 2,4,8,10 or 16 and must be specified in decimal; expressions are not allowed.

The default is decimal (base 10). Two reasons for using this command are to enter tables in a non-decimal base and to assemble code that has been generated by a disassembler or other tool that emits non-decimal numbers without the appropriate prefix.

When using hexadecimal base (16) numbers must still start with a *decimal* digit. For example,

```
radix 16
dc.b  0ff
dc.b  ff
```

Here `0ff` would have the value `255` whereas ff would refer to the label `ff`.

__G2 (reserved symbol)

This is a reserved symbol that can be used to detect whether a Devpac family assembler (other than Devpac 1) is used. To test that a Devpac family assembler is being used to use the `IFD` conditional. The value of this symbol depends on the version of the assembler and is always absolute.

To ensure that the assembler facilities over and above those of Devpac 2 are available (for example `RADIX`) you should check that the lower 8 bits of G2 are at least 43 (don't ask why!). This does not guarantee that the 68030 and co-processor instructions are supported.

To check for which processor you are assembling look at bits 8-15: these give the last two digits of processor number. For example $1E if you are producing code for a 68030.

To ensure that you are running on an Atari machine (rather than, say, an Amiga) check that bits 16 to 23 are 0.

__LK (reserved symbol)

This is a reserved symbol that can be used to detect which output mode is specified. The value of this symbol is always absolute and one of the following:

0	Atari executable
1	GST linkable
2	DRI linkable
6	Motorola S-records
7	Lattice C linkable code

Other values are reserved for other members of the Devpac family.

Repeat Loops

It is often useful to be able to repeat one or more instructions a particular number of times and the repeat loop construct allows this.

[label] ***REPT*** *expression*
...
ENDR

Lines to be repeated should be enclosed within REPT and ENDR directives and will be repeated the number of times specified in the expression. If the expression is zero or negative then no code will be generated. It is not possible to nest repeat loops; for example

```
REPT        512/4 copy a sector quickly
move.l      (a0)+,(a1)+
ENDR
```

Program labels should not be defined within repeat loops to prevent label defined twice errors.

Listing Control

LIST

This will turn the assembly listing on during pass 2, to whatever device was selected at the start of the assembly (or to the screen if None was initially chosen). All subsequent lines will be listed until an END directive is reached, the end of the text is reached, or a NOLIST directive is encountered.

Greater control over listing sections of program can be achieved using LIST+ or LIST- directives. A counter is maintained, the state of which dictates whether listing is on or off. A LIST+ directive adds 1 to the counter and a LIST- subtracts 1. If the counter is zero or positive then listing is on, if it is negative then listing is off. The default starting value is -1 (i.e. listing off) unless a listing is specified when the assembler was invoked, when it is set to 0. This system allows a considerable degree of control over listing particularly for include files. The normal LIST directive sets the counter to 0, NOLIST sets it to -1.

If you would like a listing on pass 1, you can use:

```
OPT   LIST1
```

For further details of pass one listing see the *Options* section.

NOLIST

This will turn off any listing during pass 2.

When a listing is requested onto a printer or to disk, the output is formatted into pages, with a header at the top of every page. The header itself consists a line containing the program title, date, time and page number, then a line showing the program title, then a line showing the sub-title, then a blank line. The date format will be printed in the form DD/MM/YY, unless the assembler is running on a US machine, in which case the order is automatically

changed to MM/DD/YY. Between pages a form-feed character (ASCII FF, value 12) is issued.

PLEN *expression*

This will set the page length of the assembly listing and defaults to 60. The expression must be between 12 and 255.

LLEN *expression*

This will set the line width of the assembly listing and defaults to 132. The value of the expression must be between 38 and 255.

TTL *string*

This will set the title printed at the top of each page to the given string, which may be enclosed in single quotes. The first TTL directive will set the title of the first printed page. If no title is specified the current include file name will be used.

SUBTTL ***string***

Sets the sub-title printed at the top of each page to the given string, which may be enclosed in single quotes. The first such directive will set the sub-title of the first printed page.

SPC *expression*

This will output the number of blank lines given in the expression in the assembly listing, if active.

PAGE

Causes a new page in the listing to be started.

LISTCHAR *expression[,expression ...]*

This will send the characters specified to the listing device (except the screen) and is intended for doing things such as setting condensed mode on printers. For example, on Epson printers and compatibles the line

```
listchar      15
```

will set the printer to 132-column mode.

FORMAT *parameter[,parameter ...]*

This allows exact control over the listed format of a line of source code. Each parameter controls a field in the listing and must consist of a digit from 0 to 2 inclusive followed by a + (to enable the field) or a - (to disable it):

0 line number, in decimal

1 section name/number and program counter

2 hex data in words, up to 10 words unless printer is less than 80 characters wide, when up to three words are listed.

Label Directives

label ***EQU*** *expression*
label *=* *expression*

These directives set the value and type of the given label to the result of the expression. It may not include forward references, or external labels. If there is any error in the expression, the assignment will not be made. The label is compulsory and must not be a local label.

label ***EQUENV*** *var*

This directive finds the value of the environment variable var and assigns it to the label exactly as per EQU. Note that you may not use this to perform a string equate.

label ***EQUR*** *register*

This directive allows a data or address register to be referred to by a user-name, supplied as the label to this directive. This is known as a *register equate. A* register equate *must* be defined before it is used.

label ***SET*** *expression*

This is similar to EQU, but the assignment is only temporary and can be changed with a subsequent SET directive. Forward references cannot be used in the expression. It is especially useful for counters within macros, for example, using a line like:

```
zcount      set   zcount+1
```

(assuming zcount is set to 0 at the start of the source). At the start of pass 2 all SET labels are made undefined, so their values will always be the same on both passes.

label ***REG*** *register-list*

This allows a symbol to be used to denote a register list within MOVEM instructions, reducing the likelihood of having the list at the start of a routine different from the list at the end of the routine. A label defined with REG may be used in expressions, with a warning; they have a value which is the same as that used in the MOVEM postincrement opcode.

Defining offsets

There are three different ways to define lists of constant labels without using explicit numbers that would need to be changed if you decided to add or delete an item near the front of the lists. The first is using the RS directives, the second using an OFFSET section and the last is using the CARGS directive. The first two methods provide the same functionality although OFFSET directives usually require more lines of code than RS directives. CARGS requires less typing than the other two methods but can not be used for items of sizes other than 2 or 4 bytes.

[label] *RS.B expression*

[label] *RS.W expression*

[label] *RS.L expression*

These directives let you set up lists of constant labels, which is very useful for data structures

and global variables and is best illustrated by a couple of examples.

Let's assume you have a data structure which consists of a long word, a byte and another long word, in that order. To make you code more readable and easier to update should the structure change, you could use lines such as

```
            rsreset
d_next      rs.1  1
d_flag      rs. b 1
d_where     rs.l  1
```

then you could access them with lines like

```
            move.l      d_next(a0),a1
            move.l      d_where(a0),a2
            tst.b       d_flag(a0)
```

As another example let's assume you are referencing all your variables off register A6 (as done in Gen and Mon) you could define them with lines such as

```
onstate     rs.b  1
start       rs.l  1
end         rs.l  1
```

You then could reference them with lines such as

```
move.b      onstate(a6),d1
move.l      start(a6),d0
cmp.l       end(a6),d0
```

Each such directive uses its own internal counter, which is reset to 0 at the beginning of each pass. Every time the assembler comes across the directive it sets the label according to the current value (with word alignment if it is .W or .L) then increments it according to the size and magnitude of the directive. If the above definitions were the first RS directives, onstate would be 0, start would be 2 and end would be 6.

RSRESET

This directive will reset the internal counter as used by RS.

RSSET *expression*

This allows the RS counter to be set to a particular value.

RS *(reserved symbol)*

This is a reserved symbol having the current value of the RS counter.

OFFSET *expression*

This switches code generation to a special section to generate absolute labels. The optional expression sets the program counter for the start of this section (otherwise the value left over from the last OFFSET section will be used). No bytes are written to the disk and the only code-generating directive allowed is DS. Labels defined within this section will be absolute.

To return to ordinary code generation, use a suitable SECTION directive. See under the different output formats below.

Thus if the current section is TEXT then

```
            OFFSET      $400
labl        ds.w        1
lab2        ds.l        2
SECTION     TEXT
```

works in a similar way to

```
labl        rs.w        1
lab2        rs.l        2
```

and would assign the same values to lab1 and lab2.

Here is an example that defines some of the operating system's variables:

```
            OFFSET      $400
etv_timer   ds.l  1     will be     $400
etv_crit    ds.l  1     $404
etv_term    ds.l  1     $408
ext_extra   ds.l  5     $40C
memvalid    ds.l  1     $420
memcntlr    ds.w  1     $424
```

CARGS [#offset,]lab1.size[,lab2.size ...]

This directive is designed for accessing subroutine parameters that have been passed on the stack and as such it is very useful when interfacing with high-level languages.

This defines lab1 to have the value given by offset. The value of lab2 would then depend on the size used for lab1. If this was .L then it will be 4 more than of f set; if it is .W or .B then it will be 2 more than offset. Subsequent labels are defined in a similar way. The default value for offset is 4 and the default size for labels is 2 bytes.

This directive is compatible with the Atari MadMAC assembler command of the same name.

Here is an implementation of the C function strcat which appends one null terminated string to the end of another. Its first parameter in C is the original string and the second is the string to be added. As is usual in C the second parameter is pushed on the stack, and then the first parameter. The assembly language code is:

```
strcat      cargs       original.l,added.l
            move.l      original(sp),a0
findend     tst.b       (a0)+
            bne.s       findend
            subq.w      #1,a0                   ready to replace null
            move.l      added(sp),a1
copylp      move.b      (a1)+,(a0)+
            bne.s       copylp
            rts
```

Thus original will have a value of 4 and added will have a value of 8 corresponding to their offsets on the stack after a jsr or bsr instruction has been used.

If you are using a language in which parameters are passed in 'Pascal order' where the first parameter is pushed on the stack first, then you will need to reverse the order of the arguments in the CARGS directive.

Also note that although in many ways the CARGS directive is equivalent to use the RSSET directive to the value of the offset expression followed by the equivalent RS directives for the labels, it differs in one very important respect - using .B is exactly equivalent to .W. This is because the instruction

```
move.b      d0,-(sp)
```

will decrease the stack pointer by 2 and place the low byte of the register on the even address of the new stack pointer. Thus to access such a parameter on the stack, previously pushed parameters will be two bytes further up the stack; therefore CARGS cannot be used for defining data structures that contain byte aligned data.

Floating Point Directives

Note that DC.S, DC.D and DC.X are really floating point directives but they are documented above with their integer cousins.

label ***FEQU.x*** *constant*

This directive will set the value and type of the given label to be a floating point constant of the given value. The constant may be specified in hexadecimal or decimal as described previously under expressions; alternatively you may use a previously defined floating point constant.

The label is compulsory and must not be a local label.

Note that the size (.x) is compulsory and should be one of

.S	single precision
.D	double precision
.X	extended precision
.P	packed decimal
.W	word
.L	long

For example:

```
ten         fequ.x      10.0
two         fequ.s      :40000000
million     fequ.x      1E6
nemillion   fequ.x      -million
```

FOPT *option[,option...]*

This directive allows you to set the floating point co-processor identifier and the rounding and precision of the assembler's internal floating point calculations. The valid options are:

ID=<id> This sets the co-processor identifier. By default, this is 1 as used on the Atari TT and as recommended by Motorola. However for systems with more than one FPU you will need to set this.

ROUND=<type> This is used to set the rounding method used by internal floating

point operations. <type> should be one of:

N	round to the nearest
Z	round towards zero
P	round towards + infinity
M	round towards - infinity

These correspond to the RND portion of the FPCR mode control byte. The default value is N.

PREC=<type> This is used to set the precision used by internal floating point operations. <type> should be one of:

X	extended precision
S	single precision
D	double precision

These correspond to the PREC portion of the FPCR mode control byte. The default value is X.

For example:

```
fopt        ID=2        set the co-processor ID
fopt        ROUND=z     round towards 0
fopt        PREC=S      single precision
```

Conditional Assembly

Conditional assembly allows the programmer to write a comprehensive source program that can cover many conditions. Assembly conditionals may be specified through the use of arguments, in the case of macros, and through the definition of symbols in EQU or SET directives. Variations in these can then cause assembly of only those parts necessary for the specified conditions.

There are a wide range of directives concerned with conditional assembly. At the start of the conditional block there must be one of the many IF directives and at the end of each block there must be an ENDC directive. Conditional blocks may be nested up to 65535 levels.

Labels should not be placed on IF or ENDC directives as the directives will be ignored by the assembler.

IFEQ *expression*
IFNE *expression*
IFGT *expression*
IFGE *expression*
IFLT *expression*
IFLE *expression*

These directives will evaluate the expression, compare it with zero and then turn conditional

assembly on or off depending on the result. The conditions correspond exactly to the 68000 condition codes. For example, if the label DEBUG had the value 1, then with the following code,

```
            IFEQ        DEBUG
logon       dc.b        'Enter a command:',0
            ENDC
            IFNE        DEBUG
            opt         XDEBUG              labels please
logon       dc.b        'Yeah, gimme man:',0
            ENDC
```

the first conditional would turn assembly off as 1 is not EQ to 0, while the second conditional would turn it on as 1 is NE to 0.

IFNE corresponds to IF in assemblers with only one conditional directive.

The expressions used in these conditional statements *must* evaluate correctly on the assembler's first pass.

IIF *exp-statement*

This directive can be used for pieces of conditionally assembled code that only consist of one line. IIF stands for Immediate IF. If the value of exp is non-zero then the given statement is assembled, otherwise it is ignored. No ENDC should be used in conjunction with this directive. For example,

```
      IIF         BASIC       clr.b       basic_flag(a6)
```

will cause the line

```
      clr.b       basic_flag(a6)
```

to be assembled if the variable BASIC has a non-zero value.

The statement part cannot contain a label field, but you may include a label before the IIF. For example

```
mary  IIF         John        equ         42
```

will set the value of the label mary to be 42 if the value of the label John is non-zero. If the expression evaluates to 0 then mary will have the value of the current program count as if the line

```
mary
```

had been included in the code. As a result it is generally not a good idea to use IIF to assign to variables, although it is suitable for ordinary program labels that are the targets of branch instructions.

IFD *label*
IFND *label*

These directives allow conditional control depending on whether a label is defined or not.

With IFD, assembly is switched on if the label is defined, whereas with IFND assembly is switched on if the label is not defined. These directives should be used with care otherwise different object code could be generated on pass 1 and pass 2 which will produce incorrect code and generate phasing errors. Both directives also work on reserved symbols.

IFC *"string1", "string2"*

This directive will compare two strings, each of which must be surrounded by single quotes. If they are identical then assembly is switched on, else it is switched off. The comparison is case-sensitive.

IFNC *"string1", "string2"*

This directive is similar to the above, but only switches assembly on if the strings are not identical. This may at first appear somewhat useless, but when one or both of the parameters are macro parameters it can be very useful, as shown in the next section.

ELSEIF
ELSE

This directive toggles conditional assembly from on to off, or vice versa. ELSE can be used instead of ELSEIF although ELSEIF is the traditional Devpac name for this directive.

ENDC

This directive will terminate the current level of conditional assembly. If there are more IFs than ENDCs an error will be reported at the end of the assembly.

Macro Operations

Gen fully supports extended Motorola-style macros, which together with conditional assembly allows you greatly to simplify assembly-language programming and the readability of your code.

A macro is a way for a programmer to specify a whole sequence of instructions or directives that are used together very frequently. A macro is first *defined*, then its name can be used in a *macro call* like a directive with up to 36 parameters.

label ***MACRO***

This starts a macro definition and causes Gen to copy all following lines to a macro buffer until an ENDM directive is encountered. Macro definitions may not be nested.

If the word MACRO is followed by .W or .L then when expanding the macro the program counter will be rounded up to an even boundary.

ENDM

This terminates the storing of a macro definition, after a MACRO directive.

MEXIT

This stops prematurely the current macro expansion and is best illustrated by the INC example given later.

NARG (reserved symbol)

This is not a directive but a reserved symbol. Its value is the number of parameters passed to the current macro, or 0 if used when not within any macro. If Gen is in case-sensitive mode then the name should be all upper-case. \# may be used as a synonym for ***NARG***.

Macro Parameters

Once a macro has been defined with the MACRO directive it can be invoked by using its name as a directive, followed by up to 36 parameters. In the macro itself the parameters may be referred to by using the backslash character (\) followed by an alpha-numeric (1-9,A-Z or a-z) which will be replaced with the relevant parameter when expanded or with nothing if no parameter was given. There is also the special macro parameter \0 which is the size appended to the macro call and defaults to W if none is given. If a macro parameter is to include spaces or commas then the parameter should be enclosed in between < and > symbols; in this case a > symbol may be included within the parameter by specifying >>.

A special form of macro expansion allows the conversion of a symbol to a decimal or hexadecimal sequence of digits, using the syntax \<symbol> or \<$symbol>, the latter denoting hex expansion. The symbol must be defined and absolute at the time of the expansion.

\? may be used to find the length of the text of a macro parameter; \?1 gives the length of the first parameter, etc. This mechanism is ideal for generating Pascal style length-prefixed strings.

The parameter \@ can be useful for generating unique labels with each macro call and is replaced when the macro is expanded by the sequence _nnn where nnn is a number which increases by one with every macro call. It may be expanded up to five digits for very large assemblies.

A true \ may be included in a macro definition by specifying \\.

The abbreviation \# is equivalent to NARG giving the number of parameters that have been passed to the macro.

A macro call may be spread over more than one line, particularly useful for macros with large numbers of parameters. This can be done by ending a macro call with a comma then starting the next line with an & followed by tabs or spaces then the continuation of the parameters.

In the assembly listing the default is to show just the macro call and not the code produced by it. However, macro expansion listings can be switched on and off using the OPT MEX and NOMEX options described previously.

Macro names are stored in a separate symbol table to normal symbols so will not clash with similarly-named routines, and may start with a period.

Macro Examples

Example I - Calling the BDOS

As the first example, the general GEMDOS calling-sequence for the BDOS is:

put a word parameter on the stack

invoke a TRAP #1

correct the stack afterwards

A macro to follow these specifications could be

```
gemdos      MACRO
            move.w      #\1,-(a7)   function
            trap        #1
            lea         \2(a7),a7   correct stack
            ENDM
```

The directives are in capitals only to make them stand out: they don't have to be. If you wanted to call this macro to use GEMDOS function `c_conout` (print a character) the code would be

```
            move.w      #'X',-(a7)
            gemdos      c_conout,4
```

When this macro call is expanded, `\1` is replaced with c_conout and `\2` is replaced with 4. `\0`, if it occurred in the macro, would be `W` as no size is given on the call. So the above call would be assembled as:

```
            move.w      #c_conout,-(a7)
            trap        #1
            lea         4(a7),a7
```

Example 2 - an INC instruction

The 68000 does not have the INC instruction of other processors, but the same effect can be achieved using an `ADDQ #1` instruction. A macro may be used to do this, like so:

```
inc         MACRO
            ifc         "','\r
            fail        missing parameter!
            MEXIT
            ENDC
            addq.\0       #1,\1
            ENDM
```

An example call would be

```
            inc.l       a0
```

which would expand to

```
            addq.l      #1,a0
```

The macro starts by comparing the first parameter with an empty string and causing an error message to be issued using `FAIL` if it is equal. The `MEXIT` directive is used to leave the macro without expanding the rest of it. Assuming there is a non-null parameter, the next line does the `ADDQ` instruction, using the `\0` parameter to get the correct size.

Example 3 - A Factorial Macro

Although unlikely actually to be used as it stands, this macro defines a label to be the factorial of a number. It shows how recursion can work in macros. Before showing the macro, it is

useful to examine how the same thing would be done in a high-level language such as Pascal.

```
function factor(n:integer):integer;
begin
            if n>0 then
                  factor:=n*factor(n-1)
            else
                  factor:=1
            end;
```

The macro definition for this uses the SET directive to do the multiplication n*(n-1)*(n-2) etc. in this way:

```
* parameter 1=label, parameter 2='n'
factor      MACRO
            IFND        \1
\1          set         1           set if not yet defined
            ENDC
            IFGT        \2
            factor      \1,\2-1     work out next level down
\1          set         \1*(\2)     n=n*factor(n-1)
            ENDC
            ENDM
*           a sample call
factor    test,3
```

The net result of the previous code is to set test to 3! (3 factorial). The reason the second SET has (\2) instead of just \2 is that the parameter will not normally be just a simple expression, but a list of numbers separated by minus signs.

So it could assemble to

```
test        set   test*5-1-1-1
```

(i.e. test*5-3) instead of the correct

```
test        set   test*(5-1-1-1)
```

(i.e. test*2).

Example 4 - Conditional Return Instruction

The 68000 lacks the conditional return instructions found on other processors, but macros can be defined to implement them using the \@ parameter. For example, a return if EQ macro could look like:

```
rtseq       MACRO
            bne.s \@
            rts
\@
            ENDM
```

The \@ parameter has been used to generate a unique label every time the macro is called, so will generate in this case labels such as _002 and _017.

Example 5 - Numeric Substitution

Suppose you have a constant containing the version number of your program and wish this to appear as ASCII in a message:

```
showname    MACRO
            dc.b  \1,'\<version>',0
            ENDM
            .
            .
version     equ   42
showname    <'real Ale Search Program v'>
```

will expand to the line

dc.b 'real Ale Search Program v','42',0

Note the way the string parameter is enclosed in <>s as it contains spaces.

Example 6 - Processor selection

Suppose you are writing a program that you intend to provide both ST and TT specific versions. Say you use the label PROC30 with value 1 to indicate that you are producing the 68030 version and with a value of 0 for the ST version then you could define macros like these:

```
*           An extb.l instruction if available
extbl       MACRO
            IFNE  PROC30
            opt   p=68030
            extb.l      \1
            ELSE
            opt   p=68000
            ext.W \1
            ext.l \1
            ENDC
            ENDM
*           Move 4 characters to memory using post decrement
            movel MACRO
            IFNE  PROC30
            move.l      #'\1\2\3\4',\5
            ELSE
            move.b      #'\1',\5
            move.b      #'\2',\5
            move.b      #'\3',\5
            move.b      #'\4',\5
            ENDC
            ENDM
```

Then an appropriate call would be:

```
            extbl       d0
```

which would expand to

```
            extb.l      d0
```

or

```
            ext.w       d0
            ext.l       d0
```

and

```
            movel       F,R,E,D,(a0)+
```

would expand to

```
            move.l      #'FRED',(a0)+
```

or

```
            move.b      #'F',(a0)+
            move.b      #'R',(a0)+
            move.b      #'E',(a0)+
            move.b      #'D',(a0)+
```

Example 7 - Complex Macro Call

Suppose you program needs a complicated table structure which can have a varying number of fields. A macro can be written to only use those parameters that are specified, for example:

```
tbl_entry   MACRO
            dc.b  .end\@-*    length byte
            dc.b  \1          always
            IFNC  '\2',''
            dc.w  \2,\3       2nd and 3rd together
            ENDC
            dc.l  \4,\5,\6,\7
            IFNC  ' \8',"
            dc.b  '\8'        text
            ENDC
            dc.b  \9
.end\@      dc.b  0
            ENDM
* sample call
            tbl_entry   $42,,,t1,t2,t3,t4,
&                       <Enter name:>,%0110
```

This is a non-trivial example of how macros can make a programmer's life much easier when dealing with complex data structures. In this case the table consists of a length byte, calculated in the macro using \@, two optional words, four longs, an optional string, a byte, then a zero byte. Note the use of the macro continuation character &.

The code produced in this example would be

```
            dc.b  .end_001
            dc.b  $42
            dc.l  t1,t2,t3,t4
            dc.b  'Enter name:'
            dc.b  %0110
.end_001    dc.b  0
```

Output File Directives

This section details those directives whose actions depend on the output file format chosen. The file format itself can be selected by one of the following methods: command line options using GEN.TTP; using the appropriate pop-up menu of the *Assembler options - Control* dialog box from the editor; or with the OPT directive at the beginning of the source file.

As the use of these directives differs from format to format, they are discussed separately for each format.

Atari Executable (ATARI, L0)

This is the native TOS executable format, and supports three sections; TEXT, DATA and BSS. The operating system forces no special requirements on the division between the TEXT and DATA sections, except that execution starts at the beginning of the TEXT section. The BSS section is guaranteed to be initialised to zero and occupies no disk space.

Programs do not know where in memory they will be loaded, so the file supports load-time relocation; all relocatable references are fixed up when the program is loaded. One section may refer to a part of another with PC-relative addressing, as well as absolute (really relocatable) addressing, although on the 68000 processor you are subject to the 32K limit of the chip for PC-relative addressing.

To allow debugging there is a standard symbol table format that can be included within the executable file, which is ignored by the normal program loader. Unfortunately this format restricts symbols to 8 characters, so the HiSoft extended debug format was created which extended the basic idea to allow up to 22 characters of symbols to be defined.

In addition Devpac 3 supports the idea of a debug section attached to your program; in addition to Devpac 3 the following products (at the time of writing) as support this extension: Lattice C, HiSoft BASIC 2, Highspeed Pascal 1.6. These enable the debugger to find the program counter corresponding to a source line and vice versa.

Filename extensions can be .PRG (default), .TOS, .TTP, .ACC, .APP and .GTP; the extension determines the different uses of the program file.

SECTION *name*

Switches to the given section, name must be TEXT, DATA or BSS and is not case sensitive. All the code in the TEXT segment will be output together, followed by all the code (or data) in the DATA section. The BSS section may only be used for DS directives. You can use this so that your variables can be defined near the code that uses them rather than altogether at the end of the file. For example:

```
            SECTION     BSS
var1        ds.l        1
            SECTION     TEXT
text        moveq       #0,d0
            move.l      d0,var1(a6)
```

This code fragment relies on the fact that the register a6 has been set up to point to the start of the BSS area. This is achieved using the information in the program's base-page; see the examples on disk.

OPT DEBUG

The first 8 characters only of all relative labels are written to the file and will be upper-cased if Gen is in case-insensitive mode. The 8-character limit is due to the DRI standard file format and may be improved on by using the `XDEBUG` option, described below.

OPT XDEBUG

This is a special version of the DEBUG option which uses the HiSoft extended debug format to generate debugging information with symbols of up to 22 character significance.

OPT LINE

Causes a LINE debug section to be attached to the executable; note that this option considerably increases the size of executable files, requiring 8 bytes are required for each line that generates code.

OPT HCLN

Causes a HCLN (HiSoft Compressed Line Numbers) debug section to be attached to the executable. This provide the same information as a LINE section but requires, on average, only 2 bytes of extra information per line that generates code.

COMMENT HEAD=*expression*

This allows the program load longword in the file header to be set to any particular value; the default is zero. `HEAD` *must* be in upper-case.

The currently defined bits are:

0	Fast load; the whole TPA area past the end of the BSS is not zeroed. This results in reduced loading times on large memory machines, for those programs that are compatible with it.
1	Alternative RAM load; the program will be loaded into alternative RAM if there is enough alternative RAM available.
2	Alternative RAM `m_alloc`; `m_alloc` calls will be satisfied with alternative RAM if possible.
28-31	The program's TPA size field as a multiple of 128K bytes. When bit 1 is set and this field is zero the program will be loaded into alternative RAM if there is enough room for its CODE, DATA and BSS and 128K of RAM. If you would like your program to have at least 256K of TPA in addition to the CODE, DATA and BSS, then make this field one and then if there is insufficient alternative RAM but enough system RAM then your program will load there. In this case you might well use `COMMENT HEAD=$1000007`

Programs that keep their stack in the `BSS` section and use `m_alloc` or `m_xalloc` calls for dynamic memory can usually use:

```
COMMENT HEAD=7
```

to give the fastest possible load and execution times. This is the case for most of the tools in Devpac with the notable except for the auto-resident version of Mon which stores its screen in its TPA and so *must* be loaded into system RAM.

TEXT
CODE
DATA
BSS

These are synonyms for `SECTION TEXT`, `SECTION TEXT`, `SECTION DATA` and `SECTION BSS` respectively.

ORG *expression*

This will make the assembler generate position-dependent code and set the program counter to the given value. Normal GEMDOS programs do not need an `ORG` statement even if position-dependent. It is included to allow code to be generated for the ROM port or for other 68000 machines. More than one `ORG` statement is allowed in a source file but no padding of the file is done.

`ORG` should be used with great care as the binary file generated will probably not execute correctly when double-clicked, as no relocation information is written out. The binary file produced has the standard GEMDOS header at the front, but no relocation information.

This directive is very unlikely to make sense when assembling to memory.

RORG *expression*

This directive changes the program counter to the specified number of bytes from the start of the current section. Note that the value specified *must be greater than* the current PC and the file will be padded with zeroes to the approrpiate location.

GST Linkable (GST, L1)

This format was originally created for the Sinclair QL, but became popular on the ST and is supported by a wide range of European programming tools. The format is an extremely flexible linkable format, although its lack of word-alignment within the file structure can be a source of reduced performance in linkers, for example.

The file format supports up to 32767 sections with up to 32767 symbols per section. Symbols and section names may be up to 32 characters long.

Libraries in GST format are simply a concatenation of multiple .BIN files, though there are some unofficial extensions to this standard. Gen is capable of generating library files from a single source file using the `MODULE` directive.

Symbol imports are particularly flexible; any number of imports may be used within an expression, which can be byte, word or long, PC relative or absolute. Only + and - operators are permitted between imports.

The normal extension for GST files is .BIN.

MODULE *name*

Gen supports multiple modules per source file; this means complete libraries may be built from a single source file, without resorting to multiple assemblies or librarian usage. The use of the `MODULE` directive effectively switches to a different environment for the assembler, with a new symbol table, except that absolute symbols are global (i.e. can be seen by all modules). The default module name is the main input filename with any path specification removed.

SECTION *name*

There are no restrictions on name, except that it is significant to the first 32 characters. Code with the same section name will be merged together by the linker.

XDEF *symbol*

Symbols defined within the current module may be exported using `XDEF`; the symbols type (relative or absolute) will also be exported.

XREF *symbol*
XREF.L *symbol*

Symbols may be imported from other files using `XREF`; normally imported symbols are treated as relocatable quantities like ordinary subroutine labels. If the `.L` form is used, then the symbol is treated as an absolute quantity. The assembler needs this information in order to generate the correct fixup information.

COMMENT *string*

This inserts the comment into the output file which may be displayed by some linkers; some librarians may have particular uses for this, such as storing date information.

OPT *DEBUG*

This has the effect of declaring all relative (non-local) symbols within the current module as exports. Care should be taken as misuse of this option can create multiple symbols with the same name (e.g. loop).

TEXT
CODE
DATA
BSS

These are synonyms for `SECTION TEXT`, `SECTION TEXT`, `SECTION DATA` and `SECTION BSS` respectively.

ORG *expression*

This will make the assembler generate position-dependent code and set the program counter to the given value. Normal GEMDOS programs do not need an `ORG` statement even if position-dependent. It is included to allow code to be generated for the ROM port or for other 68000 machines. More than one `ORG` statement is allowed in a source file as this sends the `ORG` directive to the linker which will pad the file with zeroes to the given address.

RORG *expression*

This directive changes the program counter to the specified number of bytes from the start of

the current section. Note that the value specified must be greater than *or less than* the current PC. Unlike the other formats this does not pad the output file, although the linker may perform this operation to adhere to the requirements implied by the directive.

Expressions containing imports

Imports may be used in expressions, with up to ten per expression. They may only be added or subtracted from each other though can be combined with arbitrarily complex expressions, so long as the complex expression lexically precedes it, for example:

```
move.l      3+(1«count+5)+import1-import2
```

There are a number of different sorts of possible imports as shown below:

Name	Example	
PC-byte	`move.w`	`import(pc,d3.w)`
	`bsr.s`	`import`
PC-word	`move.w`	`import(pc),a0`
	`bsr`	`import`
byte	`move.b`	`#import,d0`
word	`move.w`	`import(a3),d0`
long	`move.l`	`import,d0`

Note that a reference to a symbol in a different section is regarded as an import and subject to the above rules.

Writing GST Libraries

When using multiple `MODULE`s to generate a GST format library file care must be taken with backward references to imports. Within a library file, higher level routines should be first, lower level routines last. For example the source file skeleton shown below will not link when used as a selective library.

```
            MODULE      low_level
            XDEF  low_output
low_output
            …
            MODULE      high_level
            XDEF  high_output
            XREF  low_output
high_output
            …
```

This is because the second module references a label defined in an earlier module, which is not allowed. The corrected version is:

```
            MODULE      high_level
            XDEF  high_output
            XREF  low_output
high_output
            …
            MODULE      low_level
            XDEF  lowoutput
```

```
low_output
            …
```

DRI Linkable (DRI, L2)

This format is based on the CP/M 68k original and was used by the original Atari development kit, as well as some programming tools of American and German origin; it is also the format used by Highspeed Pascal. It is a very inflexible format but easy to read and write.

The format supports the standard Atari sections of TEXT, DATA and BSS. Symbols are only significant to 8 characters.

Inter-section references within the same file may only be absolute and no byte-sized PC references are allowed to imports or other sections.

Symbol imports may only be of the form symbol ± constant.

The normal extension for DRI files is .O.

SECTION *name*

The only permitted names are TEXT, DATA and BSS.

XDEF *symbol*

All symbols will be truncated (without warning) to 8 characters before being exported. OPT C8 is therefore recommended.

XREF *symbol*
XREF.L *symbol*

This defines labels to be imported from other programs or modules. If any of the labels specified are defined an error will occur. The normal XREF statement should be used to import a relative label (i.e. program reference), while XREF.L should be used to import absolute labels (i.e. constants). Importing a label more than once will not produce an error.

The DRI format does not actually *need* to know the type of imports but it is recommended that both forms of XREF are used to allow the assembler to type check.

COMMENT *string*

This directive is ignored unless it is the single word PASCAL, which is used to tell Gen to output the special file format Personal Pascal uses; it is not required with Highspeed Pascal. You should declare your functions and/or procedures using the XDEF directive and their names must be in upper case. Your code should be in the TEXT section and we recommended placing any global variables in the BSS section. Do not try to use the DATA section - this seems to confuse the Personal Pascal linker.

OPT *DEBUG*

Normally only those labels declared as XDEF will be exported within the file. However this option forces all relative symbols to be exported as what are known as local symbols (not to be confused with Gen local symbols) which will not be visible to the linker, but will be included in the final debug area.

TEXT
CODE
DATA
BSS

These are synonyms for `SECTION TEXT`, `SECTION TEXT`, `SECTION DATA` and `SECTION BSS` respectively.

RORG *expression*

This directive changes the program counter to the specified number of bytes from the start of the current section. Note that the value specified *must be greater than* the current PC and the file will be padded with zeroes to the approrpiate location.

Using Imports in Expressions

Imports may be used in expressions but only one import per expression is allowed. The result of an expression with an import in must be of the form import + number or import - number. Imports can be combined with arbitrarily complex expressions, so long as the complex expression lexically precedes it. For example

```
move.l      3+(1<<count+5)+import
```

There are a number of different sorts of possible imports as shown below:

Name	Example	
PC-word	move.w	import(pc),a0
	bsr	import
word	move.w	import(a3),d0
long	move.l	import,do

Note that byte-sized relocation is not supported. PC-word access is also not allowed for references between sections in the same program.

Motorola S-records (SREC, 16)

S-records are a standard way of transferring binary images between machines, using 7-bit ASCII codes only. It is particularly useful for uploading data to EPROM programmers.

The S-record file produced by the assembler is of the following format:

```
S0          module name
<for each section>
S1/2/3      data
S9/8/7      execute address
```

The file may be split into low and high bytes (or 4 if generating code for machines with 32-bit buses) if required by the use of the SRSplit utility, described in Chapter 6.

`S1/S2/S3` records are produced for the data according to whether the address is a 16, 24 or 32 bit value respectively. Up to 28 data bytes per line are generated. The execute address is taken as the first

ORG in the program, with an S9/S8/S7 as appropriate to the value.

The individual S-records contain 5 fields, mostly in the form of ASCII hex bytes as follows:

type	(2 bytes) Sx where x is the type of the record (as above)
count	(2 bytes) The number of address, data and checksum bytes remaining on this line
address	(4,6 or 8 bytes) the address of this data
data	(varies) the actual data, upper-case hex (2 for each byte)
checksum	(2 bytes) checksum of everything (taken as bytes) except the type

The default extension is .MX.

SECTION *name[,offset]*

If offset is specified then the section will be assembled to run at the address specified in the following ORG (as normal) but the addresses contained within the S-records themselves will start at the offset address. This is useful for writeable data areas that will initially be in EPROM and are copied into RAM at startup, or for the situation where a PROM programmer requires the data to be uploaded to a particular address.

TEXT
CODE
DATA
BSS

These are synonyms for SECTION TEXT; SECTION CODE; SECTION DATA and SECTION BSS respectively.

ORG *address*

Should always follow a SECTION directive. The first ORG in a non-BSS section is taken as the execute address. Using more than one ORG per section is at your own risk; it is your responsibility to put the code in the correct place if you intend executing it.

Lattice C linkable (LATTICE, 17)

This is the format that was introduced by Lattice C 5 for the ST; it is also used by HiSoft BASIC 2.

The format supports an unlimited number of sections, of general types CODE, DATA and BSS. BSS sections are placed together in the final executable file as one zeroed BSS section by the supplied linker, CLink. There are no limits on the length of sections or symbols. To produce libraries you require the librarian supplied with Lattice C, OML.

Although it is not quite as flexible as the GST format in that multiple externals are not allowed in a single expression, it does have the unique feature of support for base relative symbols as described below.

The normal extension for Lattice C files is .O

MODULE *name*
IDNT *string*

This sets the name of the module. Such names may be up to 32 characters long.

SECTION *name[,rtype]*

There are no restrictions on name and the optional type may be one of the following (in upper or lower case):

CODE	code section
DATA	data section
BSS	BSS section

The default type is CODE. Data and BSS sections that are called __MERGED are treated specially by the linker; the __MERGED data section is placed as the last section in the data section and the __MERGED BSS section as the first BSS section. This, coupled with the CLink reserved symbol __LinkerDB, enables both initialised and uninitialised data references to be made via a single global address register. See the CLink section for more details. Do not use __MERGED as the name of a CODE section.

Note that sections with the same name are not merged together; only the type of the section is important (with the exception of __MERGED, of course).

CSECT *name[,type]*

This is a subset of the Lattice C assembler CSECT directive. It is equivalent to the appropriate SECTION directive except that type is a number as follows:

0	CODE
1	DATA
2	BSS

Note that whilst Gen does not support the extra parameters of the Lattice assembler, it does allow CSECT to be used more than once for the same section name, although you should remember that the linker will not merge such sections together.

XDEF *symbol*

Symbols defined may be exported using XDEF; the symbols type (relative or absolute) will also be exported.

XREF *symbol*
XREF.L *symbol*

This defines labels to be imported from other programs or modules. If any of the labels specified are defined an error will occur. The normal XREF statement should be used to import a relative label (i.e. program reference), while XREF.L should be used to import absolute labels (i.e. constants). Importing a label more than once will not produce an error.

The Lattice format does not actually *need* to know the type of imports but it is recommended

that both forms of XREF are used to allow the assembler to type check.

OPT DEBUG

This places all relative (non-local) symbols into special symbol sections which will be included in the symbol section created by the linker.

OPT XDEBUG

This will only place those symbols declared with XDEF into symbol sections.

OPT LINE

Causes a LINE debug hunk to be written to the linkable file. This is the format that is supported by Lattice C and by CLink. If an error occurs when linking CLink will report the appropriate line number. This considerably increases the size of executable files however. 8 bytes are required for each line that generates code.

OPT HCLN

Causes a HCLN (HiSoft Compressed Line Numbers) debug hunk to be written to the linkable file. This provide the same information as a LINE section but requires, on average, only 2 bytes of extra information per line that generates code.

TEXT
CODE
DATA
BSS

These are synonyms for `SECTION TEXT, CODE; SECTION CODE,CODE;SECTION DATA,DATA` and `SECTION BSS,BSS` respectively.

RORG *expression*

This directive changes the program counter to the specified number of bytes from the start of the current section. Note that the value specified *must be greater than* the current PC and the file will be padded with zeroes to the approrpiate location.

Using Imports in Expressions

Only one import may be used in each expression; however, they may be added to an arbitrarily complex expression, so long as this lexically precedes it, for example:

```
move.l      3+(1«count+5)+import
```

There are a number of different sorts of possible imports as shown below:

Name	Example	
PC-byte	`move.w`	`import(pc,d3.w)`
	`bsr.s`	`import`
PC-word	`move.w`	`import(pc),a0`
	`bsr`	`import`
byte	`move.b`	`#import,d0`
word	`move.w`	`import(a3),d0`

long	`move.l`	`import,d0`
word base relative	`move.l`	`import(a4)`
long base relative	`move.l`	`import(a4,d0),d0`

Note that a reference to a symbol in a different section is regarded as an import and subject to the above rules, except that PC-relative inter-section references are not supported.

The base-relative facilities allow references to imports and other sections to be word offsets, to allow such things as:

```
move.l   _symbol(a4),d0
```

where _symbOl is a *relative* import, which, strictly speaking, is nonsense. However this is converted to:

```
move.l   _symbol- LinkerDB(a4),d0
```

__LinkerDB is a symbol created by the linker. See the CLink section for further details of the memory map.

Directive Summary

Assembly Control

`CNOP`	align PC arbitrarily
`DC`	define constant
`DCB`	define constant block
`DS`	define space
`END`	terminate source code
`EVEN`	ensure PC even
`FAIL`	force assembly error
`INCBIN`	read binary file from disk
`INCLUDE`	read source file from disk
`OPT`	option control
`RADIX`	set number base

Repeat Loops

`ENDR`	end repeat block
`REPT`	start repeat block

Listing Control

`FORMAT`	define listing format
`LIST`	enable listing
`LISTCHAR`	send control character
`LLEN`	set line length
`NOLI ST`	disable listing
`PAGE`	start new page
`PLEN`	set page length
`SUBTTL`	set sub-title
`TTL`	set title

Label Directives

CARGS	define parameter labels
EQU	define label value
EQUENV	define label from environment variables
EQUR	define register equate
OFFSET	define offset table
REG	define register list
RS	reserve space
RSRESET	reset RS counter
RSSET	set RS counter
SET	define label value temporarily

Floating Point Directives

FEQU	define floating point constant
FOPT	floating point options

Conditional Assembly

ELSE IF	switch assembly state
ENDC	end conditional
IFC	assemble if strings same
IFD	assemble if label defined
IFEQ	assemble if zero
IFGE	assemble if greater than or equal to
IFGT	assemble if greater than
IFLE	assemble if less than or equal to
IFLT	assemble if less than
IFNC	assemble if strings different
IFND	assemble if label not defined
IFNE	assemble if non-zero
IIF	immediate IF

Macros

EN DM	end macro definition
MACRO	define macro

Output File Directives

BSS	
CODE	
COMMENT	send linker comment
CSECT	Lattice C switch section directive
DATA	
IDNT	Lattice C synonym for MODULE
MODULE	set module name
ORG	set absolute code generation
SECTION	switch section
TEXT	abbreviated section commands
XDEF	define label for export
XREF	define label for import

Reserved Symbols

NARG	number of macro parameters
__G2	internal version number

__LK	output file type
__RS	RS counter

Chapter 4 - The Debugger

Introduction

Programs written in assembly language are particularly error-prone; even a slight coding mistake can result in the entire machine crashing since you are programming at such a low level.

These programming mistakes (known as *bugs*, after a spider that was found crawling around the core memory of one of the early computers) can range from the trivial, such as a missing CR in a printout, through the usual (an incorrect result) to the very serious where the computer crashes because you have used the wrong register or corrupted the system memory (like that spider).

To help you find and correct all forms of bugs, Devpac includes a debugger, Mon. Mon is a powerful symbolic debugger and disassembler which lets you examine programs and memory, execute programs an instruction at a time and trap processor exceptions caused by programmer error.

Although Mon is a *low-level* debugger, displaying such things as 680x0 instructions and registers, it can also be used for debugging programs written with any compiler that generates machine-code output. If the compiler has the option to output the symbols into the executable file then you will see your procedure and function names within the code; you can even view your original source code and step through it, if the package that produced the code has line number debug support.

As Mon uses its own screen memory, the display of your program is not destroyed when you single-step or breakpoint, making it particularly useful for graphical-output programs such as GEM applications or games. It also uses its own screen drivers so it is possible to single-step into the operating system screen routines such as the AES or BIOS without affecting the debugger.

Mon Concepts

Here is a swift look at the concepts behind Mon; it is a good idea to read this section before moving on to the next sections, even if you are an experienced programmer.

Exceptions

Mon employs the 680x0 processor *exceptions* to stop runaway programs and to single-step, so at this point it would be useful to explain them and detail what normally happens when they occur under TOS.

While using the 680x0 processors, there are various types of exception that can occur, some deliberately, others accidentally. An exception is a special condition that takes priority over normal processing - it might be an interrupt from an external device, an illegal instruction, an address error, a co-processor violation or a number of other pre-defined events.

When an exception occurs the processor's context is saved on the supervisor stack and

execution is then transferred to any one of 256 different addresses, held in the *exception table* (on the 68010 upwards, the address of the start of this table is held in the *vector base register*, or *VBR).* When Mon is active it re-directs some of these exceptions so it can take control when they occur. The various forms of exceptions, their usual results, and what happens when they occur with Mon active is shown in the following table:

The various forms of exceptions, their usual results, and what happens when they occur with Mon active is shown in the following table, which is a summary of the exception table. Note that the first 64 vectors are defined by Motorola:

Number	Exception	Mon active
0	reset stack pointer	not trapped
1	reset program counter	not trapped
2	bus error	trapped
3	address error	trapped
4	illegal instruction	breakpoint
5	zero divide	trapped
6	CHK instruction	trapped
7	TRAPV instruction	trapped
8	privilege violation	trapped
9	trace	single-step
10	line 1010 emulator	VDI support
11	line 1111 emulator	trapped
12	reserved	trapped
13	co-processor protocol violation	trapped
14	format error	trapped
16-23	reserved	trapped
24	spurious interrupt	trapped
25-31	level x interrupt autovector, where x=26-exception no.	not trapped
32	trap #0	trapped
33	trap #1	GEMDOS call
34	trap #2	AES/VDI call
35-44	trap #3-#12	trapped
45	trap #13	XBIOS call
46	trap #14	BIOS call
47	trap #15	trapped
48	FPCP branch or set on unordered condition	trapped
49	FPCP inexact result	trapped
50	FPCP divide by zero	trapped
51	FPCP underflow	trapped
52	FPCP operand error	trapped
53	FPCP overflow	trapped
54	FPCP signalling NAN	trapped
55	reserved	trapped
56	MMU configuration error	trapped
57	68851 illegal operation	trapped
58	68851 access level violation	trapped

59-63	reserved	trapped
64-255	user defined vectors	not trapped

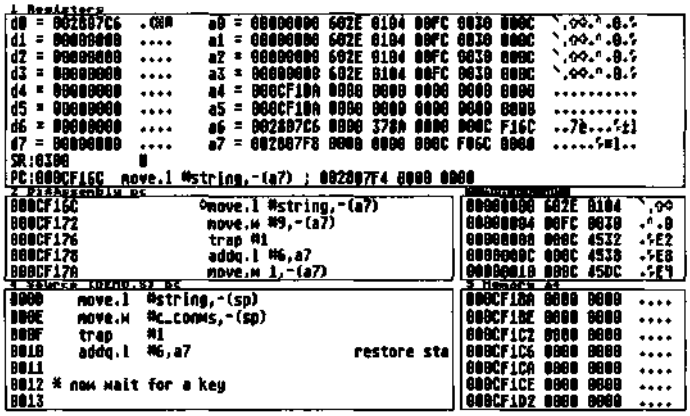
The causes of the above exceptions (and how best to recover from them) are given at the end of this section.

Front Panel Display

When Mon is invoked it displays a *Front Panel* showing registers, memory, source code and instructions. The name Front Panel stems from the type of panels that were mounted on mainframe and mini computers to provide information on the state of the machine at a particular moment, usually through the use of flashing lights. These lights represent whether or not particular flip-flops (electronic switches) within the computer are open or closed; the flip-flops that are chosen to be shown on this panel are normally those that make up the internal registers and flags of the computer thus enabling programmers and engineers to observe what the computer is doing when running a program.

These were *hardware* front panel displays; what Mon provides you with is a *software* front panel - the code within Mon works out the state of the computer and then displays this information on the screen.

The Mon display consists of a number of windows through which you can view the 680x0 registers, a disassembly of your program, your program's source code or a portion of memory - you choose what you want in each window (within certain limitations). The layout of Mon's front panel is shown below:



Mon's front panel

Mon's Windows

As we have said, there are four different types of view through a window:

a *register* window in which you can see the various 680x0 data and address registers, the program counter (PC), the status register (SR) and the current instruction. The values of the data and address registers are shown in hexadecimal together with some information about the locations to which the registers point.

a *disassembly* window which shows a 680x0 disassembly of the memory that it is addressing, including any symbols that are found.

a *memory* window which displays the contents of memory locations in hexadecimal and ASCII.

a *source code* window. In this type of window you can view a text file which may be the source code of the program that you are debugging, assuming that this exists. You can display line numbers if you wish and, if the program that owns the source code has line number information attached to it, you will be able to use this information to step through the program's source code and set breakpoints on source lines.

Up to five windows can be shown simultaneously or, by changing the width and height of the windows you, can show just two.

Each window is numbered from 1 to 5 and can display different types of information - window 1 can be of any type, register, memory, source code or disassembly; windows 2 and 4 can be memory, disassembly or source code windows whilst windows 3 and 5 are restricted to being memory windows.

Stacking Windows

Each window also has depth - you can stack views beneath a window so that you have almost limitless flexibility in what you choose to display.

In addition you can *split* and *widen* most windows; split means to grow or to shrink the window vertically whilst widen means to do the same horizontally. These operations may hide other windows temporarily or they may uncover hidden windows.

Locking Windows

Each window may also be locked to an arbitrary expression. Thus, you can lock a memory window to a register so that it displays the contents of the memory addressed by that register. Or you might want to lock a disassembly window to the PC, which is the default condition for window 2 unless you have saved.

Each view on the window stack can be locked to a different expression although it does not make sense to lock the register window.

All the above window features will be discussed in more detail later.

The Current Window

Mon has the concept of a *current window* - this is denoted by displaying its title highlighted and is the window on which any operation will take place.

The current window may be changed by pressing the Tab key to cycle between them, or by pressing the Alt- key together with the window number, for example Alt-2 selects window number 2, even if it is hidden currently.

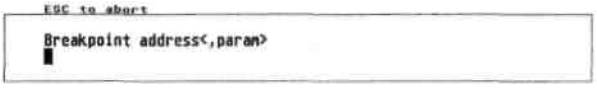
Symbolic Debugging

A major feature of Mon is its ability to use symbols taken from the original program whilst debugging. Mon uses the standard executable symbol section as produced by most Atari programs that produce executable files, such as linkers, compilers and Gen.

Mon can also accept line number information from various different types of line debug information attached to the program, which enables the debugger to handle source code files that are connected with the program being debugged on a line basis. If the program to be debugged contains this line number information, you will be able to set breakpoints in its source code and even single-step it, source line by source line. Products that support this, currently, are: Devpac 3, HiSoft BASIC 2 and Lattice C 5.5.

Mon Dialogs

Mon makes extensive use of dialogs which are similar in concept to those in GEM programs but have several differences.



a Mon dialog

A Mon dialog displays the prompt `ESC to abort` above the top left corner of the box together with a prompt, normally followed by a blank line or some text to edit, with a cursor. At any time a dialog may be exited by pressing Esc, or data may be entered at the cursor by normal typing. Various keys may be used to edit the text:

←,→	move the cursor left or right through the text
Shift-→, Shift-→	move the cursor to the start of the line or to the end of the line
Backspace	delete the character behind the cursor
Del	delete the character under the cursor
Alt-X	delete the entire line
Esc	abandon the dialog

commands available within Mon dialogs

When you have finished entering a line, press the Return key; if the line contains errors the screen will flash and the Return key will be ignored allowing correction of the data before pressing Return again.

Some Mon dialogs simply display a message together with the prompt Return; these are normally used to inform you of some form of error. The box will disappear on pressing the Return or Esc keys, whichever *you* find more convenient.

Command Input

Mon is controlled by single-key commands which gives a fast user-interface, although this can take getting used to if you are familiar with a line-oriented command interface of another debugger. Users of HiSoft Devpac on other machines such as the Commodore Amiga will find many commands are identical.

In general the Alt- key is the window key - when used in conjunction with other keys it acts on the *current window.* The Control key is usually used to invoke commands connected with

execution of the program that is being debugged.

Commands may be entered in either upper or lower case. Those commands whose effects are potentially disastrous require the Control key to be pressed in addition to a command key. The keys used were chosen to be easy to remember, wherever possible. Commands take effect immediately - there is no need to press Return and invalid commands are simply ignored. The relevant sections of the front panel display are updated after each command so any effects can be seen immediately.

Mon is a powerful and sometimes complex program and we realise that it is unlikely that many users will use every single command. For this reason the remainder of the Mon manual is divided into two sections - the former is an introduction to the basic commands of the program, while the latter is a full reference section. It is possible for new users and beginners to use the debugger effectively while having only read the *Overview;* but don't be intimidated by the *Reference* section.

Mon Overview

Starting Mon

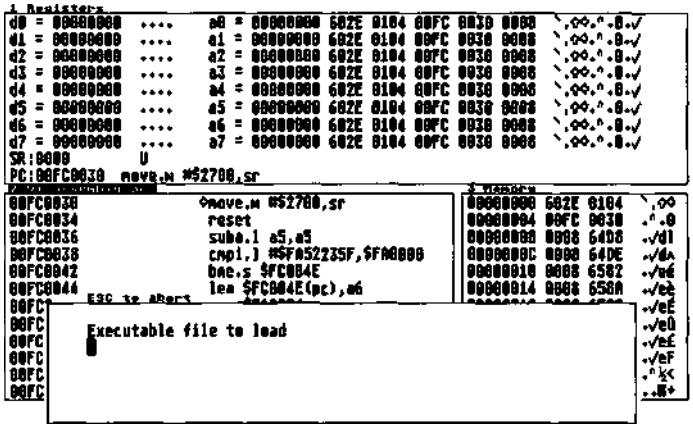
Mon is invoked by double clicking on MON.PRG from the desktop, or by calling it from the Devpac editor.

If you start Mon from a CLI you can include, optionally, a program name and a command line to be passed to the program. For example,

```
mon mytest examples\demo.s  [Return]
```

will cause Mon to be invoked which will load a program called mytest and pass a filename to this program.

When Mon has loaded, the screen will look like this:



The Mon initial screen

If you started Mon without asking for a program to be loaded, the prompt `Executable file to load` will appear. This gives you another chance to load a program to debug; either type the filename of the program that you want to investigate and hit Return or press Return by itself (or Esc) to quit the dialog.

Should Mon have been called from the Devpac editor, the program that you are developing will be loaded automatically or used from memory, if it was assembled there.

Debugging a Program

If you have asked Mon to load a program to debug you may now be prompted for a command line, if you haven't already given one; enter the line you want or just press Return. Mon will then try to load the program. If it fails, it will display an appropriate error message.

You can use the *Load Program* command to try to load the program again.

Assuming the filename is valid, Mon will load the symbol table from the file and any line number information for the first source file, together with the first source file before loading the executable. After the file and its symbols have been loaded successfully, the message

```
Breakpoint
```

will appear; this is because Mon places a breakpoint at the first instruction of the program and then executes it.

The most common command in Mon is probably *single-step*, obtained by pressing Control-Z (or Control-Y if you find it more convenient, perhaps because you have a German keyboard). This will execute the instruction at the PC, shown in the Register window and, normally, also in the Disassembly window. After executing it the debugger re-displays the values of the windows, so you can watch the processor execute your program, step by step. Single-stepping is the best way of going through sections of code that are suspect and require deeper investigation, but it is also the slowest - you may only be interested in a section of code near the end of your program which could take a long tome to reach if you have to single-step all the way. There is, of course, an answer.

A *breakpoint* is a special instruction placed into your program to stop it running and enter Mon. There are many types of breakpoint but we will restrict ourselves to the simplest for now. A breakpoint may be set by pressing Alt-B, then entering the address you wish to place the breakpoint. You can enter addresses in Mon in hex (the default base), as a symbol, or as a complex expression. Examples of valid addresses are `1A2B0`, `prog_start`, `10+mydata`. If you type in an invalid address the screen will flash and allow you to correct the expression.

Having set a breakpoint you need some way of letting your program actually *run*, and Control-R will do this. If will execute your program using the values of the registers displayed and starting from the PC. Mon will be re-entered if a breakpoint has been hit, or if an exception occurs.

Mon uses its own *screen display* which is independent from your program's. If you press the V key you will see your current program's display, pressing another key switches you back to Mon. This allows you to debug programs without disturbing their output at all.

Mon uses its own *windows* too, and any window may be *zoomed* to the full screen size by pressing Alt-Z. To return to the main display press Alt-Z again, or the Esc key. The Esc key is also the best way of getting out of anything you may have invoked by accident. The Zoom command, like all Alt- commands, works on the *current window* which you can change by pressing Tab. You can dump the current window to your *printer* by pressing Alt-P.

To change the *address* from which a window displays its data, press Alt-A, then enter the new address. The locking of a window to an expression is detailed in the *Reference* section.

To *quit* Mon press Control-C. Strange as it may sound this will not always work - what

Control-C does is terminate the *current program,* which may be Mon or, more likely, the program you are debugging. You know when you have terminated the program under investigation because it will say so in the lower window. Once your program has been terminated, pressing Control-C will terminate Mon. If you used the Debug option from the editor then Control-C will always terminate Mon as well as your program.

We hope this overview has given you a good idea of the most common features of Mon to let you get on with the complex process of writing and debugging assembly language programs. When you feel more confident you should try and read the *Reference* section, probably best taken, like all medicine, in small doses.

Mon Reference

This is the reference section to Mon; it is a complete description of the features and commands of this powerful debugger.

Numeric Expressions

There are many occasions within Mon when you will want to enter a numeric expression; perhaps to lock a window to an expression, to assign a value to a register or to set the start address of a window.

For these cases, Mon has a full expression evaluator, based on that in Gen, including operator precedence. The main differences are that the default base is hexadecimal (decimal may be denoted with a \ sign *not* # as in Mon version 1), there is no concept of a *type* of an expression (relative or absolute), * is used *only* for multiplication, there are two source operators (# and ?).

The precedence table for Mon's operators is given below:

Precedence	Operator
1	unary minus (-) and plus (+), source operators (# and ?)
2	bitwise not (-)
3	shift left («) and shift right (»)
4	bitwise And (&), Or (!) and Xor (^)
5	multiply (*) and divide (/)
6	addition (+) and subtraction (-)
7	equality (=), less than (<), greater than (>), inequality (<> and ! =), less than or equals (<=), greater than or equals (>=)

Symbols may be referred to and are normally case-insensitive and significant to 22 characters although this can be changed with the Mon *Preferences* command.

Registers may be referred to simply by name, such as `A3` or `d7` (case insensitive), but this causes a clash with certain hex numbers. To obtain such hex numbers precede them with either a leading zero or a `$` sign. `A7` refers to the *user* stack pointer. In addition you can access the `SR`, `SSP`, `SFC`, `DFC`, `CACR`, `CAAR`, `VBR`, `MSP`, `ISP`, `MMUSR`, `TTO`, `TT1`, `TC`, `FPCR`, `FPSR`, and `FPIAR` (on those processors on which they are present!). Note that the `CRP`, `SRP` cannot be used in expressions since they are 64 bits long.

There are several reserved symbols which are case insensitive, namely TEXT, DATA, BSS, END, SP. END refers to one byte past the end of the BSS section and SP refers to either the user- or supervisor-stack, depending on the current value of the status register.

Source Operators

There are two operators which allow debugging at a source code level; these are the # and ? operators.

To use these operators, you must have a source window open which is associated with the loaded executable program. In turn, this loaded program must have been produced by a package that attaches line number information to the program. Otherwise the # and ? operators are invalid.

The # operator takes a source line number as its argument and returns the associated memory address, within the loaded program. So, say you have the source of hello.s loaded into window 2 and the executable of hello loaded as the current program then:

m3=#20

will set the start address of window 3 to the address of line number 20 of the hello program (assuming that window 3 is not locked to another expression).

If the line number is out of range of the source (e.g. if you ask for line number 100 when there are only 90 lines of source), the result will be the address of the first or last line of the source, accordingly. If you use the # operator when there is no line number information available, the result will be 0.

The ? operator is the reverse of #; it returns the source line number, given a memory address. If the address is out of range of the code connected with the source window, ? returns a value of 0.

If you have only one source file loaded, the use of these operators is unambiguous. However, if you have loaded two or more source files into Mon's windows, # and ? may return unpredictable results; in this case it is best to use them when one source file is open in the current window - they will then relate to this file.

These operators allow you to perform a variety of commands on a source level such as: *Set Breakpoint, Run Until* and *Lock Window.* This can make the process of debugging a complex program a far simpler and less tiresome task.

Indirection

The Mon expression evaluator also supports indirection using the { and } symbols. Indirection may be performed on a byte, word or long basis, by following the } with a period then the required size, *which defaults to long*. If the pointer is invalid, either because the memory is unreadable or even (if word or longword indirection is used) then the expression will not be valid.

For example, the expression

```
{data_start+10}.w
```

will return the word contents of location `data_start+10`, assuming `data_start` is even. Indirection may be nested as you would nest ordinary parentheses.

Memory Registers

In addition there are 10 memories numbered `M0` through `M9`, which are treated in a similar way to registers and can be assigned to using the *Register Set* command. These are available for your own use although some have special functions as described below - you can view the memory registers by zooming the register window.

The values of memories 1 through 5 inclusive are the current start address of the relevant window (including source code displays) and assigning to them will change the start address of the display within that window. Here's a full table of the memory registers:

Memory Register	Contents
`m0`	the destination effective address of the current instruction
`m1`	the start address of window 1
`m2`	the start address of window 2
`m3`	the start address of window 3
`m4`	the start address of window 4
`m5`	the start address of window 5
`m6`	spare
`m7`	spare
`m8`	the start address of any binary file that has been loaded
`m9`	the end address of any binary file that has been loaded

`m8` and `m9` are useful if you have loaded a binary file and then want to save it out to disk again - you do not have to remember the start and end addresses of the file, just use `m8` and `m9` when saving.

If window 1 has a register display in it, `m1` will be meaningless but will retain any previous value.

Window Types

There are five possible windows within the Mon display and the exact contents of these windows and how they are displayed is detailed below. The allowed types of each window are:

Window	Allowed Types
1	register, memory, disassembly, source
2	memory, disassembly, source
3	memory only
4	memory, disassembly, source
5	memory only

A window can have a number of different views attached to it; you can think of the window

as a *stack*, having depth.

So, in window 2, you can view a disassembly of code, a section of memory and a portion of an ASCII file, although only one of these at a time is visible. To cycle through the different views use the *Next/Previous View* commands and to create or delete a display use the *Open View* and *Close View* commands.

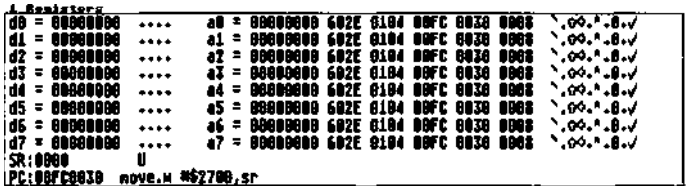
Most windows can also be *split*, either vertically or horizontally so that more, or less, can be displayed within the window - this action may hide or reveal other windows and it is best to experiment with the split commands (described below) to understand how they work.

A window can be locked to an expression so that its start address is dependent on the value of that expression - see the *Lock to Expression* command below.

You can also *zoom* a window; it will then occupy the whole of Mon's screen.

Each type of window will now be described.

Register Window



the register window

The data registers are shown in hex, together with the ASCII display of their four bytes. The address registers are also shown in hex, together with a hex display of the memory that each register is addressing. This is word-aligned or byte-aligned as necessary, with non-readable memory displayed as * *. To the right of this hex display is its ASCII interpretation.

The status register is shown in hex and in flag form, additionally with U or S denoting user- or supervisor-modes.

The `PC` value is shown together with a disassembly of the current instruction. Where this involves one or more effective addresses these are shown in hex, together with a suitably-sized display of the memory they point to.

For example, the display

```
st.l $12A(a3)    ;00001FAE 0F01
```

signifies that the value of `$12A` plus register `A3` is `$1FAE`, and that the word memory pointed to by this is `$0F01`. A more complex example is the display

```
move.w $12A(a3),-(sp)    ;00001FAE  0F01    >0002AC08  FFFF
```

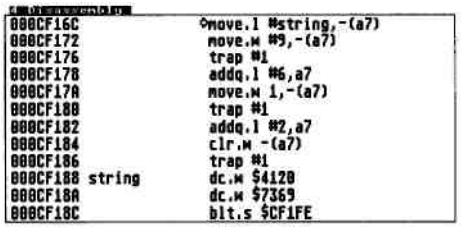
The source addressing mode is as before but the destination address is `$2AC08`, presently containing `$FFFF`. Note that this display is always of a suitable size (`MOVEM` data being displayed as a quad-word) and when pre-decrement addressing is used this is included in the address calculations.

The floating point registers (if present) are then displayed followed by the supervisor and

Mon's memory registers.

The number of lines displayed in the register window may be altered using Control-← and Control—→; in addition Alt-F (to change the font) will allow you to view the floating point registers.

Disassembly Window



the disassembly window

Disassembly displays show memory as disassembled instructions to the standard described below. On the left the hex address is shown, followed by any symbol, then the disassembly itself. The current value of the PC is denoted with a ⇨, if it is visible. In screen modes with less than 80 characters across a label will replace the address if relevant.

You can scroll through the disassembly window as described under *Cursor Keys* below.

If the instruction has a breakpoint placed on it this is shown using square brackets ([ ]) afterwards, the contents of which depend on the type of breakpoint.

For stop breakpoints this will be the number of times left for this instruction to execute, for conditional breakpoints it will be a ? followed by the beginning of the conditional expression, for count breakpoints it is an = sign followed by the current count and for permanent breakpoints a * is displayed.

The exact format of the disassembled opcodes is to the Motorola standard, as Gen accepts. All output is lower-case (except upper-case labels) and all numeric output is in upper-case hexadecimal, except `TRAP` numbers. Leading zeroes are suppressed and the $ hex delimiter is not shown on numbers less than 10. Where relevant numbers are shown signed.

The only deviation from Motorola standard is the register lists shown in `MOVEM` instructions - in order to save display space the type of the second register in a range is abbreviated, for example

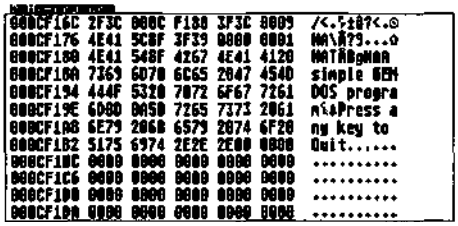
```
movem.l d0-d3/a0-a2,-(sp)
```

will be disassembled as

```
movem.l d0-3/a0-2,-(sp)
```

Floating point constants are shown as the corresponding hexadecimal values; with the `FMOVECR` instruction the value of the constant being obtained from the ROM is given as a scientific format number or appropriate mathematical expression.

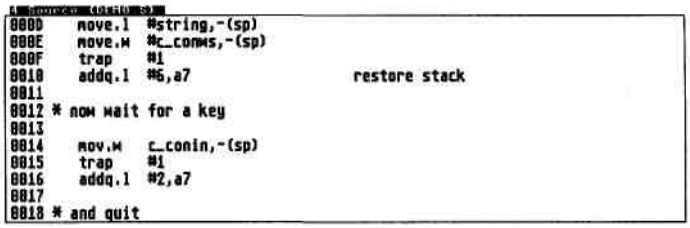
Memory Window



the memory window

Memory displays show memory in the form of a hex address, word-formatted hex display and ASCII. Unreadable memory locations are denoted by * *. The number of bytes shown is calculated from the window width, up to a maximum of 16 bytes per line. You can scroll through the memory window as described under *Cursor Keys* below. Note that you may read values from the hardware area using the *Query Port* instruction described later.

Source Window



the source window

The source window shows ASCII files in a similar way to a screen editor with the name of the file displayed in the title bar. The default tab setting is 8 though this can be toggled to 4 with the *Edit Window* command.

You can choose whether or not to display line numbers for the file and whether they are shown in decimal or hexadecimal. When line number information is attached to your program, you can use the medium level debugging features of Mon to step through the source and set breakpoints within it, rather like you can with a source code debugger.

You can scroll through the source window as described under *Cursor Keys* below.

Cursor Keys

The cursor keys can be used on the current window, the action of which depends on the display type.

On a memory display all four cursor keys change the current address, by byte or line, while `Shift` ↑ and `Shift` ↓ move a page in either direction.

On a disassembly display ↑ and ↓ change the start address on an instruction basis, ← and → change the address on a word basis and `Shift` ↑ and `Shift` ↓ on a page basis.

On a source-code display ↑ and ↓ change the display on a line basis, and `Shift` ↑ and `Shift` ↓ on a page basis.

Window Commands

Commands that are reached through the use of the Alt- key are normally available at any time. Many of these commands are connected with and apply to the *current window.* The current window is denoted by having an inverse title and it can be changed by pressing Tab or Alt- plus the window number.

Most window commands work in any window, zoomed or not, though when it does not make sense to do something the command is ignored.

The exceptions to the above are the *Stack, Unstack* and *View Stack* commands which, for ease of use, are not reached through the Alt-key and do not work on a zoomed window.

Alt-A *or* M — *Set Address*

Allows you to set the starting address of a memory, disassembly or source window (the latter only if line number information is attached to your program). You can use any valid expression to generate this start address e.g.

```
_main
$C227B8
StartProgram+8
PC
```

Alt-E — *Edit View*

On a memory window this lets you edit memory in hexadecimal or ASCII. Hex editing can be accomplished using keys 1-9, A-F, together with the cursor keys. Pressing Tab switches between hex & ASCII, ASCII editing takes each keypress and writes it to memory. The cursor keys can be used to move about memory. To leave edit mode press the Esc key.

On a register display using this command is the same as using *Alt-R*, *Register Set,* described shortly.

Within a source window this command toggles the tab setting between 4 and 8.

You cannot edit a disassembly window.

Alt-F — *Font size*

This changes the font size in a window. In most resolutions 16 and 8 pixel high fonts are used, except when the screen is less than 400 pixels high (e.g. the ST colour resolutions) where 8 and 6 pixel high fonts are used. This allows a greater number of lines to be displayed, although with some loss of readability.

Changing the font size on the register window causes more or less information to be displayed.

Alt-G — *Goto Source Line*

This command works on source windows and allows you to choose the line that will appear at the top of the window. If you select a line that is beyond the end of the file, the last line will be shown at the top of the window.

Alt-L — *Lock to Expression*

This allows source (with line number information), disassembly and memory windows to be locked to a particular expression. After any exception the start address of the display is re-calculated, depending on the locked expression. Each stacked view within a window can have its own lock.

Mon will ignore you if you try to lock a source window that refers to a program that does not have line number information attached to it.

If you try to lock a source window to an expression that lies outside the address range of the source file you will be ignored. This, in fact, is very useful; it means that if you have a stack of source windows (see below for details of stacking windows) which make up the executable that you are debugging and you lock each display to the `PC`, you will be able to trace the path of the program through each source file.

If an instruction in the top view calls a subroutine in the stack, the top view will not change but, if you then view the relevant stacked view, it will change to show you the called subroutine.

To unlock, simply enter a blank string.

You can lock one window to another window by using the memory registers such as `M2`. You can even lock a window to the indirection of its own memory register (e.g. `{m2}`) which might be useful to step through a linked list (in conjunction with the `Esc` key to update the window each time).

Alt-P — *Print Window*

Dumps the current window contents onto the printer or to a file. This command can be aborted by pressing Esc.

Alt-S — *Split Window*

Splits a window vertically i.e. makes it taller or shorter depending on its current state; this may hide or uncover another window. You would normally use this to set up the display as you like it and then save the set-up with the *Save Preferences* command. It can be useful at any time, though, if you would like to see more information in a window or you need another window.

This command has no effect on window 1.

Alt-T — *Type*

This command works on windows 1,2 and 4; it changes the type of the display between register (for window 1), disassembly, memory and source (if a source file has been loaded into the window).

Alt-W — *Widen Window*

Splits a window horizontally i.e. makes it wider or narrower depending on its current state; this may hide or uncover another window. You would normally use this to set up the display as you like it and then save the set-up with the *Save Preferences* command. It can be useful at any time, though, if you would like to see more information in a window or you need

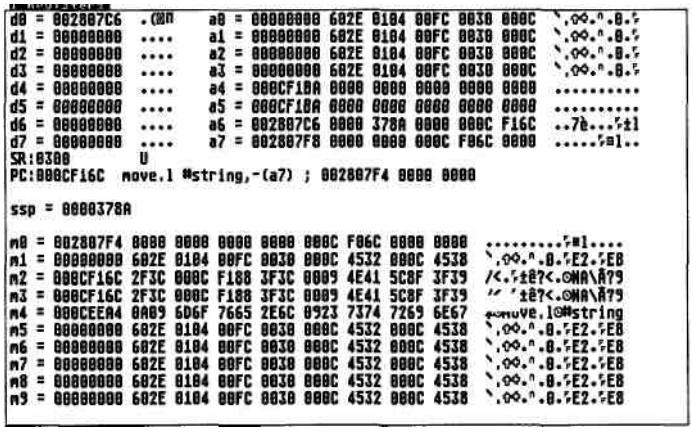
another window.

This command has no effect on window 1.

Alt-Z — *Zoom Window*

This zooms the current window to be full size. Other Alt- commands are still available and normal size can be achieved by pressing Esc or Alt-Z again.

Zooming a register window shows some extra information (which depends on the processor type) and the memory registers (m0 - m9):



the zoomed register display (on a 68000 machine)

A zoomed window behaves differently from a normal window in that, as you scroll through it, it does not update the associated memory register (m1 to m5).

Also, if you change the value of the memory register while in a zoomed window , the start address of the display will not change. Think of a zoomed window as only temporary.

Shift-. — *Open View*

Creates a new view on the current window and numbers it accordingly. The type of the new view will be the same as the previous one if this is possible.

The display will be numbered xa, xb, xc, xd etc. where x is the number of the window e.g. if you stack a new display on window 2, it will be numbered 2b with the original display being numbered 2a. Remember, though, that there is only one memory register per window, but you can lock each display to a different expression. This gives a tremendous amount of flexibility.

This command does not work on a zoomed window.

The associated memory register is bound to the top view only, although all locks on all views are re-calculated where necessary.

Shift-, — *Close View*

Removes the visible display from the current window's display list, unless there is only one display attached to this window, in which case the command does nothing. If you close a view on a source window, the source file will be removed from memory and a disassembly

window will replace the closed source view.

All other displays attached to this window will be re-numbered if necessary i.e. if you remove display 2c from (2a, 2b, 2c, 2d), 2d will be re-numbered to be 2c.

This command does not work on a zoomed window.

. and , — *Next/Previous View*

These two commands allow you to cycle through views that have been stacked onto a window. Pressing . (full stop or period) cycles forward through the available displays whilst , (comma) cycles backwards. Both will roll round in a loop.

For example, say you have 3 displays stacked on window 4 (4a Source, 4b Memory and 4c Disassembly) and you are currently displaying 4b Memory. Press . and 4c Disassembly will appear, press . again and you will see 4a Source.

These commands do not work on a zoomed window.

Esc

Pressing Esc will update all the window displays, if necessary and re-calculate the addresses to which any windows and views are locked.

This can be very useful in many cases; for example say you have window 3 locked to `{m5}` (the address pointed to by window 5) and you then scroll through window 5. Normally this will not update window 3. However, all you have to do is to press Esc when you want to update window 3 (and all the other windows).

Other Alt- Commands

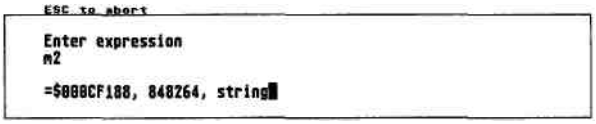
All Alt- commands (like the window commands described above) are available for use at any time whilst you are using Mon. There are a few other such commands that are not related to the current window:

Alt-B — *Set Breakpoint*

Allows the setting of any type of breakpoint, described later under *Breakpoints.*

Alt-0 or 0 — *Show Other Bases*

This prompts for an expression and displays its value in hexadecimal, decimal and as a symbol if relevant.



example of Show Other

Alt-R — *Register Set*

Allows any register to be set to a value, by specifying the register, an equals sign and its new value. It can also be used to set the value of the memory registers. For example the line

```
a3=a2+4
```

sets register A3 to be A2 plus 4 whereas:

```
m3=m2
```

will set the value of the window 3 register to be the same as the window 2 register. All windows will then be re-drawn, which may cause a display that you did not expect if, say, the display in window 3 is locked to an expression.

This command may be used to set all the 68030 and 68881 control registers, so use it with care! The standard floating point registers (`FP0-FP7`) must be followed by a floating point constant either in decimal or hexadecimal using the same rules as for Gen. Hexadecimal floating point numbers should be prefixed with either $ or : and must use the full 12 byte extended format complete with unused second word of `$0000`.

This command may be used to set the 64-bit `CRP` and `SRP` registers; these must be assigned a single 16 digit hexadecimal number without any lead-in character.

You can also use this to set the start address of windows when in zoom mode so that on exit from zoom mode the relevant window starts at the required address.

Screen Switching

Mon uses its own screen display and drivers to prevent interference with a program's own screen output. To prevent flicker caused by excessive screen switching when single-stepping the screen display is only switched to the program's after 20 milliseconds, producing a flicker-free display while in the debugger. In addition the debugger display can have a different screen resolution to your program's if using a colour monitor.

V — *View other Screen*

This will put the Mon screen to the back, showing your program's screen; pressing any key will return the Mon screen.

Control-0 — *Other Screen Mode*

This cycles the screen mode of Mon between the available screen modes (when using a colour monitor). It has no effect when using a high resolution mono monitor.

After changing screen resolutions it re-initialises window font sizes and positions to the initial display. This will not affect the screen mode of the program being debugged.

As Mon has its own idea of where the screen is, what mode it is in and what palettes to use you can use Mon to actually look at the screen memory in use by your program, ideal for low-level graphics programs.

If your program changes screen position or resolution, via the XBIOS or the hardware registers, it is important that you temporarily disable screen switching

using Preferences while executing such code otherwise Mon will not notice the new attributes of your program's screen.

When a disk is accessed, when loading or saving, the screen display will probably switch to the program's during the operation. This happens in case a disk error occurs, such as write-protected or read errors, as it allows any GEM alert boxes to be seen and acted upon.

Breaking into Programs

Shift-Alt-Help — *Interrupt Program*

While a program is running it can be interrupted by pressing this key combination, which will cause a trace exception at the current value of the PC. With computationally-intensive program sections this will be within the program itself but with a program making extensive use of the ROM, such as the BDOS or AES, the interruption will normally be in the ROM itself. If this is the case it is recommended that a breakpoint be placed in your actual program area then a Return to Program command (Control-R) issued.

Pressing Alt-Help without the Shift key will normally produce a screen dump to the printer - if you press this accidentally it should be pressed again to cancel the dump.

It is possible for this key combination to be ignored when pressed - if this occurs press it again when it should work. Pressing it when in Mon itself will produce no effect.

A program should never be terminated (using Control-C) if it has just been interrupted in the middle of a ROM routine. This is likely to cause a system crash.

Breakpoints

Breakpoints allow you to stop the execution of your program at specified points within it. Mon allows up to eight simultaneous breakpoints, each of which may be one of five types. When a breakpoint is hit Mon is entered and it then decides whether to halt execution of your program (when it will enter the front panel display) or continue; this decision is based on the type of the breakpoint and the state of your program's variables.

Simple Breakpoint [1]

These are one-off breakpoints which, when executed, are cleared and cause Mon to be entered.

Stop Breakpoint [n]

These are breakpoints that cause program execution to stop after the break-pointed instruction has been executed a specified number of times. In fact a simple breakpoint is really a stop breakpoint with a count of one.

Count Breakpoint [=]

Merely counters; each time such a breakpoint is reached a counter associated with it is

incremented, and the program will resume. These breakpoints are more like monitors - they never cause a program to stop and are useful for profiling.

Permanent Breakpoint [*]

These are similar to simple breakpoints except that they are never cleared - every time execution reaches a permanent breakpoint Mon will be entered.

Conditional Breakpoint [?]

The most powerful type of breakpoint; these allow program execution to stop at a particular address only if an arbitrarily complex set of conditions apply.

Each conditional breakpoint has associated with it an expression (conforming to the rules already described). Every time the breakpoint is reached this expression is evaluated, and if it is nonzero (i.e. true) then the program will be stopped, otherwise the program will continue.

Alt-B Set Breakpoint

This is a window command allowing the setting or clearing of breakpoints at any time. The line entered should be one of the following forms, depending on the type of breakpoint required:

```
<address>
```

will set a simple breakpoint.

```
<address>,<expression>
```

will set a stop breakpoint at the given address, which will execute <expression> times. The expression is evaluated before the program is executed.

```
<address>,=
```

will set a count breakpoint. The initial value of the count will be zero.

```
<address>,*
```

will set a permanent breakpoint.

```
<address>,?<expression>
```

will set a conditional breakpoint, using the given expression.

```
<address>,-
```

will clear any breakpoint at the given address.

Breakpoints cannot be set on addresses which are odd, unreadable, or within ROM.

Every time a breakpoint is reached, regardless of whether the program is interrupted or resumed, the program state is remembered in the History buffer, described below

Help — *Show Help and Breakpoints*

This displays the text, data and BSS segment addresses and lengths, together with every current breakpoint. Alt- commands are available within this display.

Control-B — *Simple Breakpoint*

Included mainly for compatibility with Mon 1, this sets a simple breakpoint at the start address of the current window, so long as it contains a disassembly display. If a breakpoint is already there then it will be cleared.

U — *Run Until*

This prompts for an address and a breakpoint specifier (1, n, =, *, or ?). The chosen type of breakpoint is then placed at the given address and program execution resumed.

Control-K — *Kill Breakpoints*

Clears all set breakpoints.

Control-A — *Breakpoint After*

A command that places a simple breakpoint at the instruction *after* the instruction at the PC and resumes execution from the PC. This is particularly useful for DBF-type loops if you don't want to go through the loop, but just want to see the result after the loop is finished.

Control-D — *BDOS Breakpoint*

This allows a breakpoint to be set on specific BDOS (GEMDOS) calls. The required BDOS number should be entered, or a blank line if any existing BDOS breakpoint needs to be cleared.

History

Mon has a *history buffer* in which the machine status is remembered for later investigation.

The most common way of entering data into the history buffer is when you single-step, but in addition every breakpoint reached and every exception caused enters the machine state into the buffer. The various forms of the Run command also cause entries to be made into this buffer.

The history buffer has room for five entries - when it fills the oldest entry is removed to make room for the newest entry.

H — *Show History Buffer*

This opens a large window displaying the contents of the history buffer. All register values are shown including the PC as well as a disassembly of the next instruction to be executed.

If a disassembly in the History display includes an instruction which has a breakpoint placed on it, the [ ] s will show the *current* values for that breakpoint,

not the values at the time of the entry into the history buffer.

Only the 68000 registers are retained in the history buffer due to lack of space in the history buffer and in order to keep the 'trace' instructions fast.

Quitting Mon

Control-C — *Exit Mon*

This will issue a terminate trap *to the current GEMDOS task. It* a program has been loaded from within Mon it will be terminated and the message Program Terminated appear in the lower window. Another program can then be loaded, if required.

If no program has been loaded into Mon it will itself terminate when this command is used.

If the Debug option has been used from the Devpac editor then Mon will terminate automatically when the program it is debugging has terminated.

Terminating some GEM programs prematurely, before they have closed workstations or restored window control properly can seriously confuse the AES and VDI.

This may not be noticeable immediately but often causes crashes when a subsequent program is executed.

Loading & Saving

Control-L — *Load Program*

This will prompt for a filename and a command line and will attempt to load the file ready for execution. If Mon has already loaded a program it is not possible to load another until the former has terminated.

The file to be loaded must be an executable file - attempting to load a non-executable file will normally result in the error "Invalid program load format" and further attempts to load executable files will normally fail as GEMDOS does not de-allocate the memory it allocated before trying to load the errant file. If this occurs terminate Mon then re-execute it and use the Load Binary File command.

This command is not available in the auto-resident version of Mon or if Mon is invoked using Debug from the editor.

B — *Load Binary File*

This will prompt for a filename and an optional load address (separated by a comma) and will then load the file where specified. If no load address is given then memory will be allocated from the system. M8 will be set to the start address of the loaded file and M9 to the end address.

This is a change from previous versions of Mon, where MO and M1 were set to the start and end addresses of the loaded file.

S — *Save Binary File*

This will prompt for a filename, a start address and an (inclusive) end address. To re-save a file recently loaded with the *Load Binary File* command

```
<filename>,M8,M9
```

may be specified, assuming of course that M8 and M9 have not been reassigned.

A — *Load ASCII File*

This powerful command allows an ASCII file, normally of source code, to be loaded and viewed within Mon. This can be loaded into window 2 or window 4. If the loaded program has line number information relevant to this source file, you will be able to use line number operators on this display to step through the source code, set breakpoints within it etc.

A new view on this window will be opened if the window already contains an ASCII file, otherwise the text will replace the current window. You can unload a source window using the *Close View* command.

The source window will be locked automatically to the PC.

Memory for source code displays is taken from the system so sufficient free memory must be available.

E — *Executable file to use*

This command is used to just load the symbol table & line number information from an executable file, *without* loading the executable itself. This command is ideal for debugging desk accessories and for programs loaded by others as overlays. The filename specified may be optionally followed the address of the text segment which is to be assumed.

Executing Programs

Control-R — *Return to program / Run*

This runs the current program with the given register values at full speed and is the normal way to resume execution after entry via a breakpoint or an exception.

Control-Z — *Single-Step*

Single-steps the instruction at the PC with the current register values. Single-stepping a Trap, Line-A or Line-F opcode will, by default, be treated as a single instruction.

Control-Y — *Single-Step*

Identical to Control-Z above but included for the convenience of users of German keyboards.

Control-W — *Single-Step*

Identical to Control-Z above but included for the convenience of French users.

Control-T — *Trace Instruction*

This interprets the instruction at the PC using the displayed register values. It is similar to Control-Z but obeys BSRs, JSRs, Traps, Line-A and Line-F calls as if one instruction, re-entering the debugger on return from them to save stepping all the way through the routine or trap. It works on instructions in ROM or RAM.

Control-S — *Skip Instruction*

Control-S increments the PC register by the size of the current instruction thus causing it to be skipped. Use this instead of Control-Z when you know that this instruction is going to do something it shouldn't.

R — *Run (various)*

This is a general *Run* command and prompts for the type of execution, selected by pressing a key.

Run (G) — *Go*

This is identical to Control-R, Run, and resumes the program at full speed.

Run (S) — *Slowly*

This will run the program at reduced speed, remembering every step in the history buffer.

Run (I) — *Instruction*

This is similar to Run Slowly but allows a count to be entered, so that a particular number of instructions may be executed before Mon is entered.

Run (U) — *Until*

You will be prompted for an expression which will be evaluated after every instruction. The program will then run, albeit at reduced speed, until the given expression evaluates to non-zero (true) when Mon will be entered. For example if single-stepping a `DBF` loop which used d6 in the ROM code you could say Run Until `d6&ffff=ffff` (waiting for the low word of `d6` to be `$FFFF`) or, alternatively, `PC=E08B1A`, or whatever.

This should not be confused with the Until command, which takes an address, places a breakpoint there then resumes execution.

With all of these commands (except Run Go) you will then be asked Watch Y/N? If Y is selected then the Mon display will be shown after every instruction and you can watch registers and memory as they change, or interrupt execution by pressing both Shift keys simultaneously. If N is selected then execution will occur while showing your program's display and execution may be interrupted by pressing Shift-Alt-Help.

Selecting Watch mode with screen switching turned off is likely to result in a great deal of eye strain as the display will be flipped after each and every instruction, particularly alarming in colour modes.

With any of these Run modes (except Go) all information after every instruction will be remembered in the history buffer. In addition Traps will be treated as single-instructions,

unless changed with Preferences, though see the warnings under that command about tracing all the way through ROM routines.

When a program is running with one of the above modes a couple of pixels near the top left of the display will flicker, to denote that something is happening, as it is possible to think the machine has hung when, in fact, it is simply taking a while to Run through the code an instruction at a time.

Searching Memory

G — Search Memory (Get a sequence)

You will see the prompt `Search for B/W/L/T/I?`, standing for Bytes, Words, Longs, Text and Instructions.

If you select `B`, `W` or `L` you will then be prompted to enter the sequence of numbers you wish to search for, each separated by commas. Mon is not normally fussy about word-alignment when searching, so it can find longs on odd boundaries, for example. However, if you wish to force a specific alignment, this can be done by terminating the list of items to search for with ,W for words, or , L for longs. For example:

1234,w

would only find $1234 on a word boundary it would *not* match if the $12 was on an odd addressed byte.

If you select T you may search for any given text string, for which you will be prompted.

If you select I you can search for part or all of the mnemonic of an instruction, for example if you searched for `$14(A` you would find an instruction like `MOVE.L D2,$14(A0)`. The case of the string you enter *is* unimportant unless you have chosen it to be so, but you should bear in mind the format that the disassembler produces, e.g. always use hex numbers, refer to A7 rather than SP and so on.

If you select either text or instruction searching you also be asked whether you wish to ignore the case of the string that you are searching for. If you type Y then HiSoft will match HISOFT, hisoft etc.; if you press N then only HiSoft will be found.

Having selected the search type and parameters, the search begins, control passing to the *Next* command, described below.

Searching Source-Code Windows

If the G command is used on a source-code window the T sub-command is automatically chosen and if the text is found the window will redisplay the line containing it.

N — Find Next

N can be used after the G command to find subsequent occurrences of the search data. With the B, W, L and T options you will always find at least one occurrence, which will be in the buffer within Mon that is used for storing the sequence. With the T option you may also find a copy in the system keyboard buffer. With these options, the Esc key is tested every 64k bytes and can be used to stop the search. With the I option, which is very much slower, the

Esc key is tested every 2 bytes.

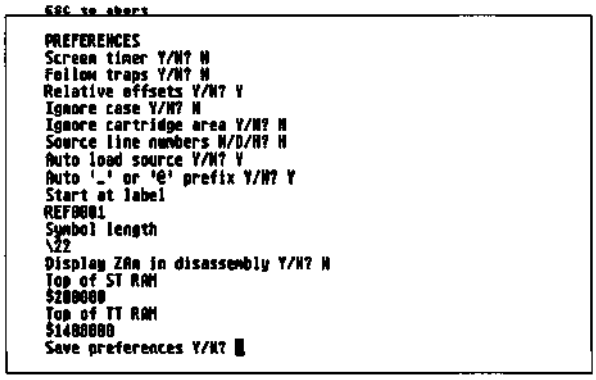
The search will start just past the start address of the current window (except register windows) and if an occurrence is found redisplay the window at the given address.

The search area of memory goes from 0 to the end of system RAM, then via the system ROM and cartridge areas to any alternative (TT RAM) and then back to 0. Mon will not search the cartridge area if you have set the appropriate option or the environment variable NOCARTRIDGE exists. This will avoid accessing any hardware attached via the cartridge port.

Miscellaneous

Control-P *Preferences*

This permits control over various options within Mon. The first three require Y/N answers, pressing Esc aborts or Return leaves them alone.



the Preferences display

Screen timer

Defaulting to On, this causes the display to switch to your program's only after 20 milliseconds. It should be switched off when a program is about to change a screen's address or resolution, then turned back on afterwards.

Follow traps

By default single-stepping and the various forms of the Run command treat Traps, and Line-A calls as single instructions. However by turning this option On the relevant routines will be entered allowing ROM code to be investigated.

This option should be used with *care.* Certain time critical routines, such as the floppy- or hard-disk drivers have portions of code designed to be atomic, i.e. not interruptible, and being traced will cause malfunctions within such code and possible loss of data.

On the other hand it can be fun to watch the AES as it draws pulldown menus or opens windows.

If you have let ROM execute for a while you can interrupt it by pressing Shift-Alt-Help, then resume at normal speed by pressing Control-R. However the AES and VDI both use Line-A calls and it is very likely that there are pending stack frames left with the Trace bit set, so

having resumed a traced program it is likely that seemingly spurious trace exceptions will be generated. Pressing Control-R will resume at normal speed, though a few more such exceptions are likely until program flow reaches the *lowest level*, i.e. your program.

NOTRACE Program

There is a side effect of this that can cause machine to crash though: if you have traced through any AES event-type calls then stack frames can be created *in desk accessories* with the Trace bit set. If your program terminates before the accessory has a chance to respond to its own event call, a trace exception will occur *after* Mon terminates and returns to the Desktop or the Devpac editor, causing a system crash, unless an auto-resident Mon is installed or the NOTRACE.PRG program is used.

This is a very small program intended to be added to the AUTO folder of your boot disk which causes trace exceptions to be ignored, instead of producing a large number of bombs as it will do by default. The source code is also supplied.

Auto load source file

When switched to Yes, upon loading a program, Mon will attempt to load the first source file associated with the program. This will only occur if the executable file contains line number debugging information. The new source file window will then be locked to the Program Counter in order to track program flow. This is of most use when debugging a program generated from a single source file.

Source line numbers

Affects whether line numbers are shown for all debugger source windows. You may select No line numbers, Decimal numbers or Hex numbers. Hexadecimal is often the preferred setting because by default, Mon treats all numbers as hex. Decimal line numbers, used with the # operator for example, require a prefix of backslash.

Automatic '_' or '@' prefix

This is provided mainly for the convenience of C compiler users. With it enabled, Mon will automatically add a leading underscore or @ character to the appropriate symbols. However, symbols without the leading character will still take precedence.

Ignore case

Mon version 3 defaults to using *case insensitive* symbols, i.e. upper and lower case characters are not distinguished between. Selecting No will mean that you must match the case of each symbol character exactly as with previous versions of Mon.

Start at label

When an executable file is loaded normally Mon stops at the first location in the program. If a different label is specified using this option (e.g. `main` for C, `REF0001` for HiSoft BASIC), then the program will instead be stopped at that point; this means you can start debugging at the start of your code, rather than the going through the compiler's startup code.

Note that this feature may also be useful if you find you are always debugging starting at a particular point in your code.

Symbol length

This prompts for the significant length of symbols, which is normally 22 but may be reduced to as low as 8. Although reducing this can save some typing, using too low a value can make some symbols impossible to select.

Relative offsets

This option defaults to Yes and affects the disassembly of *address register indirect with offset* addressing modes, i.e. `xxx(An)`. With the option on, the current value of the given address register is added to the offset then searched for in the symbol table. If found it is disassembled as `symbol(An)`. This option is very useful for certain styles of assembly language programming as well as high level languages which use a base register as a major offset, such as Lattice C which uses `A4` as a pointer to the merged data section.

Display ZAn in disassembly

Is normally switched off but advanced programmers may wish to enable the display of the normally hidden Z registers used by some 680x0 instructions.

Ignore Cartridge Area

When this option is selected the Find command will not search the ROM cartridge area of the memory map. You should select this is you have hardware other than a ROM in this slot.

Top of RAM/Top of ST RAM

This indicates to Mon which memory location should be considered the top of system RAM by the *Search Memory* (G) command. Normally you will not need to change this as it defaults to the system variable phys_top; but you may need to modify it if you are debugging software that lowers phys_top.

Top of TT RAM

This indicates to 68030 versions of Mon which memory location should be considered the top of TT RAM by the *Search Memory* (G) command. Normally you will not need to change this as it defaults to the appropriate system variable but you may need to modify it in special circumstances.

Save preferences

Reply Y to this command to save your current preferences to the file MON.INF in the current directory. When Mon loads it will read your current preferences from this file. MON.INF must be in the current directory when Mon is loaded.

Intelligent Copy

This copies a block of memory to another area. The addresses should be entered in the form

```
<start>,<inclusive_end>,<destiriation>
```

The copy is intelligent in that the block of memory may be copied to a location which overlaps its previous location.

No checks at all are made on the validity of the move; copying to non-existent areas of memory is likely to crash Mon and corrupting system areas may well

crash the machine.

L — List Labels

This opens up a large window and displays all loaded symbols. Any key displays the next page, pressing Esc aborts. The symbols will be displayed in the order they were found on the disk (or in memory if using the Debug option from the editor).

W — Fill Memory With

This fills a section of memory with a particular byte. The range should be entered in the form

```
<start>,<inclusive_end>,<fillbyte>
```

The warning described previously about no checks applies equally to this command.

P — Disassemble to Printer/Disk

This command allows the disassembly of an area of memory to printer or disk, complete with original labels and, optionally, an automatic list of labels created by Mon, based on cross-references. The first line should be entered as

```
<start_address>,<end_address>
```

The next line prompts for the area of memory used to build the cross-reference list, which should be left blank if no automatic labels are required else should be of the form

```
<buffer_start>,<buffer_end>
```

Next is the prompt for data areas which will be disassembled as `DC` instructions, of the form

```
<data_start>,<data_end>[,<size>]
```

The optional size field should be `B`, `W` or `L`, defaulting to `L`, determining the size of the data. When all data areas have been defined, a blank line should be entered.

Finally a filename prompt will appear; if this is blank all output will be to the printer, else it will be assumed to be a disk file.

If automatic labels were specified there may be a delay at this point while the table is generated. Automatic labels are of the form Lxxxxx where xxxxx is the actual hex address.

Printer Output

This is of the form of an 8 digit hex number, then up to 10 words of hex data, 12 characters of any symbol, then the disassembly itself. Printer output may be aborted by pressing Esc.

Disk Output

This is in a form directly loadable by Gen, consisting of any symbol, a tab, then the disassembly itself, with a tab separating any operand from the op-code. If you are disassembling an area of memory without loaded symbols then the `XREF` option should be used else no symbols will appear at all in the output file. Pressing Esc or a disk error will abort the disassembly.

M — *Modify Address*

Included for compatibility with Mon 1, equivalent to Alt-A.

O — *Show Other Bases*

Included for compatibility with Mon 1, equivalent to Alt-O.

D — *Change Drive & Directory*

This allows the current drive and sub-directory to be changed.

Control-E — *Re-Install Exceptions*

This command causes Mon to re-install the exception vectors; useful if you are debugging a high-level language program whose runtime routines use the exceptions. This must be used *after* the user's program has modified the exceptions.

Q — *Query (read) port*

Normally Mon will not let you read the hardware ports directly (to prevent 'upsetting' the system by reading from a number of areas at once, however you can achieve this by using this command. You will be prompted to enter the address you wish to read. The byte value read from this address will then be displayed. To access the memory a word or long word at a time you should follow the address by a `,w` or `,l` respectively.

Note you should use this instruction with great care as careless use can result in a bus error or even a crashed system.

T — *Transfer to (write) port*

Normally Mon will not let you write to the hardware ports directly, however you can achieve this by using this command. You will be prompted for the data to transfer, of the form

```
<address>,<data>[,<size>]
```

Normally the single byte value data will be written to port address although this may be over-written by using the optional size field which must be either W or L.

Note you should use this instruction with great care as careless use can result in a bus error or even a crashed system.

C — *Compare Memory*

This command compares two areas of memory; you will be prompted for start and end addresses of the first block, together with the start address of the second block. If the two blocks differ, windows 2 and 3 will be placed at the first difference in the first block, whilst windows 4 and 5 will be placed at the equivalent place in the second block. The N command (Find Next) may then be used to step forward through differences, based on windows 3 and 5.

Auto-Resident Mon

The additional version of Mon called AMON.PRG will now be described. When placed in the AUTO folder on your boot disk, it will be loaded and initialised automatically on boot-up.

Once booted, this version of Mon lies *dormant*, ready to be invoked when any exception occurs in the machine, such as an address error. It is intended primarily for programmers writing and debugging desk accessories or other AUTO-type applications, as if there is a problem in the code which gets called as the machine boots, it hangs before you get a chance to use the normal Mon. If required you can deliberately put an illegal opcode, such as ILLEGAL, at the start of your auto program so that Mon will be invoked and then use it to investigate any problems your code has.

The auto-resident version may be double-clicked from the Desktop and will initialise itself in the same way as from the AUTO folder, unless a version of Mon is already resident.

Once invoked the auto-resident version is very similar in use to the other versions except that programs or labels cannot be loaded and the base page variables are unknown and so set to 0. The other difference is that when the program being debugged exits or Control-C is pressed within Mon, Mon itself stays active in memory.

In addition any program may be interrupted by pressing the Shift-Alt-Help key combination when a resident version of Mon is installed.

The resident version of Mon cannot be reclaimed from memory except by resetting the machine and booting with a disk which does not contain Mon in the AUTO folder.

When an auto-resident version of Mon is loaded, the usual versions can still be used as normal, memory permitting, and the resident version will be ignored until the non-resident version exits, when it will become active once again.

Do *not* invoke an auto-resident Mon from within a program other than the Desktop, such as using Run Other from within Gen, as large areas of system memory will become locked away and unusable until a machine reset.

If both Shift keys are held down during the installation of the auto-resident Mon, the debugger is itself entered, allowing the editing of memory or setting of BDOS breakpoints. When entered via this method the debugger should be left using Control-C when the debugger will remain resident or if you do not wish to have the auto-resident Mon exit with Control-R and this will abort its installation.

Command Summary

Window Commands

Alt-A	Set Address
Alt-B	Set Breakpoint
Alt-E	Edit View
Alt-F	Font Size
Alt-G	Goto Source Line
Alt-L	Lock to Expression
Alt-P	Print Window
Alt-R	Register Set
Alt-S	Split Window

Alt-T	Change Type
Alt-W	Widen Window
Alt-Z	Zoom Window
Control ←	Reduce Register Window Height
Control →	Increase Register Window Height
Shift-.	Open View
Shift-,	Close View
. and ,	Next/Previous View
Esc	Update all Windows

Screen Switching

V	View Other Screen
Control-0	Other Screen Mode

Breakpoints

Control-A	Breakpoint After
Control-B	Simple Breakpoint
Control-D	BDOS Breakpoint
Control-K	Kill Breakpoints
Control-X	Stop Executing
Alt-B	Set Breakpoint
U	Run Until
Help	Show Help and Breakpoints

Loading and Saving

Control-L	Load Program
A	Load ASCII File
B	Load Binary File
E	Use New Executable
S	Save Binary File

Executing Programs

Control-R	Return to program / Run
Control-S	Skip Instruction
Control-T	Trace Instruction
Control-Y	Single-Step
Control-Z	Single-Step
R	Run (various)

Searching Memory

G	Search Memory (Get a sequence)
N	Find Next

Miscellaneous

Alt-0 or 0	Show Other Bases
Control-C	Terminate Process
Control-E	Re-install breakpoints
Control-P	Preferences
C	Compare Memory
D	Change Drive & Directory
H	Show History Buffer
H	Show History Buffer
I	Intelligent Copy
L	List Labels
M	Modify Address

P	Disassemble to Printer/Disk
Q	Query (read) port
T	Transfer to (write) port
W	Fill Memory With
Shift-Alt-Help	Interrupt Program

Debugging Stratagem

Hints & Tips

If you have interrupted a program using Shift-Alt-Help or by a Run Until command and have found yourself in the middle of the ROM, there is a way of returning to the exact point in your program which called the ROM. Firstly ensure the Follow Traps option is on, then do Run Until with an expression of sp=a7. This will re-enter Mon the moment user mode is restored which will be in your program.

If you are in a subroutine which doesn't interest you and want to let it run but return to Mon the easiest way is to use Until (not Run Until) then specify the expression `{sp}` - this sets a breakpoint at the return address.

If the subroutine has placed something on the stack then try Run Until `{pc}.W=4e75` which will run slowly until the instruction `RTS` is reached. This won't work if the subroutine in question calls another, so it may require a further condition, such as `({pc}.W=4e75) & (sp>xxx)` where `xxx` is one less than the current value.

If the subroutine uses a local stack frame (normally the case for compiled programs) then try Run Until `{4+a6}` (assuming that the language uses a 6 as its frame pointer) - this attempts to set a breakpoint at the return address.

When using Run Until and you know it will take a quite a while for the condition to be satisfied, give Mon a hand by pre-computing as much of the expression as you can.

For example

```
(a3>(3A400-\100+M1))
```

could be reduced to

```
a3>xxx
```

where `xxx` has been calculated by you using the Alt-0 command.

Bug Hunting

There are probably as many strategies for finding bugs as there are programmers; there is really no substitute for learning the hard way, by experience. However, here are some hints which we have learnt, the hard way!

Firstly, a very good way of finding bugs is to look at the source code and think. The disadvantage of reaching first for the debugger, then second for the source code, is that it gets you into bad habits. You may switch to a machine or programming environment that does not offer low-level debugging, or at least not one as powerful you are used to.

If a program fails in a very detectable way, such as causing an exception, debugging is normally easier than if, say, a program sometimes doesn't quite work exactly as it should.

Many bugs are caused by a particular memory location being stepped on. Where the offending memory location is detectable, by producing a bus error, for example, a conditional breakpoint placed at one or more main subroutines can help greatly. For example, suppose the global variable `main_ptr` is somehow becoming odd during execution, the conditional expression could be set up as

```
{main_ptr}&1
```

If this method fails, and the global variable is being corrupted somewhere undetectable, the remaining solution is to Run Until that expression, which could take a considerable time. Even then it may not find it, for example if the bug is caused by an interrupt happening at a certain time when the stack is in a particular place.

Count breakpoints are a good way of tracking down bugs *before* they occur. For example, suppose a particular subroutine is known to eventually fail but you cannot see why, then you should set a count breakpoint on it, then let the program run. At the point where the program stops, because of an exception say, look at the value of the count breakpoint (using Help). Terminate the program, re-load it, then set a stop breakpoint on the subroutine for that particular value or one before it. Let it run, then you can follow through the subroutine on the very call that is fails on, to try and work out why.

Good luck!

AUTO-folder programs

If these crash during initialisation then use AMON (which must be before your program in the directory) to catch the exception. Including a deliberate `ILLEGAL` instruction at its beginning will let you single-step the initialisation.

Desk Accessories

If an accessory is misbehaving during normal execution then use AMON. To find a desk accessory in memory, enter the debugger by pressing Shift-Alt-Help then start looking from location 0 for the upper-cased name of your .ACC file, padded to eight characters with spaces. Ignore occurrences within directory buffers (these will be followed by .ACC) and in Mon's own buffer (these will be preceded by an ASCII T character). The correct occurrence will have a longword 12 bytes after the start of the name. This will point to the basepage of your accessory and $100 bytes after that will be the start of your program. From looking at this you should be able to find your main loop and set a suitable breakpoint. Normal execution should be resumed with Control-R then Mon will be re-entered when your breakpoint is reached. Then load the symbol table for the accessory using the E command.

If an accessory is misbehaving during its initialisation then you have to stop it at the very beginning before it has a chance to do anything. The recommended way is to re-assemble the accessory with an `ILLEGAL` instruction at the beginning and let AMON catch it, but this is sometimes not possible. There follows a method that works on current ROMs to stop the AES just before it executes your program, but please note the method is complicated and not recommended for beginners

Firstly hold down both shift keys to enter AMON during the boot sequence then set a BDOS

Breakpoint on the Open call, $3D, then press Control-C to let the boot sequence resume.

Mon will be re-entered every time something tries to open a file, so make window 3 the current window and after every BDOS breakpoint is hit set its address to `{sp+2}` - if the name is *not* your accessory then Control-Z, to execute the Open call, set another BDOS breakpoint on $3D then Control-R, and try again. If the name is your accessory then set a BDOS breakpoint on $4B, then Control-R. Mon will then be entered just before it loads the accessory, so Control-Z to do the GEMDOS call, then Alt-B and enter `d0+100` which sets a breakpoint on the very first instruction. Now Control-R and the next time Mon appears it will be on the first instruction of the accessory. This method takes a while but it's often the only way of finding bugs in accessories.

Exception Analysis

When an unexpected exception occurs, it's very useful to be able to work out where and why it occurred and, possibly, to resume execution. Some of the most common exception types are listed below with their possible causes.

Bus Error

If the `PC` is in some non-existent area of memory then look at the relevant stack to try and find a return address to give a clue as to the cause, probably an unbalanced stack (i.e. some data was placed on the stack and never retrieved, causing the program to `RTS` to an incorrect location).

If the `PC` is in a correct area of your program then the bus error must have been caused by a memory access to non-existent or protected memory. Recovering from bus errors and resuming execution is generally difficult.

Address Error

If the `PC` is somewhere strange then the method above should be used, otherwise the error must have been caused by a program access to an odd address. Correcting a register value may be enough to resume execution, at least temporarily.

Note well that 68020 processors and upwards do not consider this an error and can quite happily read words from odd addresses, albeit at reduced efficiency. This is often the cause of programs working on a 680x0 which crash on machines with a 68000. However, such processors will cause an address error if the PC becomes odd.

Illegal Instruction

If the PC is in very low memory, below around `$30`, it is probable that it was caused by a jump to location 0. If you use Mon to look here you will normally various `ORI` instructions (really longword pointers) and eventually an illegal instruction.

Privilege Violation

This is caused by executing a privileged instruction in user mode, normally meaning your program has gone horribly wrong. Bumping the `PC` past the offending instruction is unlikely to be much help in resuming the program.

Divide by Zero

Signifies that your program has attempted to divide another value by zero. This is normally due to an error in some previous calculation.

Floating Point Exceptions

Such exceptions are caused by a 68881 or 68882 maths co-processor after some error in calculation or protocol is detected. They differ from most exceptions in that they will often be caused some time after the error was actually detected, typically at the time of the next floating point instruction. This is due to the fact that an FPU instruction merely initiates the sequence of actions, the processor itself will continue to execute the instruction concurrently with further CPU instructions.

Chapter 5 – Clink The Linker

CLink was originally developed for Lattice C but may be used for assembly-only or mixed language projects. It may be run in the integrated mode as described in the editor section, from a command line interpreter or from the Desktop.

The linker command line specifies which files are to be linked together and in what order. Note that the order of linking is significant as this allows a symbol defined in a module linked earlier to override one in a later module; this is often useful when replacing standard library routines with your own custom versions.

A simple CLink command line

To link together two simple object files the command line used could be:

```
CLINK a.o b.o
```

this will produce an executable program (assuming no errors occur) named b.prg; note that the name of the executable is taken from the second named file in the link sequence (this is because of the C heritage of CLink) if available. If only one file is linked then the name will be the name of that module with .PRG added.

Concepts

CLink provides several unusual features whilst linking, this allows more flexibility when initially writing your program leaving many of the decisions up to the linker.

ALVs

When CLink is collecting all of the CODE type sections together, if any are more than 32K apart and a 16-bit PC relative access is attempted, rather than simply fail with and out-of-range error message, CLink redirects the access to a `JMP` to the same location. This jump is known as an *automatic link vector* or *ALV*. Note that this may cause problems if you attempt to access data using PC-relative mode, although this is not recommended anyway since on the 68030 there are separate code and data caches which can cause consistency problems.

Near DATA/BSS

CLink supports a 64K near data section which can be accessed via a global base register (traditionally A4). This section is formed from all sections which are named `__MERGED` (as described in the assembler section) and then several variables are created by the linker to allow the initial base of this to be set up. This is discussed later under the Reserved symbols section.

Directives

The CLink directives allow the input files and the format of the output file to be specified.

Input directives

The input directives allow the names of the object files to be linked to be passed to the linker. The linker works by collecting all sections which have identical types into a single output section; note that apart from the special name __MERGED section names are ignored when generating executable files.

When a file is required by CLink it initially looks in the current directory for the file, if it is found there then that file is used, otherwise a search is made for it in the paths mentioned in the LIB environment variable. The LIB variable consists of a list of semicolon (;) or comma (,) separated items which indicate paths where the file should be searched for, e.g.

```
LIB=c:\lc\lib;c:\mylibs
```

FROM *files* Specifies the object files that are the input files for the linker. If the first item on the command line is a filename then the FROM keyword is optional and may be omitted. FROM may be used more than once with the files for each FROM adding to the list of files to be linked.

To specify more than one file in a single FROM statement they may either be listed after it separated by spaces or +, e.g.

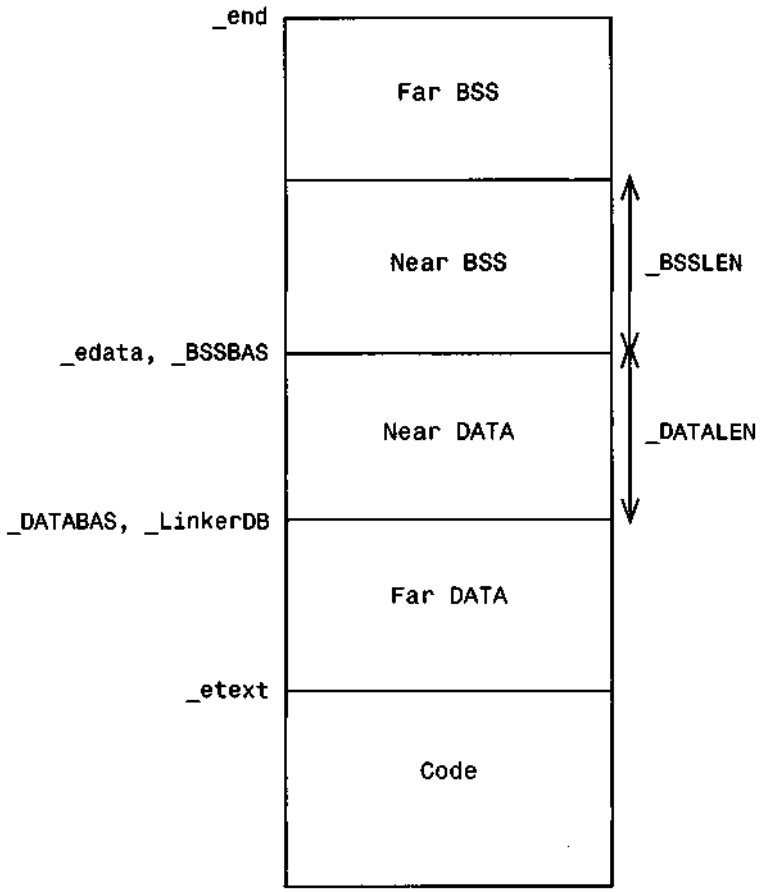
```
FROM a.o+b.o
```

LIB *files* Specifies the files to be scanned as libraries. Only modules within the library which contain symbols which are referenced will be included in the final object module. Note that LIBRARY is a synonym for LIB. The same syntax used for specifying multiple FROM files may be used for multiple libraries.

Output directives

The output directives control the format and type of the final file created by the linker when a link has been completed successfully. The output file generated by the linker is normally directly executable by GEMDOS (unless the PRELINK option has been used) and is, by default, named the same as the second object module supplied by a FROM option with its .o suffix replaced by .prg; if only one file is linked then the output name will be based on that file. The format of the file is identical to the normal GEMDOS executable file, but with the DATA and BSS sections split so that they contain both the Near (__MERGED) data and Near (__MERGED) BSS sections.

This leads to a load map of the following form:



Note that the symbols marked are all discussed under the Reserved symbols section below.

ADDSYM Replace symbol table with table built from exported symbols.

BSS *base* These keywords are used when generating an CODE *base* absolute format executable (either the Atari DATA *base* absolute format or S-records).

The base parameter gives the absolute base address of the BSS, code and data sections respectively.

Note that GEMDOS *will not execute* absolute format programs.

NODEBUG Suppresses any symbol table information or symbolic debug information in the final object file. This is equivalent to the object file that would be produced if strip were run on the final object file. Note that ND is a synonym for NODEBUG.

NOFASTLOAD This disables the setting of the 'fast load' bit in the program header of an executable program. This means that the whole of the TPA will be zeroed rather than just the BSS section. Note that this option is only effective when generating an executable file.

PREFIX *file* This specifies a file which is to be prepended to the output file; this is particularly useful for building control panel extensions. Note that this option is only effective when generating an executable file.

PRELINK Causes CLink to output an object module with references and definitions still intact so that it can be linked later on to produce a final executable file. This is designed for development of large projects where the programmer is only changing a single source

module. Note that a prelinked object file cannot have ALVs inserted into it and so CLink may be unable to satisfy all 16 bit PC-relative references when linking with the prelinked file.

SRECORD Cause CLink to output an absolute load module in Motorola S-record format; S-records are a standard way of transferring binary images between machines, using 7-bit ASCII codes only. It is particularly useful for uploading data to EPROM programmers.

When generating S-records you *must* specify a base for each and every section which is used (CODE/DATA/BSS); in addition S-record absolute programs *may not* have any __MERGED data.

TO *file* Specifies the name of the output file which is to be created, overriding the default name generation discussed above. If the file name specified begins with a period (.) then the normal default name generation is performed using the extension specified after the period rather than .PRG.

TPASIZE *n* Sets the size of TPA required for loading into alternative RAM. This value sets the minimum amount of alternative RAM, in Kbytes, which must be free for a program which has the TTLOAD bit set. The minimum value is 128, the maximum 2048 (2Mb). Note that this option automatically enables the TTLOAD option. Note that this option is only effective when generating an executable file.

TTLOAD This sets the load into alternate RAM bit in the program header of an executable program. Note that this option is only effective when generating an executable file.

TTMALLOC This sets the m_alloc-from alternate RAM bit in the program header of an executable program. Note that this option is only effective when generating an executable file.

Pre-linking

Pre-linking is similar to a normal link, however instead of producing the five load sections from identically typed sections, it coalesces only identically typed *and named* sections into *output sections.* If a section is unnamed then it is merged with the first named section of the same type.

Note that the special name __MERGED is considered a type-modifier and hence only sections named __MERGED will be coalesced with __MERGED sections.

When pre-linking ALVs are applied according to the normal rules, i.e. ALVs will be generated for out of range branches within a section, and *all* cross-output-section references.

During pre-linking variables will often have undefined values (since the modules in which these are defined are to be linked later) and so all of these variables are reported. Note that this means that an error has technically occurred and the return code from CLink will be non-zero. This is likely to be important to users of make type utilities.

Map files

A map file is a file describing the order and location of files and variables processed by the linker written to a normal file for perusal by the user. These files provide a large number of options for the programmer to customise the output format; they are enabled using the MAP directive which has the format:

```
MAP [[filename],option,option,...]
```

The filename gives the name of the file to which the map file is to be written, this may be of the form .MAP to indicate that the filename should be based on the output file name. The options specify which parts of the map file are to be written and all consist of single letters:

Option	Meaning
F	Produce a mapping of input files in the output file
H	Show where the input hunks (sections) were placed
L	Map the library placements
S	Show all external symbols
X	Show a cross reference of external symbols

When generating cross-reference information it is often useful to be able to separate this from the map file information. This can be done using the XREF directive which allows a separate cross-reference file to be specified. It has the form:

```
XREF filename
```

To control the layout of the map file several directives are available which are used in the same way as the more normal output directives or options:

FWIDTH *n* Width of file names (default 16).

HEIGHT *n* Lines on a page in map file, 0 indicates no pagination (default 55).

HWIDTH *n* Width of hunk names (default 8).

INDENT *n* Columns to indent on a line. This is included in width (default 0).

PWIDTH *n* Width of program unit names (default 8).

SWIDTH *n* Width of symbol names (default 8).

WIDTH *n* Sets the maximum line length for the map and cross reference listings. This is useful when sending the output to a device whichohas different line length requirements. If not specified one width defaults to 80.

Options

Clink provides a large number of keywords to give the programmer a wide number of options. Although some of these may seem superfluous, the intention is to provide the programmer with as many options as possible, even if some of these options appear rather obscure.

BATCH This causes CLink to supply the default value of 0 for all undefined symbols. Normally, CLink will pause after each undefined symbol to give you an opportunity to correct the error. If you specify the BATCH option, it will not pause.

BUFSIZE *sz* If sz > 0 set input *and* output buffer sz to sz bytes, if sz < 0 set output buffer sz to -sz bytes. By default the linker buffers the whole of input source files for as long as possible, this often means that no re-reading is necessary for the second pass, although it may

run out of memory as a result. If this happens, try setting an buffer size of 1024 to try and release more memory. If you have plenty of memory you may like to increase the output buffer from the default of 4K, by specifying an output buffer size of say -32K.

`DEFINE` *`symbol=val`*
`DEFINE` *`symbol=symbol`*

This defines a symbol to be used in the linking process. This is particularly useful in conjunction with the `PRELINK` option to force certain routines to be pulled from the library even though no references to them exist. Note that you can assign either a value or another symbol.

`DRISYM` Force symbols placed in the executable to be of standard format. Note that this option is only effective when generating an executable file.

`IGNORE` Force CLink to continue after serious errors. Note that the use of this option may result in a nonexecutable file if an error has occurred.

`NOALVS` Forces CLink to warn you when it creates ALVs to resolve 16 bit PC relative code. This can be used to watch for CLink creating a non-relocatable object from what was intended to be relocatable code. Note that the related option `XNOALVS` completely suppresses ALV generation but introduces the possibility of incorrect output files.

`NOCASE` Ignore casing of symbols whilst resolving externals

`QUIET` Causes CLink to print out no messages unless an error occurs.

`WITH` *`file`* Specifies a file containing CLink command options to be processed for this link. More than one `WITH` file may be specified and `WITH` files may contain `WITH` statements. The contents of all `WITH` files will be treated as if they were specified on the CLink command line.

`VER` *`file`* Specifies a file to contain all the messages output by the linker. If this is not specified all messages are written to the standard output stream. Note that `VERIFY` is a synonym for `VER`.

`VERBOSE` Causes CLink to print out the names of each file as it processes it and a summary of memory usage and elapsed time on completion.

`XNOALVS` Prevents CLink from creating ALVs to resolve 16 bit PC-relative code. Note that the use of this option may force CLink to fail in pass 2 with a fatal error.

'WITH' files

A `WITH` file provides a method for encapsulating long and complex (or short and simple) CLink command lines in a control file, known as a `WITH` file, traditionally with the extension .LNK. The format of a `WITH` file is identical to the normal command line driven structure, except than line breaks may be used in place of spaces. For example the first simple command line example could have the `WITH` file:

```
FROM a.o b.o
```

Consider a slightly more complex example of program which is to consist of two modules (object files) and a library:

```
FROM        a.o+b.o     ; the object files
LIB         mylib.lib   ; and a simple library
TO          progl.prg   ; output file name
XADDSYM                 ; add HiSoft extended symbols
VERBOSE                 ; output verbose messages
MAP         .map,F,H,X  ; produce map file
```

Note the use of the ; to delimit comments in a WITH file. This file can then be passed for execution to the linker using the command line (assuming the WITH file is saved as mywith.lnk)

```
CLINK WITH mywith.lnk
```

A more complex example would be to consider a mixed language example with both C and assembler modules. Assuming that the main project was written in C, the normal C runtimes would have to be included, additionally it may be necessary to force some external data items defined in the assembly language to use the _ prefix required by C, this can be done using the DEFINE directive:

```
FROM c.o                ; C startup code
a.o+b.o                 ; assembler object files
d.o+e.o                 ; C object files
LIB lcg.lib+lc.lib      ; GEM & C runtime libraries
TO prog2.prg            ; output file
DEFINE _menu=menu       ; alias menu defined in assembly
                        ; to menu  referenced in C
MAP .map,f,h,l,s        ; map file
XREF .xrf               ; separate cross-reference file
HEIGHT 66               ; longer page length
FWIDTH 10               ; narrower filename width
```

Note that the contents of WITH files are always processed *after* any files explicitly named on the command line, hence if the last WITH file were named mywith2.lnk, then the command line:

```
CLINK WITH mywith2.1nk LIB mylib.lib
```

would search the mylib.lib file *before* searching the leg.lib or lc.lib files.

CLINKWITH; the Clink environment variable

The environment variable CLINKWITH, if available, is taken by CLink to be the name of a WITH file whose contents is to be searched *before* any of the other files mentioned on the command line. This allows a template WITH file to be generated with the standard startup and library files mentioned in the CLINKWITH file, whilst the additional files are specified on the command line. The format of the CLINKWITH variable should be:

```
CLINKWITH=c:\devpac\default.lnk
```

Note that if you are running on a TT you usually want the load bits set to run in alternate RAM etc., but CLink defaults to TTLOAD etc. off, for compatibility. If a CLINKWITH file is specified and includes the lines:

```
TTLOAD
TTMALLOC
```

programs will automatically be linked to go into alternate RAM.

Reserved symbols

To provide access to the base of the sections created by the linker various symbols are invented by the linker. These are as follows:

_RESBASE, _RESLEN — Reserved symbols

These are reserved symbols used in the Lattice C resident startup code. If you use them in your own code your programs are almost certain not to work correctly.

_LinkerDB — Pointer to static merged data section

The address of this external variable points to the base of the merged data section. This allows a global data register (e.g. A4) to be set up. This is normally done by a piece of code of the form:

```
XREF        LinkerDB

lea         LinkerDB,a4
```

BSSBAS, DATABAS — Base of merged data sections

These names refer to the base locations in the __MERGED data section. The location of _BSSBAS is the first byte of the merged BSS, whilst _DATABAS is the first byte of the merged data. These variables may be accessed using the code sequence:

```
XREF        BSSBAS,       DATABAS

lea         BSSBAS,a0
lea         DATABAS,a1
```

_BSSLEN, _DATALEN — Merged section lengths

The addresses of these names give the length of the respective __MERGED data section in *longwords.* Note that these variables *must* be accessed as longs otherwise the assembler may attempt to relocate them, giving random values as a result.

```
            XREF    _BSSLEN, _DATALEN

            move.l    #_BSSLEN,d0
            move.l    #_DATALEN,d1
```

_end, _edata, _etext — Last locations in program

These names refer to the last locations in the program. The address of _etext is the first location above the executable program text, that of _edata the first location above the initialised data area and _end the location immediately after the uninitialised data area.

CLink Messages

Whilst running CLink may discover things which it needs to bring to your attention. These may either be error messages or observations on the program which is being built.

CLink Warnings/messages

The messages in this section although warnings, will often indicate that the final program will be unusable in the form intended and you should not run it unless you are certain that you understand what you are doing.

Warning MERGED data > 64K

The merged data section has exceeded the limit of 64K. The problem may be rectified by moving some of your `__MERGED` out of this section.

Warning! Absolute reference to *name* module: *mod* file: *file*

An absolute reference was detected to a merged data item, whilst building a resident load module. This warning will only be given if a reference has been made to the symbol `__RESBASE`, i.e. the linker is building a resident load module.

Warning: ALVs were generated

This message is generated when the `NOALVS` option is used, indicating that ALVs were generated-. Note that this message will not be issued if the `XNOALVS` option is used.

Enter a DEFINE value for *name* (default __stub):
Undefined symbols... First Referenced

These messages indicate that the linker has encountered a reference to a symbol for which it cannot locate a definition. The second message is issued if the `BATCH` keyword is specified, whereas the first allows you to specify an alternate name for the reference.

Clink Errors

These are the errors which may be issued by the linker. In general errors may be ignored by use of the `IGNORE` keyword to CLink, however programs so produced may not function correctly. The error numbers are broadly divided so that 200-400 may be issued by either pass. 401-500 are issued by pass 1, whilst 501-599 are issued during pass 2.

Note that if a module has been compiled with line debugging turned on then the line number on (or near) to where the problem occurred will also be reported.

200 Out of memory!

The linker does not have enough memory left to successfully complete the link.

300 System error *val* on read

A system error occurred whilst attempting to read from the disk. This should only occur if the disk has been damaged in some way. The value of the error is given by `<val>`.

301 System error *val* on write

A system error occurred whilst attempting to write to the disk. This will normally indicate that the disk is full. The value of the error is given by `<val>`.

400 *** Break: CLink terminating

This message is printed when the operation of the linker is interrupted by the user pressing Control-C. Note that the keyboard is only checked whilst screen input or output is occurring.

425 Cannot find library *file*

The file named in a `LIB` statement could not be located by the linker. This is probably due to a full pathname not being given for the file.

426 Cannot find object *file*

The file named in a `FROM` statement could not be located by the linker. This is probably due to a full pathname not being given for the file.

443 *'file'* is an invalid file name

The filename specified in a `FROM` or `LIB` statement is invalid. Typically this will be because the name is null.

444 hunk_symbol has bad *val* symbol *file*

A hunk_symbol hunk type was encountered by the linker which did not have the external type set to zero, but instead to **val.** If this error occurs it indicates that the named input file was damaged in some manner.

445 Invalid hunk_symbol *name*

A hunk_symbol hunk type was encountered by the linker during parsing of the external definitions. The named symbol was attached to this hunk.

446 Invalid symbol type *val* for *file*

Whilst parsing external declarations an unknown symbol type `<val>` was encountered in the named file.

448 *file* is not a valid object file

The named file did not match the specifications for an object module.

449 No hunk end seen for *file*

On reaching the end of a hunk within the named file an end marker did not appear.

450 Object file *file* is an extended library

An attempt has been made to use a library as the operand of a FROM statement. Libraries may only be searched, not included.

501 Invalid Reloc 8 or 16 reference

An attempt has been made to generate a branch between two differently named sections. Branches may only occur within a common section. This error will normally indicate an attempt to execute the data section!

502 *name* symbol - Distance for Reloc 16 > 32768

The target of a 16 bit branch is more than 32K away from the reference. In general you should not see this message due to ALV generation.

503 *name* symbol - Distance for Reloc8 > 128

The target of an 8 bit branch is more than 128 bytes away from the reference.

504 *name* symbol - Distance for Data Reloc 16 > 32768

A 16 bit base-relative data section access is attempting to reach more than 32K. This error will normally indicate you are very close to the 64K limit on near data, and a module has had its data section fall off the end of the merged data section (biased by 32K). The solution is to reorder your modules putting the ones with large data sections alternatively you may have to move some of your near data to far.

505 *name* symbol - Distance for Data Reloc8 > 128

An 8 bit base-relative data section access is attempting to reach more than 128 bytes. This error will normally indicate incorrect code generation from the compiler.

506 Can't locate resolved symbol *name*

During the second pass the linker could not locate the named symbol in its table. This will either indicate an internal linker failure or a damaged library file.

507 Unknown Symbol type *val,* for symbol *name*

During the second pass the linker could not match the type of the named symbol in its table. This will indicate an internal linker failure.

508 Symbol type *val* unimplemented

Whilst parsing external declarations an unknown symbol type `<val>` was encountered in the named file. Note that the equivalent error (446) is reported during pass 1.

509 Unknown hunk type *val* in Pass2

The named file did not match the specifications for an object module. Note that this message is identical to the pass 1 error 448.

510 *name* symbol - Reference to unmerged data item

A module has attempted to access an unmerged (far) data item using a `near` access.

515 An ALV was generated pointing to data *name* symbol

An ALV was generated in the data section of the program. This will only occur if code generation has been performed in a data section, and as such this error will normally indicate an internal compiler failure.

517 Cannot find prefix file *file*

The named `PREFIX` file could not be found.

518 __MERGED data not supported in absolute mode

The linker is operating in absolute mode, but a reference to a data item in the `__MERGED` has been found; such references art not supported in absolute mode.

519 Segment base not specified for *section* in absolute mode

Whilst operating in absolute mode no section base was found for the named section; when generating Motorola S-records the base of every section which is used must be specified.

600 Invalid command 'and[1]

The named command was not recognised by the linker. The commands which are recognised are discussed in the section CLink, The Linker.

601 *cmd* option specified more than once

An attempt has been made to specify a command, which may only appear once, more than once, e.g. attempting to specify two `TO` files.

602 Unable to open output file *'file'*

The named output file could not be opened. This may be because the disk or directory is full.

603 *val* is not a valid number

The value `<val>` which appeared as a numeric argument could not be parsed as such.

604 with file is not readable

An error occurred whilst reading the `WITH` file.

605 Cannot open with file *'file'*

The named `WITH` file could not be opened.

607 No FROM files specified

No `FROM` files were specified so the linker cannot start linking.

608 Premature EOF encountered

End-of-file occurred unexpectedly. This will normally indicate serious file system structure problems.

609 Error seeking in file *file*

An error occurred whilst attempting to seek about the named file. This will normally indicate serious file system structure problems.

611 Reloc found with odd address for symbol *name,* file *file*

A 16 or 32 bit relocation was attempted on a non word-aligned boundary. This is always illegal on the 68000.

ERROR: Invalid decimal constant *'vat.*

The value `<val>` which was entered in response to an undefined symbol was an invalid decimal constant.

ERROR: Invalid hex constant *'vat.*

The value `<val>` which was entered in response to an undefined symbol was an invalid hexadecimal constant.

ERROR: Multiply defined symbol *'name'.*

A symbol has been redefined. The file in which it first appears is named, as is the file in which the attempted re-definition occurs.

ERROR: Symbol *'name'* is not defined.

The named symbol which was entered in response to an undefined symbol was also undefined.

Hunk #n not written

The numbered hunk `n` was not written to disk. This will indicate an internal linker failure.

Unknown internal error

An internal error occurred whose error number was not recognised. This indicates a serious internal linker failure.

Chapter 6 - Other Tools

S-record Splitter

If you are developing code for an embedded system, you will need to 'burn' you final code into EPROM. Most EPROMs are byte-wide devices, so if you are producing a system with a 16 bit data bus, you need two EPROMs, one for the odd numbered bytes and the other for the even numbered bytes. If you are developing for a system with a 32-bit data bus, four different EPROMs are required.

Many EPROM programmer's accept Motorola S-records as input and Gen will happily generate absolute S-record code, but Gen generates the entire output file in one go. This is fine for downloading into RAM or where the ROM size matches the data bus width, but doesn't help in the situation above. This is where SRSplit, the S-record splitter comes in. It splits an S-record file into two or more S-record files. The address fields of the new files are calculated so that they are appropriate for 'burning' into EPROM as described above.

`SRSplit` is a CLI program whose command line should be of the form:

```
<-options> <filename> [filename]
```

The filename gives the file to split; more than one file may be split at once. The options available are

`-b` this specifies a base offset that will be added before the address calculation is performed. The offset should be specified in decimal or preceded by `0x` for hexadecimal. You can also use octal by specifying `0` at the start of the number. See below for an example.

`-px` this must be followed by the number of pieces, `x`, into which the file will be split. The default is 2 and the most common alternative is 4, although other values (up to 9) may be used *if you* wish.

Note that the options *must* come before the filename. The output filenames are the input filename with 1, 2 etc. added.

Command line examples

```
bootrom.mx
```

This splits bootrom.mx into bootrom.mx1 and bootrom.mx2.

```
-p4 test.mx
```

This splits the file test.mx into 4 files: test.mx1, test.mx2, test.mx3 and test.mx4.

```
-b0x14000 -p4 test.mx
```

This splits test.mx into 4 files, adding an offset of $14000 to the addresses in the S-records. You might use this if your file is designed to be run at 0 but needs to be sent directly to an EPROM programmer whose memory buffer starts at $14000.

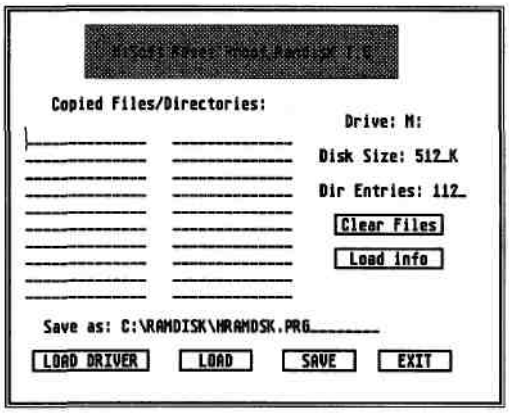
Ramdisk

The ramdisk lets you use some of your system RAM as a very fast disk drive that makes even the fast Atari hard disks seem slow. The problem with many ramdisks is that they disappear when you press reset. If you are developing a new GEM-based program and are having problems with your mouse or menu you can need to reset quite often.

RAMINST.PRG and RAMINST.RSC let you set up a ramdisk that will survive resets. Whilst this will work in 99% of cases, occasionally, if a program crashes in a particularly nasty way you will lose the contents of the ramdisk. To avoid this save the source code on to your real disk before running your program. Hramdsk will additionally copy the files and folders that you would like on the ramdisk automatically when you switch on.

The version of HRAMDSK.PRG that we supply isn't set up to copy any files initially. Before running RAMINST to tailor the ramdisk to your preferences, HRAMDSK.PRG should normally be in the AUTO folder on the current disk as this will be used as a basis for the ramdisk driver.

To run RAMINST copy it just double-click on RAMINST.PRG. If the driver cannot be found in the AUTO folder you will be presented with a file selector to enter the drive, path and file to load. Once the driver has been loaded, RAMINST will present you with a GEM dialog box like this:



You can change the files and folders that are copied by clicking on one of the relevant fields and editing it. To clear out the existing names click on the Clear Files button.

You can use simple filenames, filenames with wildcards or directory names. If you specify a directory name the entire directory (and any sub-directories within it) will be moved to the ramdisk. Note that you can specify the drive from which the files are copied.

Change the size of the ramdisk by simply modifying the Disk Size field. This is the amount of memory used by the disk and is slightly larger than the data size because some of the space is used for the directory and the file allocation table. You can use any size you like, subject to the available amount of RAM.

Normally you can have up to 112 directory entries in your main directory (just like a standard floppy disk) and this is usually sufficient. However you may change the maximum number of directory entries using the Dir entries field of the dialog box. For example, if you have a two and a half Megabyte ramdisk and using it to store (amongst other things) all the relocatable files for your 100 module wonder program and don't want to put them in a subdirectory, you can use this option to increase the number of directory entries.

If you don't like the ramdisk being called drive M you can change this too. You can also

change the disk, directory and file to which the driver will be saved.

If you wish to modify a differently installed version of the ramdisk you can click on the Load button and load another file. The Load Driver button can be used if we upgrade the ramdisk: it loads just the ramdisk driver itself leaving the installed files, disk size etc. intact.

Note that the ramdisk is only designed to be run from the AUTO folder; it can't be run once the system has booted.

Symbol Strip Utility

We supply, as strip.ttp, a utility for removing the symbol table and any information after the relocation information from an executable file.

Any number of files, which should include any extension, may be specified on its command line. If a file is not executable it is simply ignored.

Example

This example assembles MYPROG.S to produce MYPROG.PRG, which is then linked and then has its symbols and debug information removed:

```
gen -x myprog
strip myprog.prg
```

Appendix A - GEMDOS error codes

This appendix details the numeric GEMDOS errors and their meanings. The error numbers shown are those displayed by Devpac; when calling GEMDOS from your own programs these values will be negative.

0	OK (no error)	32	Invalid function number
1	Fundamental error	33	File not found
2	Drive not ready	34	Path not found
3	Unknown command	35	Too many files open
4	CRC error	36	Access denied
5	Bad request	37	Invalid handle
6	Seek error	39	Insufficient memory
7	Unknown media	40	Invalid memory block address
8	Sector not found	46	Invalid drive
9	No paper	49	No more files
10	Write fault	50	Disk full (not a GEMDOS error - only produced by the editor)
11	Read fault	64	Range error
12	General error	65	Internal error
13	Write protect	66	Invalid program load format
14	Media change	67	Setblock failure due to growth restrictions
15	Unknown device		
16	Bad sectors on format		
17	Insert other disk		

Appendix B - Devpac error messages

Devpac can produce a large number of error messages, most of which are pretty well self explanatory. This appendix lists them all in alphabetic order, with clarification for those which require them.

Please note that Devpac is continually being improved and this list may not agree exactly with the version you have, there may be additional messages not documented here.

Errors

If you get a message beginning with INTERNAL please tell us how to generate it - you should never see these.

probably missing

You have used an absolute reference where an immediate one was more likely. This will also occur if you miss out the address register when you are accessing variables via a base register. If you really mean the absolute reference, use an explicit `.L` or `.W` or disable `OPT CHKIMM`.

.W or .L expected as index size

absolute expression MUST evaluate

absolute not allowed

additional symbol on pass 2

somehow a symbol has appeared during pass 2 that did not appear during pass 1.

address register expected

addressing mode not allowed

addressing mode not recognised

assembly interrupted

bad floating point expression

Bit number should be 0-7 for byte

BSS or OFFSET section cannot contain data

OFFSET sections and BSS sections can only contain DS directives.

cannot create binary file

could be a bad filename, or a write-protected disk, etc.

cannot export symbol

cannot import symbol

cannot nest MACRO definitions or define in REPTs

macro definitions may not be nested or defined within repeat loops.

cannot nest repeat loops

colon (:) expected

in multi-register 68020 argument.

comma expected

data register expected

data too large

DCB or DS count must not be negative

division by zero

duplicate MODULE name

module names must be unique

error during listing output

listing will be stopped at this point

error during writing binary file

normally disk full.

error in command line symbol executable code only

only executable code may be assembled to memory.

expression mismatch

normally a syntax error within an expression.

fatally bad conditional

there were more ENDCs in a macro than IFs.

file not found

floating point constant not allowed

floating point constant too large

floating-point register expected

after floating point instruction.

forward reference

garbage following instruction

hex floating point number too large

illegal BSR.S

a `BSR.S` to the following instruction is not allowed - change it to `BSR`.

illegal type combination

immediate data expected

imported label not allowed

include file read error

instruction not recognised

invalid 68020 addressing mode

invalid bitfield specification

invalid floating point expression

invalid FORMAT parameter

invalid IF expression, ignored

invalid index scale

invalid k-factor

invalid MMU function code

invalid MOVEP addressing mode

invalid number

invalid numeric expansion

the symbol is not defined or relative or a syntax error.

invalid opcode size for data/address register

invalid option

invalid printer parameter

invalid radix

invalid register list

invalid section name, TEXT assumed

invalid section specified

invalid section type

MMU register expected

privileged instruction

you have used an instruction that can only be used in supervisor mode after an `OPT USER` directive.

invalid pre-assembled file

either the pre-assembled file itself is corrupt or it was produced with an earlier or later version of the assembler. Re-make the file from the include file using the Output Symbols command.

invalid size

line malformed

linker format restriction

local not allowed

maths co-processor required

missing close bracket

missing ENDC

there were more `IFcc`s then `ENDC`s.

missing quote

misuse of label

MMU register expected

not yet implemented

number too large

odd address

only (An) allowed for this instruction

only occurs with 68040 MMU instructions.

only FPIAR allowed

option must be at start

ORG/RORG not allowed

out of memory

phasing error

should never happen, unless you have symbols that evaluate to different values on different passes. Investigate immediately before the first such error.

privileged instruction

when `OPT USER` is in operation.

program buffer full

change the program buffer size when assembling to memory.

register expected

relative not allowed

relocation not allowed

repeated include file

each include file may only be included once on each pass.

short branch cannot be 0 bytes

source expired prematurely

within an `IF`, `MACRO` or `REPT` and the source ran out.

spurious ENDC

spurious ENDM or MEXIT

spurious ENDR symbol defined twice

symbol expected undefined

symbol user error

caused by a FAIL directive.

wrong processor

XREFs not allowed within brackets

Warnings

.L converted to .W

when optimising.

68010 instruction, converted to MOVE SR

MOVE CCR, is *not* a 68000 instruction (only when in 68000/8 mode).

ADD/SUB converted to LEA

when optimising.

base displacement shortened

when optimising.

Bit number should be 0-7 for byte

when OPT WARNBIT used.

branch could be short

forward branch could be optimised.

branch made short

by optimising.

directive ignored

invalid LINK displacement

if negative or odd.

LEA converted to ADDQ/SUBQ

misuse of register list

A register list created using `EQUR` has been used in an expression.

MOVEQ substituted

`move.l #nn,d0` optimised to `moveq #nn,d0`.

no ORG specified

When generating absolute code via S-records.

offset removed

`XX(An)` form reduced to `(An)` by optimising.

outer displacement shortened

when optimising.

quick form used

when optimising.

relative cannot be relocated

short branch converted to NOP

when optimising.

short word addressing used

when optimising.

sign extended operand

data in `MOVEQ` needed sign extension to fit.

size should be .W

Appendix C - TOS Memory Map

This Appendix details information about the TOS memory map.

The Different Sorts of RAM

Newer versions of TOS can have two different sorts of memory: system RAM and alternative RAM. System RAM is also known as ST or chip RAM; this is because it corresponds to the memory on Atari ST and STE computers which can be accessed by the video, ACSI DMA and DMA sound hardware directly, but because of this it is not particularly fast.

Alternative RAM is also called TT or fast RAM because it uses the 68030's burst mode feature which is very much faster than ordinary memory accesses and there is no contention between them and DMA accesses. The disadvantage is that alternative RAM cannot be used to store the actual screen image that is being displayed by the hardware.

Programs may be loaded into alternative RAM and have their GEMDOS `m_alloc` calls given alternative RAM by altering their program header. This can be achieved from Devpac using the `COMMENT HEAD=` directive; see the assembler section for details. If you are using CLink, you can achieve this with the `TTLOAD` option. Programs may specifically request a particular sort of RAM by using a new GEMDOS `m_xalloc`. This is described in Appendix D. For most programs, the best strategy is to load into alternative RAM and then use m_xalloc calls requesting alternative RAM (or system RAM if none is available). The exception to this is memory that is allocated for physical screens, which should come for system RAM only.

Processor Dump Area

When a program crashes with an exception (i.e. bombs) TOS stores a copy of the processor's state in an area of memory which is not destroyed by a reset. Thus after such a crash you can load Mon and investigate the relevant area of memory to try to ascertain what exactly went wrong. If this happens a lot you should use the auto-resident version of Mon so you will have a much better idea of the cause of the problem.

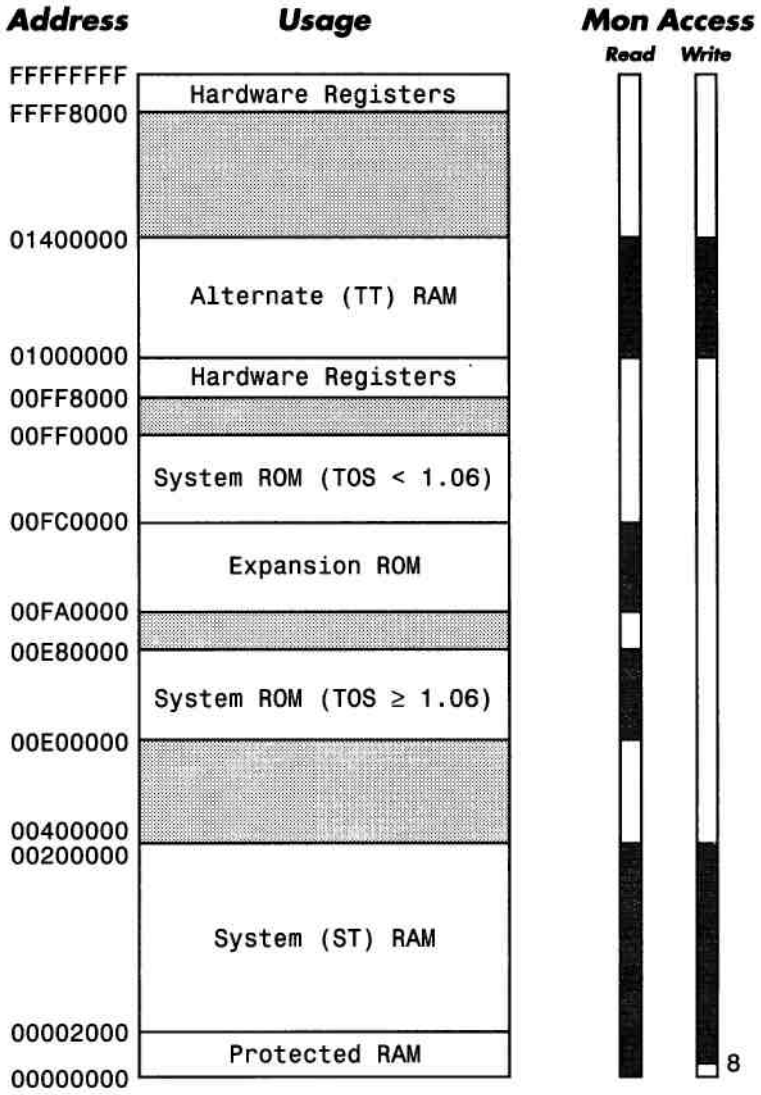
`$380`	long	contains $12345678 if valid
`$384`	8 longs	saved values of D0-D7
`$3A4`	8 longs	saved values of A0-A7 (SSP)
`$3C4`	byte	exception number
`$3C8`	long	saved USP
`$3CC`	16. words	copied from the SSP

Base Page Layout

Every program that runs under GEMDOS has a base page area which contains certain information. It is $100 bytes long.

Offset	Name	Contents
$00	p_lowtpa	base address of the TPA (i.e. here)
$04	p_hitpa	pointer to end of TPA +1
$08	p_tbase	pointer to start of TEXT area
$0C	ptlen	length of TEXT area
$10	pdbase	pointer to start of DATA area
$14	p_dlen	length of DATA area
$18	p_bbase	pointer to start of BSS area
$1C	p_blen	length of BSS area
$20	p_dta	pointer to DTA address
$24	pparent	pointer to parent's base page (0 if desk accessory)
$2C	p_env	pointer to environment string
$80	p_cmdlin	command line; length byte then string, which is guaranteed to be null-terminated

Hardware Memory Map



Not to scale

Appendix D - GST Support

LinkST, The GST format linker

Introduction

LinkST is a linker that links GST-format files. In general we recommend that you use the Lattice C format linker, CLink rather than LinkST since CLink is faster and has more facilities. LinkST does have one advantage over CLink though: it will let you link with other languages that produce GST format files.

LinkST will only link GST-format files.

Invoking LinkST

As with most of the tools supplied with HiSoft Devpac 3 you can either run LinkST from the Desktop or from a shell and can either supply a complete command line or specify a link file which contains the required information.

The command line should be of the form:

```
<filename> <-options> [filename] [-options]
```

Options are denoted by a - sign then an alphabetic character, supported options being:

`-B` generate a true BSS section for any such named sections

`-D` debug - include all symbols in the binary file using DR standard 8 character format (for Mon or other debuggers)

`-F` force pass 2 of the linker, useful if you want to see all errors (as any pass 1 errors will, by default, stop the link before the second pass)

`-L` specify that all following filenames are library filenames

`-M` dump a map file showing the order of the sections and labels. The map filename will be the main filename with an extension of .MAP

`-O` specify object code filename, may be followed by white space before filename

`-Q` 'quiet' mode, which disables the pause after the link

`-S` dump a symbol table listing, The symbol table filename will be the main filename with an extension of .SYM

`-T` truncate to eight characters

`-U` force upper case

-W specify control file filename, defaults to .LNK extension

-X extended debug, using the HiSoft extended debug format for use with Mon.

Normally any file specified given are assumed to be input files, defaulting to the extension of .BIN, though if a .LNK extension is specified it will be taken to be a control file. After a -L option, filenames are all assumed to be library files.

The output file can be specified with the -o option on the command line, or using the OUTPUT directive in the control file. If there is more than one of these directives or options, the last one is used. If there is none given, then the first input filename specified in the command line or control file is used, with an extension of .PRG.

Example Command Lines

```
PART1 PART2 -d
```

Reads PART1.BIN and PART2.BIN as input files, and generates PARTI.PRG as an output file complete with debugging information.

```
PART1 PART2 -o TEST.PRG
```

Reads PART1.BIN and PART2.BIN as input files, and generates TEST.PRG as an output file.

```
-o TEST.TOS START -1 MYLIB -S
```

Reads START.BIN as an input file, selectively reads MYLIB.BIN as a library, and generates the output file TEST.TOS and the symbol listing file TEST.SYM.

LinkST Running

LinkST has two passes - during pass 1 it builds up a symbol table of all sections and modules, and during pass 2 it actually creates the output file. When it starts it prints a logon message, then reports on which files it is reading or scanning during both passes. This gives you some idea of what takes time to do, as well as exactly where errors have occurred.

If there is enough free memory at the end of pass 1, LinkST will use a cache to store the output file, which speeds up the process greatly. If it uses the cache it will write to the disk at the end of pass 2, and report the number of errors.

When the link finishes you will be prompted to press a key before quitting. This is to give you an opportunity to read any warning or error messages before returning to the Desktop. You can disable this pause by using the - q option, useful if you are using a CLI.

Error and warning messages are directed to the screen - if you want to pause output you can press Control-S, while Control-Q will resume. Pressing Control-C will abort the linker immediately.

You can re-direct screen output to a disk file by starting the command line with

```
>FILENAME.TXT
```

or you can re-direct it to a printer by starting the command line with

```
>PRN:
```

to the parallel port, or

```
>AUX:
```

to the serial port.

If you do re-direct output in this way you should use the -q option as you won't be able to see the prompt at the end of the linking.

Control Files

The alternative way to run the linker is to have a control file for the programs which you are linking together.

If you require a lot of options which won't fit on the command line or you get bored of typing them, you can use a control file, which is a text file containing commands and filenames for the linker. The default extension is .LNK and the control filename is specified on the command line using the `-w` (for With) option. Each line can be one of the following:

INPUT *filename*

This specifies a filename to be read as an input file. The default extension is .BIN if none is given.

OUTPUT *filename*

This specifies the filename to be used for the output file. There is no default extension - you must specify it explicitly.

LIBRARY *filename*

This specifies a filename to be scanned as a library. The default extension is .BIN if none is given.

SECTION *sectionname*

This allows specific section ordering to be forced.

DEBUG

All symbol names included in the link are put in the output file so that debugging programs such as Mon can use them when the program is running.

XDEBUG

Similar to the debug option but uses HiSoft extended debug format for up to 22 character significance.

DATA *size* **[K]**

The BSS segment size is set accordingly. The size can be given either as a number of bytes or as a number of K-bytes (units of 1024). This option is particularly useful for the Prospero compilers which effectively use the BSS segment for their stack.

BSS sectionname

Specifies that the named section should lie in the GEMDOS BSS section area. This can save valuable disk space, but will generate errors if the section contains any non-zero data. This should not be used at the same time as the DATA statement.

TRUNCATE

Causes all symbols to be truncated to 8 characters. This is sometimes required to link assembly language with long labels to high-level language code with short labels.

UPPER

Forces all symbols to be automatically upper-cased. This is sometimes required when a compiler or assembler generates case-insensitive code.

Blank lines in the control file are ignored, and comments can be included by making the first character in the line a *, a ; or a !.

With the INPUT or OUTPUT directive, if the filename is specified as * it is substituted the first filename on the command line. This can be useful for having a generic control file for linking C programs for a particular memory model.

An example control file is:

*control file for linking large model gem programs

```
INPUT CNB
INPUT  *
XDEBUG
LIBRARY LCGNB
LIBRARY LCNB
SECTION TEXT
SECTION  DATA
BSS UDATA
```

Assuming this control file is called CPROG.LNK, the LinkST command line

```
TEST -w CPROG
```

will read as input files CNB.BIN and TEST.BIN, and scan the libraries LCGNB.BIN and LCNB.BIN. The object code, including extended debug information, will be written to TEST.PRG, as no output file was explicitly specified.

The two SECTION directives, above, ensure that the TEXT and DATA sections appear in the correct order in the output file. The BSS directive ensures that the UDATA section is treated as a true BSS section.

If you do not specify a drive name in the control file or on the command line, the default drive will be assumed. If you run LinkST from the Desktop, the default drive will always be the same as that containing the file on which you double-clicked; though if you run it from a CLI or from the editor this will not necessarily be so.

LinkST Warnings

Warnings are messages indicating that something might be wrong, but probably nothing too

serious.

duplicate definition of value for symbol x

The symbol was defined twice. This can happen if you replace a subroutine in a module with one of your own, for example. The linker will use the first definition it comes across, and give this warning on the second.

module name is too long

Module names can only be 80 characters long.

comment is too long

Comment directives are only allowed to be 80 characters long (don't ask us why, we don't know!).

absolute sections overlap

Two absolute sections clash with each other.

SECTION x is neither COMMON nor SECTION

A section name was specified without defining its type.

LinkST General Errors

unresolved symbol x in file x

The symbol was referred to but not defined in the file. There may also be other files which refer to the symbol, but this error gives you a start in your search!

XREF value truncated

A value was too large to fit into the space allocated for it, for example a `BSR` to an external may be out of range.

bad control line x

An illegal line was found in a control file.

non-zero data in BSS section

A section wanted as a true BSS section contained non-zero data.

LinkST Input/Output (I/O) Errors

file x not found

Can't open output file x

Can't open map file x

Can't open symbol file x

Can't open input file x

i/o error on input file disk

write failed

filename x was too long

LinkST Binary File Errors

These are errors in the internal syntax of the input file, and should not occur. If they do it probably means the compiler or assembler produced incorrect code.

missing SOURCE directive

Can occur if a file is not in GST format, for example a DRI file.

runtime relocation is only available for LONGs

attempt to redefine id of symbol x.

attempt to DEFINE x with *id* of zero

bad operator code *0x99* in XREF directive

bad truncation rule in XREF

wrongly placed SOURCE directive

bad directive *99*

***id 99* not DEFINEd as a SECTION but used as one**

attempted re-use of *id 99* as SECTION id

attempted re-use of x as SECTION name

section is COMMON but being used as though it's not

SECTION is being misused as COMMON

unexpected end of input file

'Linker Bug' Messages

These can be produced as a result of internal checks by the linker. If you get one please send us copies of the files you are trying to link!

GSTlib, The GST format librarian

GSTlib is a librarian that is designed for maintaining GST format libraries. When specifying filenames to GSTlib you must explicitly include the file extension, normally .bin.

GSTlib has a number of different possible command lines as shown below:

Replace modules

```
gstlib r[vsq][a|b obmod] library [files...]
```

This will replace any current occurrences of the modules contained in the given files. If a module is not already present in the library then it will be added. If the library does not exist then a new library will be created that just contains these files. The following additional options may be used

v (verbose). Echo when adding or replacing a module or creating a library.

a *mod* (after). If adding a new module insert it after mod.

b *mod* (before).If adding a new module insert it before mod.

S (sort). Sort the library so that it can be scanned by a linker in a single pass, if possible. If this fails due to circular references then the new library will be saved in libname.tmp and the original library left as it was.

q (quit). Wait for Return to be pressed before exiting GSTlib, for use with the Desktop.

Update modules

```
gstlib u[vsq][a|b obmod] library [files...]
```

This works in precisely the same way as the replace modules option except that the modules are only updated if the versions in the files are more up to date than the version in the library. Exactly the same options may be used as with the r option.

Load modules

```
gstlib l[vq] prog.lib [files...]
```

This option can be used to produce a library that contains just the modules that would be included when linking a program. The V and q modifiers have their usual meaning. For example:

```
gstlib 1 prog.bin c.bin yourprog.bin lc.bin
```

could be used to create a library containing the modules required by yourprog. You could then run LinkST without the need to scan the library. Once you have created a library using this option it is unwise to sort it subsequently.

Delete modules

```
gstlib d[vsq] library [modules....]
```

Deletes the modules with the given names. As usual V will cause the librarian to inform you of its progress, q will pause before exiting and S will attempt to sort the library after performing the deletions.

Move modules

```
gstlib m[vsq][a|b obmod] library [modules...]
```

Moves the given modules to the end of the library unless either a or b are specified, in which case:

a *mod* moves the modules immediately after mod and

b *mod* moves the modules immediately before mod.

The other modifiers have their usual meanings.

Tabulate modules

```
gstlib tfvvvvvq] library [modules...]
```

This form of command line displays information about the given modules in the library. If no

module list is included, the information is given about all modules. The different levels of information are as follows:

v module names only

vv as per v and the size and date

vvv as per vv and the list of exported (xdef) symbols

vvvv as per vvv and the list of imported (xref) symbols

vvvvv as per vvvv and a cross reference of the symbols

As ever, q may be included to pause before GSTlib terminates.

Extract modules

```
gstlib x[vkq] library [modules....]
```

This extracts the given modules from the library. If no modules are specified then all the modules are extracted. Note that module names may have .o, .c or .bin appended to them depending on the tool that produced them. The additional modifiers are:

k keep date stamp from library on the extracted files

v inform the user of progress

q pause before exiting

If a module that is being extracted does not have a name it will be placed in a file called dummy###.BIN where ### is a unique decimal number.

Librarian command files

If the command line to GSTlib contains an @ sign, the name following this is taken as a command file name and the command read from this. Additionally such files may contain lines starting with #; these are treated as comments. Long lines may be split by using \ as the last character of the line.

Example command lines

```
gstlib tv lc.bin
```

List all the modules in the library lc.bin; there are quite a few!

```
gstlib xk lc.bin printf.O
```

Extract the module printf.o into a file called printf.o retaining the date stamp that it had in the library.

```
gstlib d lc.bin printf.bin
```

Remove the module printf.bin from lc.bin.

Appendix D - Calling the Operating System

The operating system of the Atari is large and complex and consists of various levels. To help in your own program development, this appendix describes the calling mechanisms and routines available, but it is not intended to be definitive. It also details the various example programs and include files supplied with HiSoft Devpac 3. The various levels of the operating system are:

GEM AES	window and event manager
GEM VDI	device-independent graphics routines
GEMDOS	disk and screen I/O, similar to MS-DOS
BIOS	low level I/O
XBIOS	extended low level I/O

Each of these will now be described in varying degrees of detail.

GEMDOS - Disk and Screen I/O

GEMDOS was converted from CP/M 68k and is similar in many ways to generic CP/M but with extra facilities (e.g. sub-directories) taken from MS-DOS. It is responsible for disk I/O and character I/O via the screen, keyboard, serial and parallel ports. It is also responsible for memory management.

GEMDOS was designed to be called directly from C, so all parameters are put onto the stack and have to be removed afterwards. The calling sequence from assembler is of this general form:

```
move        ??,-(a7)    put parameters on stack
move.w      #??,-(a7)   the function number
trap        #1          call GEMDOS
add.w       #??,a7      restore the stack
```

Your code will be smaller and faster if you use `addq.w` instead of `add.w` if the stack adjustment is 8 bytes or less. If the adjustment is more than this, the best bet is

```
lea         ??(a7),a7
```

You can use the optimisation option of HiSoft Devpac 3 to automatically choose the best instruction for you - just use an unoptimised `add.w`.

If you are using a number of GEMDOS calls in a row you will save bytes by performing one large correction at the end rather than after each GEMDOS call.

Incidentally, a major source of bugs when starting programming with GEMDOS is forgetting to correct the stack, or correcting it by the wrong value.

We have supplied an include file with the names of the routines as constants in the file GEMDOS.I. To include these in your program you should use:

```
include     gemdos.i
```

near the start of your program. Using the constants rather than using the absolute numbers explicitly and including a comment, gives you no chance of having a disagreement between the comment and the number!

Program Startup and Termination

Under GEMDOS a program starts up it owns all of the largest block of free memory - normally the memory from the end of the program through to the end of usable RAM (normally just before the screen) is owned by the program, which is just as well as the stack is at the very end of this area. This also applies to alternative RAM programs that are loaded into system RAM. In a similar way, an alternative RAM program that is loaded into alternative RAM will normally own all the available alternative RAM when it starts.

If any memory management calls (such as `m_alloc`) are required, you wish to execute other programs within yours, or if you are writing a GEM program, it is important to give back some of this memory. If you don't there will be no free memory for these uses. This is normally done during at the beginning of programs using the m_shrink call, utilising the fact that a pointer to the programs basepage is 4 bytes down on the stack, like this:

```
include     gemdos.i
move.l      4(a7),a3    basepage
move.l      $C(a3),d0   text length
add.l       $14(a3),d0  data length
add.l       $1c(a3),d0  BSS length
add.l       #extra,d0   any additional memory
add.l       #$100,d0    basepage length
move.l      #mystack,sp before shrinking
move.l      d0,-(sp)
move.l      a3,-(sp)
clr.w       -(sp)
move.w      #m_shrink,-(sp)
trap        #1          do the shrink
lea         12(sp),sp
```

The extra bytes may be required for your programs storage. Note that you should move the stack to a safe area *before* the shrink, otherwise the stack will be in memory that is not owned by your program and liable to corruption.

A GEMDOS program can terminate in one of three ways: `p_term0`, which is not recommended, `p_term`, the normal way to finish a program, and `p_termres`, for system patches and the like. For normal termination use this code:

```
clr.w       -(a7)       return code of 0
move.w      #p_term,-(a7)
trap        #1
```

When a program terminates all memory it owns is freed (unless you use `p_termres`) and any open files are closed.

GEMDOS Summary

The calls will now be described in numeric order by giving the size of the parameters, in the order they should be placed on the stack, and the stack correction number. For example, using function call 2, C_conout, to print the character X, the code would be

```
move.w      #'X',-(a7)        the character
move.w      #c_conout,-(a7)   the function number
trap        #1                call it
addq.w      #4,a7             then correct
```

GEMDOS calls may corrupt the D0-D2/A0-A2 registers. Note that many of the current calls only corrupt D0 and A0; thus if you omit to save D1/D2/A1/A2, you may have a difficult bug to spot in the future!

0 - Terminate Process (old form), p_term0

Parameters: *None*
Result: *None*
Stack: *2*

This terminates the current program, with a return code of 0. It is recommended that p_term (function $4c) should be used in preference to this call. As control never returns after the call, no stack correction is actually required.

7 - Read character from keyboard, c_conin

Parameters: *None*
Result: *D0.L=key code*
Stack: *2*

This waits for a key to be struck, echoes it to the screen, and returns its value. The long result has the ASCII value in the lowest 8 bits, and a physical key number is returned in bits 16-23. All other bits are set to 0.

2 - Write character to screen, c_conout

Parameters: *word: character*
Result: *None*
Stack: *4*

This writes the given character to the screen. A 16-bit parameter is supported for future expansion, so bytes should always be ANDed with $FF before the call, though currently the upper 8 bits are ignored.

3 - Read character from serial port, c_auxin

Parameters: *None*
Result: *DO.B=character read*
Stack: *2*

This waits for a byte to be received from the auxiliary device, which is the serial port.

4 - Write character to serial port, c_auxout

Parameters: *word character*
Result: *None*
Stack: *4*

This sends the character out via the serial port. As with function `c_conout`, the upper 8 bits of the word should be 0 for upward compatibility.

5 - Write character to printer, c_prnout

Parameters: word: character
Result: DO. W=0 if failed, -1 if OK
Stack: 4

This sends the character out via the parallel printer port. As with functions 2 and 4 above, bits 8-15 of the word should be 0.

6 - Raw I/O to standard I/O, c_rawio

Parameters: word: character for output, or `$00FF` to read
Result: DO. W if $00FF passed
Stack: 4

If the character is passed as $00FF then the keyboard is scanned and a result returned in `DO.W` (or 0 if no key available). If the character is not $00FF, then it is printed on the screen.

7 - Raw input from keyboard, cjrawcin

Parameters: None
Result: DO.L=character read
Stack: 2

This waits for a key to be pressed and returns its value. It does not echo it to the screen.

8 - Read character from keyboard, no echo, c_necin

Parameters: None
Result: DO.L=character read
Stack: 2

This waits for a key to be pressed and returns its value. It does not echo, but the control keys Control-C, Control-S and Control-Q are interpreted in their usual way - Control-C will abort the program, Control-S will pause output and Control-Q will resume it.

9 - Write string to screen, c_conws

Parameters: long: address of string
Result: None
Stack: 6

This writes the given null-terminated string to the screen.

$A - Read edited string from keyboard, c_conrs

Parameters: long: address of input buffer
Result: None
Stack: 6

Before calling this, the first byte of the buffer should be set to the size of the data portion of the buffer. On return, the second byte in the buffer will be set to the length of the string, and the string itself starts at the third byte. No CR or null is stored in the returned string and pressing Control-C will terminate the entire program.

$B - Check status of keyboard, c_conis

Parameters: None

Result: *D0.L=-1 if character available, 0 if none*
Stack: *2*

This returns the status of the keyboard. The key itself should be read with another call.

$E - Set default drive, d_setdrv

Parameters: *word: drive number*
Result: *DO.L=bit map of drives in the system*
Stack: *4*

This sets the default drive; a word of 0 denotes A:, 1 denotes B:, etc. The returned value has a bit set for each installed drive, bit 0=A:, bit 1=B:, etc.

$10 - Check status of standard output, c_conos

Parameters: *None*
Result: *D0.L=-1 if ready, 0 if not*
Stack: *2*

This tests to see if the console device is ready for output.

$ 11 - Check status of printer, c_prnos

Parameters: *None*
Result: *D0.L=-1 if ready, 0 if not*
Stack: *2*

This tests the status of the printer port. If the printer is ready to receive a character it returns -1, else it returns 0.

$ 12 - Check status of serial port input, c_auxis

Parameters: *None*
Result: *D0.L=-1 if character waiting, 0 if not*
Stack: *2*

This tests the serial port and returns -1 if there is a character waiting to be read.

$13 - Check status of serial port output, c_auxos

Parameters: *None*
Result: *D01=-1 if ready, 0 if not*
Stack: *2*

This tests the serial port and returns -1 if it is ready to receive a character.

$14 - Inform GEMDOS of alternative memory, m_addalt

Parameters: *long.size, long: start of alternative memory area*
Result: *DO.W=0 if OK, else error code*
Stack: *10*

This call is used to inform GEMDOS of the presence of alternative RAM; it should not be needed unless you have added custom memory to the system. This call was added in GEMDOS version 0.25.

$19 - Get default drive, djgetdrv

Parameters: *None*
Result: *D0.W=drive number*

Stack: *2*

This returns the number of the current drive, with A:=0, B:=l etc.

$1A - Set disk transfer address, f_setdta

Parameters: *long: pointer to disk transfer address*
Result: *None*
Stack: *6*

This sets the address of a 44-byte buffer used for searching for filenames; it must be word-aligned.

$20 - Get into Supervisor/User Mode, super

Parameters: *long: value for stack, or 0 or 1*
Result: *D0.L=(depends on parameter)*
Stack: *6*

This has two functions - it can tell you if the program is in User or Supervisor mode and it can switch from one mode to another. To find which mode the processor is in, call this routine with a parameter of 1. The return value will be 0 for user mode, and -1 for supervisor. To switch modes you have to supply a new stack pointer, or pass 0 if you want the stack to remain unchanged. For example, if you are in user mode and want to switch to supervisor mode using a `SSP` at address `myssp`, the code would be:

```
move.l      #myssp,-(a7)
move.w      #$20,-(a7)
trap  #1
addq.l      #6,a7
```

When switching to supervisor mode the old value of the `SSP` is returned in `d0.l`. If you only want to go temporarily into Supervisor mode to hack protected memory, for example, the XBIOS call supexec is a lot easier.

$2A - Get date, tjgetdate

Parameters: *None*
Result: *D0.W=0 if OK, else error code*
Stack: *2*

This reads the date, with the result in this format:

Day	bits 0-4
Month	bits 5-8
Year	bits 9-15 (since 1980).

$2B - Set date, t_setdate

Parameters: *word: date*
Result: *DO. W=0 if OK, else error code*
Stack: *4*

This sets the date, using the same word format as the previous function.

$2C - Get time, t_gettime

Parameters: *None*
Result: *DO.W*

Stack: *2*

This returns the time of the day, with the result in this format:

Seconds/2	bits 0-4
Minutes	bits 5-10
Hours	bits 11-15

$2D - Set time, t_settime

Parameters: *word: time*
Result: *None*
Stack: *4*

This sets the current time of day, in the same word format as the previous function.

$2F - Get disk transfer address, fjgetdta

Parameters: *None*
Result: *DO.L=pointer to disk transfer address*
Stack: *2*

This returns the current disk transfer address, and should always be even.

$30 - Get version number, s version

Parameters: *None*
Result: *DO.W=version number*
Stack: *2*

This returns the GEMDOS version number, with the major number in the low byte, and the minor number in the high byte. Known releases at this time are:

$0D00	version 0.13 (obsolete disk-based)
$1300	version 0.19 (ROM-based and Mega TOS)
$1500	version 0.21 (Rainbow and original STE TOS)
$1700	version 0.23 (STE TOS 1.62)
$1900	version 0.25 (MegsSTE, TT TOS)

$31 - Terminate and stay resident, p_termres

Parameters: *word: exit code, long: bytes to keep*
Result: *None*
Stack: *8*

This allows a program to terminate while keeping part or all of it in memory. It is useful for programs which extend the system, such as RAM disk drivers; if they terminated normally the memory they lie in would get destroyed when the next program loaded. The memory that can be retained is that starting at the base page, and the length parameter should include the $100 of the base page, the required program length, data and stack space if relevant. Also any RAM allocated via `m_alloc` and `m_xalloc` is retained, although any open files are closed.

$36 - Get drive free space, d_free

Parameters: *word: drive code, long: pointer to buffer*
Result: *None*
Stack: *8*

This returns various bits of information about a particular disk drive. The drive code should be 0 for the default drive, 1 for A:, 2 for B:, etc. The buffer should be 16 bytes long, and word aligned. On return, it will contain 4 longs of information: free space, number of available clusters, sector size (in bytes), and cluster size (in sectors).

$39 - Create a sub-directory, djcreate

Parameters: *long: address of pathname*
Result: *DO. W=0 if OK, else error code*
Stack: *6*

This creates a new directory, according to the null-terminated string.

$3A - Delete a sub-directory, djdelete

Parameters: *long: address of pathname*
Result: *DO.W=0 if OK, else error code*
Stack: *6*

This deletes a directory, so long as it has no files or other directories in it.

$3B - Set current directory, d_setpath

Parameters: *long: address of pathname*
Result: *DO. W=0 if OK, else error code*
Stack: *6*

This sets the current directory, according to the null-terminated string. Note that drive specifiers are *not* allowed - you should set the current drive then its directory.

$3C - Create a file, f_create

Parameters: *word: attributes, long: pointer to string*
Result: *DO.W=file handle if successful, else error (and longword negative)*
Stack: *8*

This will attempt to create the given file and if successful will return a file handle that can be used in other file GEMDOS calls. The attribute word can be these values:

01	read only
02	hidden file
04	system file
08	filename contains volume name in first 11 bytes

File handle numbers returned by this call and the following one start are words normally starting at 6 and go upwards. Handles 0 to 5 are standard handles which are already open when a program starts. They correspond to the following devices:

0	console input
1	console output
2	serial port
3	parallel port

There are three system device names, called `CON:`, `AUX:` and `PRN:` which can be used with this and the following call. They return negative words, so to distinguish these from error returns always `TST.L / BMI` for the error case.

$3D - Open a file, f_open

Parameters: *word: mode, long: pointer to filename*
Result: *D0.W=file handle if successful, else error (and longword negative)*
Stack: *8*

This will open an existing file for reading, writing, or both. The mode word must be one of the following:

0	open to read
1	open to write
2	open for both reading and writing

If successful this will return a handle which can be used subsequently, else an error number.

$3E - Close file, f_close

Parameters: *word: handle*
Result: *DO.W=0 if OK, else an error number*
Stack: *4*

Given a file handle this will close the file. Do not close a standard handle.

This call, along with all the others that require handles, do not do very extensive checks on the validity of the handle.

If you pass an invalid one you may get an error return, or the machine may crash!

$3F - Read file, f_read

Parameters: *long: load address, long: number of bytes to read, word: handle*
Result: *DO.L=number of bytes read, or an error code*
Stack: *12*

This will attempt to read bytes from the given file. If an error occurs `DO.L` will be negative. If the end of file is reached during the read operation an error code is not returned - if you wish to check for this you have to compare the number of bytes you asked for with the result - if they are different then you tried to read past the end of file.

$40 - Write file, f_write

Parameters: *long: start address, long: number of bytes to write, word: handle*
Result: *DO.L=number of bytes written, or an error code*
Stack: *12*

This will attempt to write bytes to the given file. If an error occurs `DO.L` will be negative. If the disk becomes full an error code will not be issued, but the value returned will not be the same as the value passed to it as the number of bytes to write.

If you pass a negative length parameter GEMDOS may crash very badly.

$41 - Delete File, f_delete

Parameters: *long: pointer to filename*
Result: *DO.W=0 if successful, else error code*
Stack: *6*

This will attempt to delete the given file.

$42 - Seek file pointer, f_seek

Parameters: *word: mode, word: file handle, long: position*
Result: *DO.L=absolute position in file after seek*
Stack: *10*

This will move the file pointer to a given position in the file. The mode word should be one of the following:

0	move to N bytes from the start of the file
1	move to N bytes from the current location
2	move to N bytes from the end of the file

If you try and move past either end of the file you will get a result of 0 (for the start) or the actual length of the file.

$43 - Get/Set file attributes, f_attrib

Parameters: *word: attributes, word: get/set, long: pointer to filename*
Result: *DO.W=new attributes, or an error code*
Stack: *10*

This can be used to get or set the attributes for a given file. The attributes word can be:

$01	read only
$02	hidden file
$04	hidden system file
$08	filename is actually the volume label in first 11 bytes
$10	sub-directory
$20	file is written and closed

The other word should be 0 to get the attribute, or 1 to set it.

$48 - Allocate Memory with preference, m_xalloc

Parameters: *word.mode, long: number of bytes required*
Result: *DO.L=address of memory allocated, or 0 if failed*
Stack: *8*

This allocates the given amount of memory from the system pool, if available. The mode parameter gives the type of memory that will be allocated, as follows:

0	System RAM only
1	Alternate only
2	either, system RAM preferred
3	either, alternate preferred

Thus for 'ordinary' memory, it is generally best to use mode 3 in order to take advantage of any fast memory in the system; whereas for an area of screen memory you must use mode 0.

This call can also be used to find the amount of free memory of the particular type, if -1 is passed, in which case the size of the largest block is returned. Modes 2 and 3 return the largest block of either type. When a program terminates all its memory allocations are cleaned up.

This call was added in GEMDOS 0.25.

$45 - Duplicate File Handle, fjdup

Parameters: *word: standard handle*
Result: *D0.W=new handle, or error code*
Stack: *4*

Given a handle to a standard device (0-5), this function returns another handle that can be used to address the same device. It can also be closed without affecting the standard device handle.

$46 - Force file handle, fjforce

Parameters: *word: non-standard handle, word: standard handle*
Result: *D0.W=0 if OK, else error code*
Stack: *6*

This forces the standard handle to point to the same device or file as the non-standard one, and can be used, for example, to re-direct screen output to a disk file.

$47 - Get Current Directory, d_getpath

Parameters: *word: drive number, long: pointer to buffer*
Result: *DO. W=0 if OK, else error code*
Stack: *8*

Given a drive number (default drive=0, A:=1, B:=2 etc.) this will return the current directory in the given buffer, in null-terminated form.

$48 - Allocate Memory, m_alloc

Parameters: *long: number of bytes required*
Result: *DO.L=address of memory allocated, or 0 if failed*
Stack: *6*

This allocates the given amount of memory from the system pool, if available. On the TT, the system will attempt to allocate the memory from alternate RAM if the appropriate bits in its header are set. See under `COMMENT HEAD=` in the assembler section of this manual. If this bit is not set then the RAM will be allocated from system RAM.

When a program terminates all its memory allocations are cleaned up. This call can also be used to find the amount of free memory, if -1 is passed, in which case the size of the largest block of system or alternative RAM is returned depending on the malloc bit in the program's header.

$49 - Free Allocated Memory, m_free

Parameters: *long: address of area to free*
Result: *DO.W=0 if OK, else an error code*
Stack: *6*

This frees a block of memory allocated with `m_alloc` or `m_xalloc` above.

$4A - Shrink Allocated Memory, mshrink

Parameters: *long: length to keep, long: start address to keep, word: 0*
Result: *DO. W=0 if OK, else an error code*
Stack: *12*

This is normally used when a program starts up and releases part of the allocated memory

back to GEMDOS. In fact, it can also be used to any block that is allocated to the program.

$4B - Load or Execute a Program, p_exec

Parameters: *long: pointer to environment string, long: pointer to command line, long: pointer to filename, word: mode*
Result: *DO.L=(depends on mode)*
Stack: *16*

This call can be used for loading and chaining programs. The mode word can be one of:

0	load and execute
3	load but do not execute
4	execute base page
5	create base page
6	execute then free (GEMDOS 0.21 and above)
7	create base page (GEMDOS 0.25 and above)

For load and execute, the return value is either an error code, or the value returned when the child program exited.

For load but don't execute the return value is either an error code, or a pointer to the base page of the loaded program.

A discussion of using modes 4 - 7 is beyond the scope of this document.

The command line should be of the form of a length byte followed by the line itself.

The environment string may be passed as 0 to inherit the programs parents basepage, or as a pointer to a list of null-terminated environment strings, ending in a double-null. The normal environment looks like this:

```
dc.b  'PATH=',0,'C:\',0,0
```

or

```
dc.b  'PATH=',0,'A:\',0,0
```

on floppy-based machines.

$4C - Terminate Program, p_term

Parameters: *word: return value*
Result: *N/A as doesn't return*
Stack: *N/A*

This terminates the current program, returning control to the calling program. The word value returned should be an error code, or 0 for no error. Returned error codes should be positive, to avoid confusion with system error codes, which are negative.

$4E - Search for First, f_sfirst

Parameters: *word: attributes, long: pointer to filespec*
Result: *DO. W=0 if found, else -33 not found*
Stack: *8*

This trap can be used to scan a directory using wild-cards to find all the files. This should be called to find the first one, then `f_snext` should be called for the rest. When a file is found

the parameters of the file are returned in the DTA buffer area. The attribute word determines which file types are to be included in the search, and may be one of:

$00	normal files
$01	read only files
$02	hidden files
$04	system files
$08	return volume name only
$10	sub-directories
$20	files that have been written to and closed

The returned values in the DTA buffer are:

0-20	reserved for internal use
21	file attributes
22-23	file time stamp
24-25	file date stamp
26-29	file size (long)
30-43	name and extension of file, null terminated

The address of the DTA buffer can be set with function $1A, and read with function $2F.

$4F - Search for Next Occurrence, f_snext

Parameters: *None*
Result: *DO. W=0 if found, else -33 not found*
Stack: *2*

After calling `f_sfirst` to find the first occurrence of a filespec, this call is used to find subsequent files. When a file is found the DTA buffer is filled as described previously. For it to work the first 21 bytes of the DTA must remain untouched between calls.

$56 - Rename a file, f_rename

Parameters: *long: pointer to new name, long: pointer to old name, word: 0*
Result: *DO.W=0 if OK, else error code*
Stack: *12*

This will attempt to rename the file to the new name. A file with the new name must not already exist.

$57 - Get/Set File Date & Time Stamp, f_datime

Parameters: *word: 0 for Get / 1 for Set, word: file handle, long: pointer to buffer*
Result: *None*
Stack: *10*

This can be used to get or set the time and date stamp on an open file. The buffer should contain two words, the first being the time, and the second the date, in the format already described.

BIOS - Basic I/O System

The Atari BIOS is intended for low-level access to the screen, keyboard and disk drives. It is accessed using the stack for parameters as described previously for GEMDOS, but using `TRAP #13` to invoke it. The BIOS handler preserves registers `D3-D7/A3-A7` - all others may be corrupted by a call. The values of the BIOS call names are supplied in the file `BIOS.I`. Thus to find the device input status you could use:

```
move.w      #2,-(sp)    console device
move.w      #bconstat,-(sp)
trap        #13
addq.w      #2,sp
tst.w       d0
beq.s       notready
```

BIOS 1 - Return device input status, bconstat

Parameters: *word: device number*
Result: *DO.W=0 no characters -1 at least one character ready*
Stack: *4*

The device number are as follows:

	ST/STE/TT	TT	MegaSTE
0	Parallel printer port		
1	Auxiliary device (the RS232 port)		
2	Console device		
3	MIDI port		
4	Keyboard port (IKBD)		
5	Raw screen device		
6		Modem 1 (ST-compatible serial)	Modem 1 (ST-compatible serial)
7		Modem 2 (SCC channel B)	Modem 2 (SCC channel B)
8		Serial 1 (3-wire TTMFP)	Serial 2 (SCC channel A)
9		Serial 2 (SCC channel A)	

Device numbers 4 and 5 are not applicable to this call. The auxiliary device (1) can be switched from the default, the ST-compatible serial port, by using the `bconmap` (XBIOS `$2C`) call described below. Note that devices 7-9 are machine specific (use the `_MCH` cookie).

BIOS 2 - Read a character from a device, bconin

Parameters: *word: device number*
Result: *DO.L character found*
Stack: *4*

The device number should be as described in the table above. For the console (device 2) bconin returns the scancode in the low byte of the upper word, and the ASCII character in the low byte of the low word.

This gives the format:

bits 31-24	bits 23-16	bits 15-8	bits 7-0
Shift key status	Keyboard scan code	0	ASCII value of character

Note that the shift key status is only returned if bit 3 in the system variable `conterm` (the byte at `$484`) is set. This defaults to off.

The non-ASCII keys (e.g. the function and cursor keys) return 0 for the ASCII value, so that the scan code is used to decipher them. The shift key status gives the state of the keyboard modifiers (Shift, Control, Alt etc.) and are as described under the BIOS function `kbshift`

BIOS 3 - Write a character to a device, bconout

Parameters: *word: character, word: device number*
Result: *D0.W=0 if OK, else error*
Stack: *6*

The device number should be as given under `bconstat`.

BIOS 4 - Read/Write logical sectors on a device, rwabs

Parameters: *word: drive (A=0, B=1...etc)*
word: first logical sector
word: number of sectors to transfer
long: buffer for the transfer
word: mode see below
Result: *D0.W=0 on success, else negative error code*
Stack: *14*

Note that all devices do not support all bits. The bits currently used are:

0	Read/Write; write when bit is set.
1	If set then do not affect or check the media change status, or check it.
2	Disable retry when set.
3	If set do not translate logical sectors to physical sectors (i.e. a physical sector rather than a logical sector number is supplied).

In order to read/write past 32767 sectors you should pass -1 as the record number and pass the real record number as a long, pushing this onto the stack *before* the drive number. In this case, the stack adjustment should be 18 bytes. This facility and Bits 2 & 3 of the mode word were added by Atari's AHDI 3.0.

BIOS 5 - Set Exception Vector, setexc

Parameters: *long: new vector address, -7 leave as is word: vector to change*
Result: *D0.L=old vector entry*
Stack: *8*

The `setexc` function is used to modify a system exception vector. The following values are currently allowed as the vector to change:

```
0-$ff   Standard 680x0 exception vectors.
$100    System timer vector (etv_timer).
```

```
$101    Critical error handler (etv_critic).
$102    Process terminate handler (etv_term).
$103    Reserved.
…
$107
```

If a program modifies any vectors it should always restore them to their original values before terminating.

BIOS 6 - Get system timer 'tick' interval, tickcal

Parameters: *None*
Result: *D0.L=system timer calibration in milliseconds*
Stack: *2*

The value return is the value passed to `etv_timer` as a parameter. For current systems it has the value 50.

BIOS 7- Get BIOS parameter block for a device, getbpb

Parameters: *word: drive (A=0, B=I...etc)*
Result: *DO.L=pointer to the BPB for this device; 0 if not found*
Stack: *4*

The BIOS parameter block returned by this function has the form:

```
rsreset
recsiz      rs.w  1     bytes per sector
clsiz       rs.w  1     sectors per cluster
clsizb      rs.w  1     bytes per cluster
rdlen       rs.w  1     length in sectors of root directory
fsiz        rs.w  1     sectors per FAT
fatrec      rs.w  1     record number of start of second FAT
datrec      rs.w  1     record number of start of data
numcl       rs.w  1     clusters per disk
bflags      rs.w  1     bit 0 = 1 - 16 bit FAT, else 12 bit
```

BIOS 8 - Return device output status, bcostat

Parameters: *word: device number*
Result: *DO.W=0 device not ready else ready for output*
Stack: *4*

The device number should be as described under bios 1 - `bconstat`

BIOS 9- Return media change status,mediach

Parameters: *word: drive (A=0, B=I...etc)*
Result: *DO. W see below*
Stack: *4*

The possible return values are:

0	Media definitely has *not* changed
1	Media *might* have changed
2	Media definitely *has* changed

BIOS $A - Return bitmap of mounted drives, drvmap

Parameters: None
Result: DO.L=Bitmap of mounted drives (Bit 0 = drive A)
Stack: 2

Note that on a bare single floppy system with no other devices installed 3 will be returned (indicating that drives A and B are present) because 'virtual disking' will be used on the single physical drive.

BIOS $B - Find state of keyboard 'shift' keys, kbshift

Parameters: word: -1 to read else bitmap of state to set
Result: DO.W=bitmap of state before call
Stack: 44

This function is normally passed -1 to read the current state of the shift keys, the return value being a bit map as follows:

Bit	Meaning (when set)
0	Right shift key down
1	Left shift key down
2	Control key down
3	Alt key down
4	Caps-lock engaged
5	Clr/Home key down
6	Insert key down

It can also be used to 'tell' the operating system that a certain set of keys are pressed by passing it a bitmap of the same form.

XBIOS Extended BIOS

The XBIOS consists of functions for a wide variety of functions including hardware access, screen control, and keyboard mapping The XBIOS handler preserves registers D3-D7/A3-A7 - all others can be corrupted by a call. The calling sequence is the usual one: put parameters on the stack, put a function word on the stack, do a TRAP #14, then restore the stack. The constant names given below are defined in XBIOS.I.

The XBIOS functions are:

XBIOS 0 - Set mouse mode and packet handler, initmous

Parameters: *long: pointer to mouse interrupt handler*
long: pointer to mouse mode parameter block
word: new mouse mode
Result: *None*
Stack: *12*

The mode parameter should be one of:

0	Disable mouse.
1	Enable relative mouse mode
2	Enable absolute mouse mode
4	Enable mouse keycode mode

The meaning of the other parameters is beyond the scope of this document.

XBIOS 2 - Get Physical Screen Address, physbase

Parameters: *None*
Result: *DO.l=start of screen*
Stack: *2*

This will return the physical address of the screen. On the ST and STe this will be 32000 bytes long. For the TT modes this is 153600 bytes. On the ST it will be aligned on a 256-byte boundary, on the STE a 2-byte boundary and on the TT an 8-byte boundary.

XBIOS 3 - Get Logical Screen Address, logbase

Parameters: *None*
Result: *DO.L=start of screen*
Stack: *2*

This will return the logical address of the screen; that is the address that GEM calls will write to at the moment.

XBIOS 4 - Get Screen Resolution, getrez

Parameters: *None*
Result: *DO. W=0 ST low, 1 ST medium, 2 ST high, 4 TT medium, 6 TT high, 7 TT low*
Stack: *2*

This will return the current screen resolution. Note that you should avoid using this call if at all possible because otherwise your program will not work on ST large screen monitors, add-on graphics hardware or future video modes. The sole legitimate use for this call is when opening a virtual workstation in order to obtain the correct set of fonts and driver for a

resolution.

XBIOS 5 - Set Screen Address & Mode, setscreen

Parameters: *word: mode, long: physical address, long: logical address*
Result: *None*
Stack: *12*

This lets you change the screen resolution and addresses. If any parameter is specified as -1 then it is left alone. Changing the screen mode will clear the screen, but GEM will not be re-initialised.

XBIOS 6 - Set display palette, setpalette

Parameters: *long: pointer to a 16 word screen palette*
Result: *None*
Stack: *6*

This function is used to change the 16 colours in the currently selected palette bank at once. The individual items are in BCD form (as per `setcolor` below). Note that this function name was originally misspelt by the Atari bindings.

XBIOS 7 - Set display palette, setcolor

Parameters: *word: new BCD colour value*
word: logical colour to set
Result: *DO.W=New BCD colour value*
Stack: *6*

This function is used to change the mapping from logical to physical colours. Colour values are stored in a BCD manner with the least-significant bit replacing the most-significant bit. A physical colour is packed in the following manner:

bits 15-12	bits 11-8 (Red)				bits 7-4 (Green)				bits 3-0 (Blue)			
Unused	R0	R3	R2	R1	G0	G3	G2	G1	B0	B3	B2	B1

`R0` represents the least-significant bit of the red component of the colour, `R3` the most-significant. Similarly, `G0-G3` give the green component and `B0-B3` the blue component.

Note that the peculiar packing method is to ensure backward compatibility from the Atari TT and STE to the Atari ST, hence bits `R0`, `G0`and `B0` are not used on the ST. If the new BCD colour value is -1 then the colour is not changed.

Note that this call effects the current bank of the TT's colour lookup table. To update any of the full 256 colours you should use `esetcolor` (XBIOS $53) as described below.

XBIOS 8 - Read sectors from a floppy disk, floprd

Parameters: *word: number of sectors to read*
word: side (0 or 1)
word: track (0 to 79)
word: first sector to read
word: drive (0=drive A, 7= drive B)
long: unused (use 0 for future compatibility)
long: pointer to word-aligned buffer where data will be stored
Result: *D0.W=0 success else error code*
Stack: *20*

This reads one or more sectors from a floppy disk. Note that this function will only read

consecutive physical sectors within a track and the BIOS `rwabs` call should be used to obtain logical sectors.

XBIOS 9 - Write sectors to a floppy disk, flopwr

Parameters: *word: number of sectors to write*
word: side (0 or 1)
word: track (0 to 79)
word: first sector to read
word: drive (0= drive A, 1 = drive B)
long: unused (use 0 for future compatibility)
long: pointer to word-aligned buffer from which data will be written
Result: DO.W=0 success else error code
Stack: *20*

This writes one or more sectors to a floppy disk. Note that this function will only write consecutive physical sectors within a track and the BIOS rwabs call should be used for logical sectors.

XBIOS $A- Format a track on a floppy disk, flopfmt

Parameters: *word: new data (normally $E5E5)*
long: magic (must be $87654321)
word: sector interleave factor
word: side (0 or 1)
word: track (0 to 79)
word: sectors per track (9 for normal disks)
word: drive (0=drive A, I = drive B)
long: pointer to skew table long: pointer to workspace buffer (word aligned)
Result: *DO.W=0 success else error code*
Stack: *26*

The sector interleave factor parameter gives the interleave which is to be used when creating the sectors, typically this will be 1 giving consecutive sectors. If it has the special value -1 then the skew table parameter is used and should point to a list of words one for sector per track giving the required layout of sectors (e.g. 1,6,2,7,3,8,4,9,5 in the normal case). The skew parameter is ignored by TOS 1.0.

The workspace buffer should be at least 8K bytes long. On return it will contain (as a list of words) the sectors which failed during the verify phase. Note that these are not necessarily in numerical order and are 0 terminated. If no sectors failed then the first word in the buffer will be 0.

XBIOS $C- Write string to the MIDI port, midiws

Parameters: *long: address of string to send*
word: number of characters to write-1
Result: *None*
Stack: *8*

This call is writes the given number of characters (less 1) directly to the MIDI port.

XBIOS $D- Set the MFP interrupt handler, mfpint

Parameters: *long: address of new interrupt handler*
word: interrupt no to change
Result: *None*
Stack: *8*

This call is use to change a multi-function peripheral adaptor (MFP) vector. The vectors are as follows:

0	Parallel port
1	RS-232 Data Carrier Detect
2	RS-232 Clear-To-Send
3	BitBlt complete
4	RS-232 baud rate generator (Timer D)
5	200Hz System clock (Timer C)
6	Keyboard/MIDI
7	Floppy and Hard disk
8	Horizontal Blank (Timer B)
9	RS-232 transmit error
10	RS-232 transmit buffer empty
11	RS-232 receive error
12	RS-232 receive buffer full
13	DMA sound (Timer A)
14	RS-232 ring indicator
15	Mono monitor detect /DMA sound complete

Note that installing a handler does not enable an interrupt this must be done separately via `jenabint`; note also that DMA sound option is only implemented on the Atari STE and TT.

XBIOS $E - Find serial device I/O structure, iorec

Parameters: *word: device number*
Result: *DO.L =pointer to I/O record*
Stack: *4*

The device number parameter should be one of:

0	RS-232
1	Keybord
2	MIDI

The I/O record returned has the form:

```
rsreset
ibuf        rs.l  1     pointer to buffer
ibufsiz     rs.w  1     size of buffer
ibufhd      rs.w  1     head index
ibuftl      rs.w  1     tail index
ibuflow     rs.w  1     low-water mark
ibufhi      rs.w  1     high-water mark
```

If the structure requested was the for the RS-232 port then a second identical structure follows the first giving the RS-232 output buffer structure.

XBIOS $F - Configure RS232 port, rsconf

Parameters: *word: synchronous character register*
word: transmit status register
word: receive status register
word: USART control register
word: flow control mode

	word: new RS-232 speed request
Result:	*DO.L= old 68901 configuration*
Stack:	*14*

The speed parameter should be one of:

0	19200
1	9600
2	4800
3	3600
4	2400

5	2000
6	1800
7	1200
8	600
9	300

10	200
11	150
12	134
13	110
14	75
15	50

The flow control modes are

0	No flow control (default)
1	XON/XOFF(^S/^Q)
2	RTS/CTS
3	XON/XOFF and RTS/CTS

The USART control register (UCR) bits are as follows:

Bit 7	Bits 6-5	Bits 4-3	Bit 2	Bit 1	Bit 0
CLK/16	00-8 bits	00-No Start/Stop	Parity	Odd	Unused
	01-7 bits	01-1 Start,l Stop		parity	
	10-6 bits	10-1 Start,l;Stop			
	11-5 bits	11-1 Start, 2 Stop			

The receiver status register (RSR) bits are

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Buffer full	Overrun error	Parity error	Frame error	Break detect	Match busy	Sync strip	Receiver enable

`tsr` sets the transmit status register (TSR), the low byte only is used:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Buffer empty	Underrun error	error	Frame error	Send break	Match busy	Sync strip	Receiver enable

Only the low byte of the synchronous character register, giving the character that will be searched for when an underrun error occurs in synchronous mode.

If any of the parameters has the value -1 then it is ignored and the current setting is unchanged.

The result contains the old UCR, RSR and TSR register values. The most significant byte is the UCR, the second most significant RSR and the third most the TSR value. If you pass -2 as the speed parameter the current speed will be returned. This is implemented on TOS 1.4 and above.

The above information assumes that the port is connected to a 68901. The only bits that are correct for devices 7 to 9 are bits 1-6 of the UCR and bit 3 of the TSR.

XBIOS $10- Get/Set keyboard translation tables, keytbl

Parameters: *long: Caps-lock translation table*
long: shift translation table
long: un-shifted translation table
Result: *DO.L=pointer to structure as shown below*
Stack: *14*

This call is used to set/get the mapping from keyboard scan codes to key-presses. Note that *all* keyboards return identical scan-codes for keys in the same place, but it is these translation tables, which give the ASCII value for the legend marked on a key, that are used to internationalise a keyboard.

The input pointers should point to arrays of 128 bytes which map scan-codes into ASCII codes when the appropriate key is depressed. If a scan-code does not have an ASCII representation the value returned is 0. If you do not wish to change one of the translation tables the value -1 should be passed.

The structure returned has the following form:

```
            rsreset
unshift     rs.l  1     pointer to the normal table
shift       rs.l  1     pointer to the shifted table
capslock    rs.l  1     pointer to the Caps-lock table
```

XBIOS $11 - Obtain random number, random

Parameters: *None*
Result: *DO.L random number*
Stack: *2*

This returns a 24 bit random number. Note that the algorithm used gives an *exact* 50% distribution for bit 0 and so this function should be used with care.

XBIOS $12 - Build prototype boot sector, protobt

Parameters: *word: O=non-executable boot sector,1 =executable, -1 leave alone*
word: disk type see below
long: serial no
long: pointer to 512 byte buffer
Result: *None*
Stack: *14*

This call is used to build a boot sector for freshly formatted floppies in the buffer that is passed as a parameter; it should contain any boot sector code you require.

If the serial number has the value -1 then the current serial number in the boot sector is unchanged, otherwise if it has a value >= 0x0l0000 then a random serial number is computed and used. The disk type should be one of:

0	40 tracks, single sided, 9 sectors per track (180K)
1	40 tracks, double sided, 9 sectors per track (360K)
2	80 tracks, single sided, 9 sectors per track (360K)
3	80 tracks, double sided, 9 sectors per track (720K)
4	80 tracks, double sided, 18 sectors per track
-1	Do not change type information

Note that if using a disk type of 4 then you should ensure that a suitable floppy device driver

is installed by interrogating the _FDC cookie.

XBIOS $13 - Verify sectors from a floppy disk, flopver

Parameters: *word: number of sectors to verify*
word: side (0 or 1)
word: track (0 to 79)
word: first sector to verify
word: drive (0=drive A, 1 = drive B)
long: unused (use 0 for future compatibility)
long: pointer to 1K word-aligned buffer where list of bad sectors will be stored
Result: *D0.W=0 success else error code*
Stack: *20*

This verifies one or more sectors within a track on a floppy disk. The buffer will be filled with a word list of sectors which is terminated with a word of zero in an identical manner to that produced by flopfmt.

XBIOS $14 - Copy screen to printer, scrdmp

Parameters: *None*
Result: *None*
Stack: *2*

This function dumps the screen to the printer in the same form as with the Alt-Help key.

XBIOS $15 - Configure VT52 cursor, cursconf

Parameters: *word: new flash rate,*
word: function no
Result: *DO.W old flash rate (if function 5)*
Stack: *6*

This is used to configure the VT52 cursor. The function number should have a value giving the parameter you wish to change:

0	Hide cursor.
1	Show cursor.
2	Enable blinking.
3	Disable blinking.
4	Set blink rate to rate parameter.
5	Return current blink rate.

The blink rate (for mode 4 and 5) is specified in half-frame rates.

XBIOS $16 - Set IKBD time, settime

Parameters: *DO.L= time/date as shown below*
Result: *None*
Stack: *6*

This returns sets the IKBD time given a packed long word as follows:

0-4	Second/2 (0 to 29)
5-10	Minute (0 to 59)
11-15	Hour (0 to 23)
16-20	Day (0 to 31)

21-24	Month (1 to 12)
25-31	Year-1980 (0 to 127)

XBIOS $17- Get IKBD time, gettime

Parameters: *None*
Result: *D0.L= time/date as shown below*
Stack: *2*

This returns the IKBD time as a packed long word in the same format as that used by settime (XBIOS $16).

XBIOS $18 - Reset keyboard translation tables, bioskeys

Parameters: *None*
Result: *None*
Stack: *2*

This is used to restore the default power-up setting of the keyboard translation tables. This will normally only be required if they have been changed via `keytbl`.

XBIOS $19- Write string to keyboard processor, ikbdws

Parameters: *long: pointer to string to write*
word: number of characters to write less 1
Result: *None*
Stack: *8*

This call writes the given number of characters (less 1) directly to the IKBD processor.

XBIOS $1A- Disable 68901 interrupt, jdisint

Parameters: *word: interrupt to enable*
Result: *None*
Stack: *4*

This call disables the given interrupt on the 68901 chip.

XBIOS $1B- Enable 68901 interrupt, jenabint

Parameters: *word: interrupt to enable*
Result: *None*
Stack: *4*

This call enables the given interrupt on the 68901 chip.

XBIOS $1C- Read/Write sound chip registers, giaceess

Parameters: *word: register to get /set*
word: new data
Result: *DO.W=value of register*
Stack: *6*

This function is used to access the Atari ST sound chip directly. If the register field has bit 7 set then the register is written to; otherwise it is read and its current value returned. The possible register values are as follows:

0,1	Channel A frequency
2,3	Channel B frequency
4,5	Channel C frequency

6	Noise period
7	Enable flags
10	Channel A amplitude
11	Channel B amplitude
12	Channel C amplitude
13,14	Envelope period
15	Envelope shape

XBIOS $1D - Reset bit on port A of sound chip, offgibit

Parameters: *word: bit mask*
Result: *None*
Stack: *4*

This call resets the given bit on port A of the sound chip atomically. This atomic access is *essential* as the BIOS often modifies these bits under interrupt control. The bits are used as follows:

0	Floppy Side Select
1	Floppy 0 Select
2	Floppy 1 Select
3	RS-232 RTS
4	RS-232 DTR
5	Centronics Strobe
6	General Purpose Output
7	Unused

A bit should be 1 to remain unchanged or 0 to clear that bit.

XBIOS $1E - Set bit on port A of sound chip, ongibit

Parameters: *word: bit mask*
Result: *None*
Stack: *4*

This call sets the given bit on port A of the sound chip atomically. The bits are described under offgibit above, except that a 1 is used to set the bit or 0 for no change.

XBIOS $1F - Configure MFP timer, mfpint

Parameters: *long: address of new handler*
word: value for timer data register
word: value for timer control register
word: timer to change (0 for A, 1 for B etc)
Result: *None*
Stack: *12*

The timers are used as follows:

A	DMA sound counter
B	HBlank counter
C	200Hz System timer
D	RS-232 baud rate generator

XBIOS $20- Initialise sound daemon, dosound

Parameters: *long: pointer to command stream*
Result: *None*
Stack: *6*

Starts a new sound sequence through the sound daemon. The parameter should point to a byte stream consisting of commands for the daemon consisting (in general) of one byte opcode and one byte operand pairs.

Commands 0-15 select a register, the following byte is then loaded into that register.

Command $80 stores the next byte into a temporary register for use by command $81.

Command $81 takes three parameters. The first is a register to load with the value in the temporary register, the second a signed value to add to the temporary register and the third the final value of the temporary register. The value of the temporary register is then stored into the register mentioned and modified by the increment until the termination condition is reached.

The final command is $82 (in fact any value >=$82) which has an argument which specifies the number of ticks (50Hz) until the next command should be executed, or the special value 0 to terminate processing.

XBIOS $21 - Set/Get printer configuration, setprt

Parameters: *word: new configuration (or-1 to get configuration)*
Result: *word: old configuration*
Stack: *4*

The currently defined bits are:

Bit	When clear	When set
0	Dot matrix	Daisy wheel
1	Monochrome	Colour
2	Atari mode	'Epson' compatible
3	Preview mode	Final mode
4	Parallel port	RS-232 port
5	Continuous	Single sheet

XBIOS $22 - Get system ACIA dispatch handler, kbdvbase

Parameters: *None*
Result: *DO.L=pointer to structure*
Stack: *2*

The use of the elements of this structure is beyond the scope of this document, but they are as follows:

```
            rsreset
midivec     rs.l  1     MIDI-input
vkbderr     rs.l  1     keyboard error
vmiderr     rs.l  1     MIDI error
statvec     rs.l  1     IKBD status packet
mousevec    rs.l  1     mouse packet
clockvec    rs.l  1     clock packet
joyvec      rs.l  1     joystick packet
```

```
midisys     rs.l  1     system MIDI vector
ikbdsys     rs.l  1     system IKBD vector
busyflag    rs.b  1     0 if IKBD is not sending
```

XBIOS $23- Get/Set keyboard repeat and delay, kbrate

Parameters: *word: new repeat rate*
word: new delay rate
Result: *DO. W=old repeat rate*
high word of DO=old delay rate
Stack: *6*

This call is use to set/get the keyboard repeat and delay rates. These are expressed in 50^{ths} of a second. If either of the input parameters is -1 then that rate is not changed.

XBIOS $24- Print bitmap, prtblk

Parameters: *long: pointer to prtarg structure*
Result: *DO.W=error status*
Stack: *2*

The use of the elements of this structure is beyond the scope of this document.

XBIOS $25 - Wait for vertical sync to occur, vsync

Parameters: *None*
Result: *None*
Stack: *2*

This is often used to prevent 'flicker' when drawing graphics or to ensure that vertical blank driven objects are complete before being reused (e.g. setpalette).

XBIOS $26 - Call Supervisor Routine, supexec

Parameters: *long: address of routine*
Result: *None*
Stack: *6*

This calls the given routine in supervisor mode. You should be careful if it wishes to call the BIOS or XBIOS since these are only re-entrant to three levels.

XBIOS $27- Discard AES, puntaes

Parameters: *None*
Result: *None*
Stack: *2*

This is used to throw away the AES and any memory it occupies. Note that this function will only work for RAM-loaded TOS.

XBIOS $29- Set floppy disk step rate, floprate

Parameters: *word: new rate,*
word: drive (0= drive A, 1 = drive B)
Result: *D0.W=old rate*
Stack: *6*

This is used to change the track-to-track stepping rate of the floppy disk controller for each drive.The rate has the values:

0	6ms
1	12ms
2	2ms
3	3ms

Note that to simply inquire the seek rate the value -1 may be used for rate. This function is only available on TOS 1.04 and above, for earlier versions the system variable seekrate should be used instead, but, unlike floprate, does not allow different seek rates on each of the drives.

XBIOS $2A- Read sectors from a device, dmaread

Parameters: *word: device number*
long: pointer to word-aligned buffer where data will be stored
word: number of sectors to read
long: first sector to read
Result: *D0.L=0 success else error code*
Stack: *14*

The device numbers that are currently assigned are as follows:

0-7	ACSI devices 0-7
8-15	SCSI devices 0-7

Note that you cannot read from an ACSI device to alternative (fast or TT) RAM. See the _FRB cookie in the Cookie Jar section of this appendix. This call was added in TT TOS.

XBIOS $2B- Write sectors to a device, dmawrite

Parameters: *word: device number*
long: pointer to word-aligned buffer from where data will be written
word: number of sectors to write
long: first sector to write
Result: *DO.L=0 success else error code*
Stack: *14*

The device numbers that are currently assigned are as follows:

0-7	ACSI devices 0-7
8-15	SCSI devices 0-7

Note that you cannot write to an ACSI device from alternative (fast or TT) RAM. See the _FRB cookie in the Cookie Jar section of this appendix. This call was added in TT TOS.

XBIOS $2C- Get/Set mapping of AUX device , bconmap

Parameters: *word=new device number mode, -1 just read,*
-2 used for adding device drivers
Result: *D0.W=previous device number*
Stack: *4*

This call is used to control the mapping of the AUX: device (BIOS device 1) which is initially set to the ST compatible serial port. Valid bconmap device assignments for the MegaSTE and TT are:

	TT		MegaSTE	
6	Modem 1 (ST-compatible serial)		Modem 1 (ST-compatible serial)	

7	Modem 2 (SCC channel B)	Modem 2 (SCC channel B)
8	Serial 1 (3-wire TT MFP)	Serial 2 (SCC channel A)
9	Serial 2 (SCC channel A)	

Note that the meanings for devices 7-9 are machine specific and you should interrogate the `_MCH` cookie to find their meanings.

This call normally returns the previous device assignment except when -2 is passed. The return value in this case is beyond the scope of this document.

To detect the presence of the bconmap call in TOS, you should call `bconmap(0)`; this will return 0 on machines which are bconmap-aware.

XBIOS $2E- Access non-volatile memory, nvmaccess

Parameters: *long: pointer to buffer from where data will be written/read*
word: number of bytes to read/write
word: first byte to read/write
word: operation 0=Read, 1=Write,2=Init
Result: *D0.L=0 success else error code*
Stack: *12*

This calls access the 50 bytes of non-volatile memory in TT's real time clock. The usage of these bytes will be specified by Atari - so don't use this call until you have contacted them! This call ensures that the checksum is maintained and was added in TT TOS.

XBIOS $40 - Get/Set blitter configuration, blitmode

Parameters: *word: new mode or -1 to read mode*
Result: *D0.W=old blitter configuration*
Stack: *4*

This is used to detect the presence and alter the configuration of a hardware blitter. Currently only a single bit in new mode is allocated, with bit 0 being set to enable the hardware blitter, or 0 to disable. Alternatively the value -1 may be used to obtain the current blitter status which is return in DO as follows:

Bit	Meaning when set
0	Perform blits in hardware
1	Hardware blitter is available

XBIOS $50 - Set current video shift mode, esetshift

Parameters: *word: new shift ,mode register value*
Result: *DO.W=previous video shirt mode*
Stack: *4*

This call is used to set the TT's entire video shift register. The meaning of the bits is as shown below:

Bit 15	Bit 12	Bits 10-8		Bits 3-0
Smear	Grey	Screen mode:		Current colour
Mode	Mode	000	ST low	bank
		001	ST medium	
		010	ST high	
		100	TT medium	

110	TT high
lll	TTlow

If you are only interested in the setting of part of the register it is best to use one of the more specific calls below or in the case of the screen mode `getrez` (XBIOS 4). `esetshift` was introduced in TT TOS and *requires* the TT video hardware.

XBIOS $51 - Get current video shift mode, egetshift

Parameters: *None*
Result: *D0.W=current video shift mode*
Stack: *2*

This call is used to return the current state of the TT's video shift register. The meaning of the bits is as shown above. If you are only interested in the setting of part of the register it is best to use one of the more specific calls below. This call was introduced in TT TOS and *requires* the TT video hardware.

XBIOS $52 - Get/Set colour look up bank, esetbank

Parameters: *word=bank number to set (0-15), or negative to read*
Result: *D0.W=previous bank number*
Stack: *4*

The TT's colour lookup table has 256 entries for use in TT low resolution mode. This call lets you select which bank (collection of 16 entires) will be used in the other modes, thus enabling you to switch between palettes very easily. When setting the bank number, the new bank's colours are copied to the old ST colour mode register. This call was introduced in TT TOS and *requires* the TT video hardware.

XBIOS $53 - Get/Set a single colour entry, esetcolor

Parameters: *word:new BCD colour value or negative to read*
word:colour number to set (0-255)
Result: *DO.W=previous colour value*
Stack: *4*

This call is used to read/write a single entry in the TT's colour palette. The BCD colour value is encoded as shown below:

bits 15-12	bits 11-8 (Red)				bits 7-4 (Green)				bits 3-0 (Blue)			
Unused	R0	R3	R2	R1	G0	G3	G2	G1	B0	B3	B2	B1

`R0` represents the least-significant bit of the red component of the colour, `R3` the most-significant. Similarly, `G0-G3` give the green component and `B0-B3` the blue component.

Note that this (and the other TT specific palette calls) do not use the ST compatible method of encoding the colour as per `setcolor` (XBIOS 7) and that this call uses the absolute colour number rather than the current bank and so can access all 256 entries. This call was introduced in TT TOS and *requires* the TT video hardware.

XBIOS $54 - Set look up table registers, esetpalette

Parameters: *long-.area to read palette from,word:*
number of colours to transfer, word: first colour to set
Result: *None*
Stack: *10*

This call is used to set the values of the TT's colour lookup table, or palette. It can be used to

set the palette for a single colour, the whole palette or part of it. The colour words are encoded in the standard manner as described under `esetcolor` (XBIOS $53). This call was introduced in TT TOS and *requires* the TT video hardware.

XBIOS $55 - Get look up table registers, egetpalette

Parameters: *long: area to store palette,*
word: number of colours to transfer,
word: first colour to move
Result: *None*
Stack: *10*

This call is used to read the values of the TT's colour lookup table, or palette. It can be used to read the details, for a single colour, the whole palette or part of it. It was introduced in TT TOS and *requires* the TT video hardware.

XBIOS $56 - Get/Set grey mode, esetgray

Parameters: *word=0 colour mode, positive grey mode, or negative to read*
Result: *D0.W=previous grey mode value*
Stack: *4*

This call is used to read/write the TT video hardware's grey mode bit. When grey mode is set, the bottom eight bits of the palette value are used as one of 256 possible grey levels. The best way to see the effect of this is using the Colour part of the Control Panel (just click on the Grey button). This call was introduced in TT TOS and *requires* the TT video hardware.

XBIOS $57- Get/Set video smear mode, esetsmear

Parameters: *word=0 normal mode, positive smear mode, or negative to read*
Result: *D0.W=previous smear mode value*
Stack: *4*

This call is used to read/write the TT video hardware's smear mode bit. When smear mode is set, the video hardware displays video pixels with value 0 as the last non-zero colour rather than colour zero itself. This can be used to change the colour of a filled-polygon by only changing its outline rather than via a complete re-fill. This call was introduced in TT TOS and *requires* the TT video hardware.

GEM Libraries

GEM itself consists of two components; the VDI and the AES.

The GEM VDI (for Virtual Device Interface) is the main part of the operating system that draws graphics and text on the screen.

The GEM AES (for Application Environment Services) is the part of the operating system that provides the user-interface facilities of GEM such as windows, menus and dialog boxes.

This section is intended to give details of the supplied library files and calling conventions used. It does not attempt to describe either the VDI or the AES in great detail - the books in the Bibliography should be referred to for this. However, details are given of information that we feel is badly documented or not documented at all.

GEM AES Library

The calling sequence to the AES is based on various arrays of words and longwords. These arrays are defined using DS directives and are:

control	words
int_in	words
addr_in	longwords
int_out	words
addr_out	longwords
aes_params	longwords
global	words

For example the C program segment

```
val = int_out[2]  + int_out[3];
```

could be converted into this assembly language:

```
            move.w      irrt_out+4,d0
            add.w       int_out+6,d0
```

Note the way that the array index is doubled before adding to the start of the array, as it is an array of words. For an array of longs the index should be quadrupled.

A macro file, called GEMMACRO.I should be used which defines various macros and, if generating executable code, the file AESLIB.S should be included at the end of assembly.

Prior to Devpac 3 GEMMACRO.I was called GEMMACRO.S.

The macros take a varying number of parameters and place them in the required places in the AES arrays, before making a call to the general AES routine. If passing a constant to a macro be sure to precede it with a # sign, for example passing the parameters 3, mypt r to a macro could generate the code

```
            move.w   3,int_in
            move.l   myptr,addr_in
```

The first line will cause a run-time error, the parameter should have been #3. There are a few AES macros which do not take all the required parameters - additional information may have to be placed in other arrays. On return from an AES macro D0.W (and the flags) reflect the contents of the array int_out [0], normally useful. Various return values can often be found in the `int_out` array.

The following descriptions assume all parameters to be word sized, unless shown with a `.L` suffix, denoting a longword parameter.

Application Library

appl_init

Must be called at the start of any AES program.

applread *id,length,buffer.L*

appl_write *id,length,buffer.L*

applfind *name.L*

Find a named program, normally a desk accessory.

appltplay *memory.L,number,scale*

appltrecord *memory.L,count*

appl_exit

Must be just before an AES program terminates. It sends `AC_CLOSE` type messages to all desk accessories.

Event Library

evnt_keybd

evnt button *clicks,mask,state*

The return value is the number of times the button entered the desired state. Array elements 1-4 of `int_out` contain the X coordinate, the Y co-ordinate, the button state and the keyboard state at the time of the event in that order.

evnt mouse *flags,x,y,w,h*

The return values are as described for the previous call.

evntmesag *buffer.L*

evnt_timer *count.L*

evnt multi flags,clicks,mask,bstate,&m1flags,m1x,m1y,m1w>m1h, &m2flags,m2x,m2y,m2w,m2h,messbuf.l,count.L

All parameters except the first are optional, specifying a null parameter means nothing is placed in the relevant element of int_in. It is shown above with the syntax of a multi-line macro call but this is not obligatory. The int_out array contains which event, mouse X, mouse Y, button, keyboard state, keyboard code and button value, respectively.

evnt_dclick ***new, get set***

Menu Library

menu_bar tree.L,shovf

menu_icheck tree.L,item,check

menu_ienable tree.L,item,enable

menu_tnormal tree.L,title,normal

menu_text tree.L,item.text.L

menu_register ***id,string.L***

Normally a menu tree is generated by a resource editor, such as HiSoft WERCS, though they can be constructed, with a great deal of care, by hand.

Another alternative is to use the MENU2ASM compiler, detailed later in this section.

Object Library

Object trees are normally constructed with a resource editor, though they can be constructed by hand if required. Dialog boxes are the easiest type of object tree to construct by hand and menus the most difficult.

objc_add ***tree.L,parent,child***

objcdelete ***tree.L,object***

objc_draw ***tree.L,startob,depth,x,y,w,h***

objc_find ***tree.L,startob,depth,x,y***

objcoffset ***tree.L,object***

Elements 1 and 2 of `int_out` contain the returned X and Y coordinates.

objc_order tree.L,object,newpos

objc_edit tree.L,object,char,idx,kind

`intout[1]` contains the new idx.

objc_change tree. L,object,x,y,w,h,new,redraw

Form Library

form do *tree.L,startob*

Never pass `startob` as -1 as often documented, use 0 instead.

form_dial *flag,x* I,y I,wI,fi I*,x2,y2,w2,h2*

form_alert *button,string.L*

form_error *errnum*

Error numbers should be positive and less than 64.

formcenter *tree.L*

form keybd *tree.L,obj,nxt_obj,thechar*

form_button *tree.L,object,elks*

Graphics Library

graf_rubberbox *x,y,w,h*

`int_out[1]` contains the finish width, `int_out[2]` the height.

grafdragbox *w,h,x,y,bx,by,bw,bh*

`int_out[1]` contains the finish X co-ordinate, `int_out[2]` the Y.

graf_movebox *w,h,x,y,dx,dy*

graf_growbox *x,y,w,h,fx,fy,fw,fh*

grafjshrinkbox *x,y,w,h,sx,sy,sw,sh*

graf_watchbox *tree.L,object,instate,outstate*

grafslidebox *tree.L,parent,obj,vh*

graf_handle

The `int_out` array will contain the VDI handle, character cell width, then height, system font width, then height.

grafmouse *number,address.L*

The address parameter is optional, only required if defining you own shape.

graf mkstate

The `int_out` array will contain a reserved value, mouse X and Y position, mouse button state and keyboard state.

Scrap Library

scrp_read *buffer.L*

scrp_write *buffer.L*

File Selector Library

fsel_input path.L,filename.L

fsel_exinput *path.L,filename.L,title.L* (TOS 1.4 and above)

The path parameter should point to a buffer containing the null-terminated path, such as A:*.S, and the new path will be returned in it, so be sure it is large enough. The filename buffer should be 13 bytes, with a maximum of 12 used for the filename, for example TEST.S. If D0.W is zero on return then it means there was not enough free memory to invoke the selector, else `intout[1]` will contain 0 if Cancelled.

On TOS 1.4 and above, the extended file selector call is available, which allows a title to be displayed in the file selector. The title parameter should point to a buffer of no more than 30 characters containing the null-terminated title.

Window Library

wind_create *kind,x,y,w,h*

wind_open *handle,x,y,w,h*

wind_close *handle*

wind_delete *handle*

wind_get *handle,field*

wind_set *handle,field*

wind_find *x,y*

wind update *begend*

wind_calc *type,kind,inx,iny,inw,inh*

wind_new **(TOS 1.4 and above)**

Resource Library

rsrc_load *filename.L*

rsrc_free

rsrc_gaddr *type/index.*

The result address may be found in `addr_out`.

rsrc_saddr *type,index,saddr.L rsrc_obfix tree.L,object*

Shell Library

shel_read *command.L,shell.L*

shel_write *doex.,sgr,scr,cmd.L,shell.L*

shel_find *buffer.L*

The buffer should be a minimum of 80 bytes.

shel_envrn *value.L,string.L*

shel_get *buffer.L,length shel_put buffer.L,length*

Debugging AES Calls

Unlike the calls to the VDI, calls to the AES are not immediately obvious when viewed from MonTT as they are of the form

```
moveq #??,d0      AES function  number
bsr   CALL AES
```

As an aid to decoding these, here is a table listing all the AES calls and their hex function numbers:

A	appl_init	B	applread
C	appl_write	D	appl_find
E	appl_tplay	F	appl_trecord
13	appl_exit	14	evnt_keybd
15	evnt_button	16	evntjnouse
17	evntjnesag	18	evnt_timer
19	evnt_multi	1A	evnt_dclick
1E	menu_bar	1F	menu_icheck
20	menu_ienable	21	menu_tnormal
22	menu_text	23	menu_register
28	objc_add	29	objcdelete
2A	objc_draw	2B	objc_find
2C	objc_offset	2D	objcorder
2E	objc_edit	2F	objc_change
32	form_do	33	form_dial
34	form_alert	35	form_error
36	forme-enter	37	formkeybd
38	form_button	46	grafrubberbox
47	grafdragbox	48	graf_movebox
49	graf_growbox	4A	graf_shrinkbox
4B	grafwatchbox	4C	grafslidebox
4D	graf_handle	4E	graf_mouse
4F	graf_mkstate	50	scrpread
51	scrpwrite	5A	fsel_input
5B	fsel_exinput	64	wind_create
65	wind_open	66	wind_close
67	wind_delete	68	wind_get
69	wind_set	6A	wind_find
6B	wind_update	6C	wind_calc
60	wind_new	6E	rsrc_load
6F	rsrc_free	70	rsrc_gaddr
71	rsrc_saddr	72	rsrc_obfix
78	shel_read	79	shel_write
7A	shel_get	7B	shelput
7C	shel_find	7D	shel_envrn

GEM VDI Library

The calling sequence itself to the VDI is, like the AES, based on various arrays of words and longwords. These arrays are defined using DS directives and are:

`contrl`	words
`intin`	words
`ptsin`	words
`intout`	words
`ptsout`	words
`vdi_params`	longwords

All (but one) VDI calls require a VDI handle, which by tradition is a parameter to every call. However, the majority of programs only use one handle, to a virtual workstation (the screen), so the supplied VDI libraries use a word called `current_handle` as the handle to pass on to the VDI itself. This saves an appreciable amount of code and is the same way the HiSoft BASIC libraries work. As the source to the library is supplied you could change this, if required.

The macro file GEMMACRO.I should be used which defines various macros and, if generating executable code, the file VDILIB.S should be included at the end of assembly.

The macros take a varying number of parameters and place them in the required places in the VDI arrays, before making a call to a VDI library routine. The warning about # signs in parameters described previously applies to the VDI too. There are a number of VDI macros which do not take all the required parameters - additional information may have to be placed in other arrays. On return, various return values can often be found in the intout and ptsout arrays.

The following descriptions assume all parameters to be word sized, unless shown with a `.L` suffix, denoting a longword parameter.

Control Functions

v_opnwk — Open Workstation

This should not be used unless GDOS is installed. The `intin` array should be suitably initialised, `current_handle` will be set to the result of this call.

v_clswk — Close Workstation

v_opnvwk — Open Virtual workstation

This uses `current_handle` to open another workstation and sets `current_handle` to the result, `intin` is normally filled with 10 words of 1 and one word of 2 (denoting RC co-ordinates).

v_clsvwk **Close Virtual Workstation**

v_clrwk **Clear Workstation**

v_updwk **Update Workstation**

vst_load_fonts **Load Fonts**

Do not attempt this unless GDOS is loaded.

vst_unload_fonts **Unload Fonts**

Fonts *must* be unloaded before a workstation is closed.

vs_clip *flag,xl,yl,x2,y2* **Set Clipping Rectangle**

Output Functions

v_pline *count* **Polyline**

The input co-ordinates should be copied to intin before the call.

v_pmarker counf **Polymarker**

The input co-ordinates should be copied to intin before the call.

v_gtext *x,y,string.L* **Text**

The string should be in the from of null-terminated bytes.

v_fillarea *count* **Filled Area**

The input co-ordinates should be copied to in tin before the call.

v_contourfill *x,y,index*	**Contour Fill**
vr_recfl *x\,y1,x2,y2*	**Fill Rectangle**
v_bar x1,yl,x2,y2	**Bar**
v_arc x,y,radius,start,end	**Arc**
vpieslice x,y,radius,start,end	**Pie**
v_circle *x,y,radius*	**Circle**
v_ellarc x,y,xradius,yradius,start,end	**Elliptical Arc**
v_ellpie x,y,xradius,yradius,start,end	**Elliptical Pie**
v_ellipse x,y,xradius,yradius	**Ellipse**
vjrbox xl,y l,*x2,y2*	**Rounded Rectangle**
v_rfbox *xl,yl,x2,y2*	**Filled Rounded Rectangle**
vjustified x,y,string.L,length,ws,cs	**Justified Graphics Text**

The string should be null-terminated.

Attribute Functions

vswr mode *mode*	**Set Writing Mode**
vs_color index,red,green,blue	**Set Colour Representation**
vsl_type *style*	**Set Polyline Line Type**
vsl_udsty *pattern*	**Set User Defined Line Style Pattern**
vsl_width *width*	**Set Polyline Line Width**
vsl color *index*	**Set Polyline Colour Index**
vsl_ends *begin,end*	**Set Polyline End Styles**
vsm_type *symbol*	**Set Polymarker Type**
vsmjieight *height*	**Set Polymarker Height**
vsm_color *index*	**Set Polymarker Colour Index**
vstheight *height*	**Set Character Height, Absolute Mode**

The `ptsout` array will contain the selected size.

vst_point *point* **Set Character Height, Points Mode**

The `ptsout` array will contain the selected size.

vstrotation *angle* **Set Character Baseline Vector**

vst_font *font* **Set Text Face**

vst_color *index* **Set Graphic Text Colour Index**

vst_effects *effect* **Set Graphic Text Special Effects**

vst_alignment horizontal,vertical **Set Graphic Text Alignment**

vsfjnterior *style* **Set Fill Interior Style**

vsf_style *index* **Set Fill Style Index**

vsf_color *index* **Set Fill Colour Index**

vsf_perimeter *vis* **Set Fill Perimeter Visibility**

vsf_udpat **Set User Defined Fill Pattern**

The `intin` array should be filled with the pattern and `contrl[3]` set suitably.

Raster Operations

vro_cpyfm *mode,source.L,dest.L* **Copy Raster, Opaque**

This is the general *blit* call, most often used for scrolling the screen. The source and destination parameters should point to a memory form definition block (MFDB) which describes the format of the memory to blit. An MFDB consists of ten words:

```
            rsreset
fd_addr     rs.l  1     form address
fd_w        rs.w  1     width in pixels
fd_h        rs.w  1     height in pixels
fd_wdwidth  rs.w  1     width in words
fd_stand    rs.w  1     form flag
fd_nplanes  rs.w  1     number of planes
fd_r1       rs.w  1     reserved,  set to 0
fd_r2       rs.w  1     reserved,  set to 0
fd_r3       rs.w  1     reserved,  set to 0
```

The address in the first two words is normally either the screen address or the address of a buffer being used for the blit. It can also be 0 if you are using a physical device such as the screen, in which case the remainder of the fields will be filled in for you.

The width and height fields should be those suitable for the screen size and the number of planes can be found from a `vq_extnd 1` call in `intout[4]`. When scrolling the screen the source and destination parameters may point to the same MFDB.

The source and destination rectangles should be placed in the `ptsin` array, each in the form `x1,y1,x2,y2`. A mode of 3 means replace.

vrt_epyfm mode,source.L,dest.L,i 1,12 — **Copy Raster, Transparent**

vr_trnfm *source.L,destination.L* — **Transform Form**

v_get_pixel x,y — **Get Pixel**

Input Functions

vex_timv *newtimer* — **Exchange Timer Interrupt Vector**

v_show_c *reset* — **Show Cursor**

v_hide_c — **Hide Cursor**

vqmouse — **Sample Mouse Button State**

vexbutv newxbuf — **Exchange Button Change Vector**

vex_motv newmofv — **Exchange Mouse Movement Vector**

vex_curv *newcursor* — **Exchange Cursor Change Vector**

vq_key_s — **Sample Keyboard State Information**

Inquire Functions

vqextnd *flag* — **Extended Inquire**

vq_color *index,flag* — **Inquire Colour Representation**

vql_attributes — **Inquire Polyline Attributes**

vqm_attributes — **Inquire Polymarker Attributes**

vqf_attributes — **Inquire Fill Area Attributes**

vqt_attributes — **Inquire Graphic Text Attributes**

vqt_extent *string.L* — **Inquire Text Extent**

The string should be null-terminated, the results will be found in ptsout.

vqt_width *char* **Inquire Character Cell Width**

vqt_name *number* **Inquire Face Name & Index**

vqt_fontinfo **Inquire Current Face Information**

AES & VDI Program Skeleton

The general structure of a GEM-type program is as follows:

shrink memory call

call `appl_init`

set current_handle to the result from `graf_handle`

open a virtual workstation using this handle

open a window, perhaps

main wait for events & act on them as required

quit close any window

close virtual workstation

call `appl_exit`

finally `p_term`

Desk Accessories

A desk accessory is an executable file with the extension .ACC loaded during AES initialisation. We have never seen any official documentation on desk accessories, and the following information has been learnt the hard way, mainly when writing our Saved! program.

The first thing to be wary of is that it is *not* a normal GEMDOS program. When it starts up all registers *including* `A7` are 0, with the exception of `A0` which points to the basepage. An accessory must include all the memory it requires within itself, the `BSS` segment being a good place. An accessory must *not* do a GEMDOS shrink call or attempt to terminate.

The main loop of an accessory is like any other AES program, consisting of an event loop, but note that most documentation details incorrect message numbers - `AC_OPEN` is really 40 and `AC_CLOSE` is 41.

Other programmers have reported problems using the VDI from within an accessory. The recommended method is to open a virtual workstation only when you have to (i.e. before creating a window) and always close it (when you close your window or, failing that, when receiving an `AC_CLOSE` message). The example accessory supplied, like our Saved! program, does not use the VDI at all - paranoia rules!

If your accessory responds to timer events ensure that no GEMDOS calls (`Trap #1`s) are made unless your window is the front one, otherwise time bombs will be set and a crash is highly likely.

The file DESKACC.S contains the source to an example accessory, which simply displays the system free memory in an alert box. It has a label called RUNNER which can be set to 1 to produce a standalone application instead of an accessory. This can be invaluable during program development as you can symbolically debug a standalone program, while an accessory has to be debugged using AMon.

Linking with AES & VDI Libraries

The supplied macro file GEMMACRO.I is designed to be used in executable or linkable programs. The files AESLIB.S and VDILIB.S contain the actual code and should be included at the end of programs when generating executable code, but if generating linkable code they should not. If you look at GEMTEST.S you can see how a conditional is used to make this automatic.

When developing a program using these libraries we recommend executable code as it greatly reduces development time. However the file size can be reduced by using the selective library feature of the GST linker and using the GEMLIB.BIN library file.

So when you have produced a linkable file called GEMTEST.BIN, it can be linked with this library by passing LinkST the command line

```
gemtest -wgemlib
```

The `GEMLIB.LNK` control file will do the rest. If you want to reduce your program to the absolute minimum then you can change the libraries as you require, which is why we supply the source code.

Menu Compiler

For those who wish to use menus without using a resource editor we supply the program MENU2ASM.TTP which converts a menu definition file into assembly language source statement for inclusion in your program. In general most people find using a resource editor, such as HiSoft WERCS, considerably easier because of the immediate visual feedback.

The menu specification should be created in a text file with the extension .MDF and an example follows:

```
[ Desk | About Program ]
[ File | New \ Load \(-------\ Quit ]
[ Search | Find ]
```

and so on. Line breaks are ignored. Each menu title and its items are enclosed in square brackets [and]. There is a vertical bar (|) after each title and the individual items separated by back-slashes (\). For grey items precede the text with an open parentheses (. The first menu is always the desk title (normally Desk); the currently loaded desk accessories will be added by the AES. (It is no coincidence that this is the same syntax as that accepted by our BASICs).

We recommend that you precede each menu item with two spaces and have at least one space

after the item. Menu titles should have one space before and after them.

To compile a file double-click on MENU2ASM.TTP and enter the filename, without an extension. It will produce a file with an extension of .MNU which may be included in your program.

The file MENUTEST.MDF contains an example definition of a menu and MENUTEST.S the source code to a program illustrating its use, as well as showing other AES features.

VT52 Screen Codes

When writing to the screen via GEMDOS or the BIOS calls, the screen driver emulates VT52 protocols. The control codes are sent via *escape* sequences, which means an escape character is sent (27 decimal, or $1B) followed by one or more other characters.

`ESC A` Cursor up; no effect if at the top line

`ESC B` Cursor down; no effect if at the bottom line

`ESC C` Cursor right; no effect if on the right hand side

`ESC D` Cursor left; no effect if on left hand side

`ESC E` Clear screen and home cursor

`ESC H` Home cursor

`ESC I` Move cursor up one line; if at top scrolls the screen down a line

`ESC J` Erase to end of screen, from the cursor position onwards

`ESK K` Clear to end of line

`ESC L` Insert a line by moving all following lines down. Cursor is positioned at start of the new line

`ESC M` Delete a line by moving all following lines up

`ESC Y` Position cursor; should be followed by two characters, the first being the Y position, the second the X. Row and column numbering starts at (32, 32) which is the top left

`ESC b` Foreground colour; should be followed by a character to determine the colour, of which the four lowest bits are used

`ESC C` Background colour; similar to above

`ESC d` Erase from beginning of display to the cursor position

`ESC e` Enable cursor

`ESC f` Disable cursor

`ESC j` Save the current cursor position

`ESC k` Restore a cursor position saved using ESC j; note that this is not supported on the original 1.0 ROMs

`ESC l` Erase a line and put cursor at start of line

`ESC o` Erase from start of line to cursor position

`ESC p` Inverse video on

`ESC q` Inverse video off

`ESC V` Wrap around at end of line on

`ESC w` Wrap around at end of line off

Note that the `ESC j/ESC k` pair do not work on the original ROM TOS (TOS 1.0).

Cookie Jar

If you wish to write a program that runs on the whole range of Atari 680x0 machines and your program has enhanced code for particular hardware, how does it check to see that these facilities are available? The answer is to look in the 'Cookie Jar'. This is a convention, introduced in STE TOS, whereby the system (and third party suppliers) can indicate the capabilities of the machine.

The long word at address `$5A0` points to list of longword pairs. The first longword in a pair is a 4 character ASCII name; the second word is a value corresponding to that name. The list is terminated by a 0 long word as the name. Cookies beginning with _ are reserved for Atari's system cookies and are as follows:

_CPU	the bottom 2 digits of the main processor number (e.g. $0 for 68000, $1E for 68030)
_FDC	This gives an indication of the highest density floppy unit installed in the machine. The high byte of its value indicates the highest density floppy present: 0 360Kb/720Kb (double-density) 1 1.44Mb (high-density) 2 2.88Mb (extra-high-density) The low three bytes give an indication of the origin of the unit, the value 0x415443 CATC) indicates an Atari line-fit or retro-fitted unit.
_FPU	This gives an indication of any floating point unit installed in the machine. Only the high word is used at the time of writing. The bits are used as follows (when set): 0 I/O mapped 68881 (e.g. Atari's SFP004) 1 68881 /68882 (unsure which) 2 If bit 1 == 0 then 68881, else 68882 3 68040 internal floating point support
_FRB	'Fast RAM Buffer'. This is used on the TT to give the address of a 64K buffer in ST RAM that all ACSI devices performing DMA can use, when transfers to TT RAM are requested. It is not present if there is no fast RAM.

_MCH	This gives the machine type; it consists of a minor number (low word) and a major number (high word) as follows: Major Minor Machine 0 0 520/1040 or Mega ST 1 0 STe 1 16 Mega STe 2 0 TT Normally you should use the more specific cookies given above, in case some one has added a 68030 processor to an STe, for example. One possible use for this cookie is to detect the presence of the extra TT serial ports.
_SND	This is bit oriented as follows: bit 0 1 if ST style GI/Yamaha chip available bit 1 1 if TT/STe style DMA sound available
_SWI	The STe and TT have internal configuration switches; this gives their value.
_VDO	the major/minor part number of the video shifter. At present the least significant word is always zero and the high word is one of: 0 ST 1 STe 2 TT

Although the cookie jar was introduced with STE TOS it can be retrofitted to earlier STs so don't assume that if there is a Cookie Jar then you are running on at least and STE.

Here is a subroutine that looks in the cookie jar; it assumes that the program is running in user mode.

```
*In         D3 Cookie we are looking for
*Out        EQ    if found D0 is value
*           NE    if not found
*           Destroys A0-2,A4,D0-D2
GetCookie
            clr.w       -(sp)
            move.w      #super,-(sp)
            trap        #1                  into supervisor
            addq.l      #6,sp
.storessp
            opt   nochkimm
            move.l      $5a0,a4             a4 is the Cookie Ptr
            opt   chkimm
            move.l      d0,-(sp)
            move.w      #super,-(sp)
            trap        #1                  back into user
            addq.l      #6,sp
            move.l      a4,d0
            beq.s       .failed
.loop       move.l      (a4)+,d0
            beq.s       .failed
            cmp.l       d0,d3
            beq.s       .success
            addq.l      #4,a3
            bra.s       .loop
```

```
.success
            move.l      (a4)+,d0
            cmp.b       d0,d0               EQ
            rts
.failed
            moveq       #-1,d0              NE
            rts
```

Below is an example of the use of this routine to check th< program is running on a 68020 or higher processor:

```
            move.l      #'_CPU',d3
            bsr         GetCookie
            bne.s       .notfound
            cmp.b       #20,d0
            bcc.s       .ok
* Less than 68020 found  -  give error message
.notfound
...
.ok
* We have at least a 68020.
```

Operating system version numbers

The operating system version numbers on Atari 16 bit computers have been the source of a great deal of confusion, not least because Atari have have changed the nomenclature they themselves use. Note that there are *many* releases of the operating system after ROM version 1.62 (there are at least 5 or 6 different TOS 2.0x - Mega STE TOS and TOS 3.0x - TT TOS releases).

Name	ROM version	`s_version`	AES version
ROM	`$100 (1.00)`	`$1300 (0.13)`	`$120 (1.2)`
Blitter	`$102 (1.02)`	`$1300 (0.13)`	`$120 (1.2)`
Rainbow	`$104 (1.04)`	`$1500 (0.15)`	`$140 (1.4)`
STE	`$106`	`$1500 (0.15)`	`$140 (1.4)`
	`$162 (1.62)`	`$1700 (0.17)`	`$140 (1.4)`
TT	`$301 (3.01)`	`$1900 (0.19)`	`$300 (3.0)`

The hex version numbers shown are those returned by the appropriate OS call or structure; the number shown in parentheses is the accepted nomenclature for these releases.

To check for BIOS and XBIOS features you should use the ROM version number or a suitable cookie jar entry. It is best to use the GEMDOS version number (as returned by `s_version`) and the AES version number (returned in the first word of the global array) when checking to see if the appropriate OS facilities are available. This is not always possible, as ROM TOS and Blitter TOS have the same AES version number, even though the AES was modified considerably between these two versions.

The OS header

The OS header gives information about the system including the operating system version

number and the 'nationality' of the system. The structure is as follows:

```
            rsreset
os_entry    rs.w  1     branch to reset handler
os_version  rs.w  1     version number as above
reseth      rs.l  1     address of reset handler
os_beg      rs.l  1     base of the operating system
os_end      rs.l  1     end of BIOS/XBIOS/VDI ram usage
os_rsvl     rs.l  1     reserved
osjnagic    rs.l  1     GEM memory usage parameter block
os_date     rs.l  1     date of system build YYYYMMDD in BCD
os_conf     rs.w  1     operating system configuration word
os_dosdate  rs.w  1     date of system build in DOS format
p_root      rs.l  1     pointer to base of the OS pool
p_kbshift   rs.l  1     pointer to keyboard shift state var
p_run       rs.l  1     pointer to current GEMDOS pid
p_rsv2      rs.l  1     reserved
```

The last four entries are only present on Blitter/Mega TOS (1.2) and above.

The bottom bit of the os_conf variable is 1 on PAL systems and 0 for NTSC. The other bits contain the country code as follows:

```
USA         equ   0     United States of America
FRG         equ   1     Germany
FRA         equ   2     France
UK          equ   3     United Kingdom
SPA         equ   4     Spain
ITA         equ   5     Italy
SWE         equ   6     Sweden
SWF         equ   7     Switzerland  (French)
SWG         equ   8     Switzerland  (German)
TUR         equ   9     Turkey
FIN         equ   10    Finland
NOR         equ   11    Norway
DEN         equ   12    Denmark
SAU         equ   13    Saudi Arabia
HOL         equ   14    Netherlands
```

The variable at $4F2 gives a pointer to the OS header, but some times this is a RAM copy created by a harddisk driver which has some of the fields incorrect. So to see if you are running on a U.K. system you could use:

```
            pea         get_osheader(pc)
            move.w      #supexec,-(a7)
            trap        #14         run routine in supervisor
            addq.w      #6,a7
            move.w      os_conf(a3),d0
            lsr.b       d0
            cmp.b       #UK,d0
            bne.s       .notuk
* UK specific code - e.g. £ for the currency symbol
get_osheader
            move.l      $4F2.w,a0
            move.l      os_beg(a0), a3
            rts
```

This code assumes that you have included XBIOS.I and the constants above.

Changing window colours

There have been two additions to the wind_set call in TT TOS which you may not find in your AES documentation, so we give their details here. There are two new field types, `WF_COLOR($12)` and `WF_DCOLOR($13)`. `WF_COLOR` is used to change the colour attributes for a particular window (the handle is passed in the word at int_in as usual) whereas `WF_DCOLOR` is used to set the default colours. You should only use `WF_DCOLOR` if you are providing a Control Panel style utility. Also, well mannered applications that set the window colours allow the user to tailor those colours to their own preferences.

The next parameter of the `field` (starting at `int_in+4`) gives the element to be changed and can be one of:

W_BOX	0	window's parent object
WJTITLE	1	parent of close,name and full areas
W_CLOSER	2	close box
W_NAME	3	title and move bar
W_FULLER	4	full box
W_INFO	5	info line
W_DATA	6	surrounds the 'lower[7] window elements
WJWORK	7	application's work area
W_SIZER	8	size box
W_VBAR	9	surrounds the vertical scroll bar
WJJPARROW	$A	vertical scroll bar up arrow
W_DNARROW	$B	vertical scroll bar down arrow
W_VSLIDE	$C	vertical scroll bar background
W_VELEV	$D	vertical scroll bar position indicator
W_HBAR	$E	surrounds the vertical scroll bar
W_LFARROW	$F	horizontal scroll bar left arrow
W_RTARROW	$10	horizontal scroll bar right arrow
W_HSLIDE	$11	horizontal scroll bar background
W_VELEV	$12	horizontal scroll bar position indicator

The following parameters (at `int_in+6` and `int_in+8`) called tcolor and bcolor give the colour words for the window when it is topped and when it is a background window respectively. If either parameter has the value -1 then that component is left as it was.

The colour word format is the same as that used by AES objects, as follows:

Bits 15-12 Border Colour	Bits 11-8 Text Colour	Bit 7 Transparent /Opaque	Bits 6-4 Fill Pattern	Bits 3-0 Fill Colour

Appendix E - The Floating Point Co-processor

This Appendix is designed to give a quick overview of the 68881/68882 maths co-processor's registers and formats as the Motorola M68000 Family Programmer's Reference Manual lacks this, although it does include full details of the co-processor instructions.

The FPUs contain 8 data registers, named `FP0-FP7`, each of which stores an 80 bit extended format number, and three control registers, the floating point control register (`FPCR`), floating point status register (`FPSR`) and floating point instruction address register (`FPIAR`).

Although the floating point data registers always store 80 bit extended precision numbers, the chip can convert these to and from a number of different formats as detailed below:

Extended precision

Extended precision format is stored in memory as 12 bytes. The bit layout is:

95	94-80	79-64	63-0
Sign	Exponent	zero	Mantissa

The sign bit is 0 for positive numbers and 1 for negative numbers. The mantissa has an implied binary point at bit 63 and thus ranges in value from 1.0 to <2.0.

The exponent is held in excess 16383 ($3FFF) format with values of 0 and $7FFF being treated specially.

When the exponent is $7FFF, the value represents Not-A-Number (NaN), the type of which is determined by the mantissa. Zero mantissas indicate infinity (°°), whilst non-zero mantissas indicate other NaN conditions.

With an exponent of 0 there are two possibilities. The number zero is represented by all bits zero, whereas other values are de-normalised numbers with an exponent of -16383 ($3FFF).

Double precision

The double precision IEEE format represents a number in 8 bytes. The bit layout is:

63	62-52	51-0
Sign	Exponent	Mantissa

The sign bit is 0 for positive numbers and 1 for negative numbers. The mantissa has an implied binary point at bit 51 and thus ranges in value from 1.0 to <2.0.

The exponent is held in excess 1023 ($3FF) format with values of 0 and $7FF being treated specially.

When the exponent is $7FF, the value represents Not-A-Number (NaN), the type of which is determined by the mantissa. Zero mantissas indicate infinity (°°), whilst non-zero mantissas indicate other NaN conditions.

With an exponent of 0 there are two possibilities. The number zero is represented by all bits zero, whereas other values are de-normalised numbers with an exponent of -1022 ($3FE).

Single Precision

The single precision IEEE format represents a number in 4 bytes. The bit layout is:

31	30-23	22-0
Sign	Exponent	Mantissa

The sign bit is 0 for positive numbers and 1 for negative numbers. The mantissa has an implied binary point at bit 23 and thus ranges in value from 1.0 to <2.0.

The exponent is held in excess 127 format with values of 0 and $FF being treated specially.

When the exponent is $FF, the value represents Not-A-Number (NaN), the type of which is determined by the mantissa. Zero mantissas indicate infinity (°°), whilst non-zero mantissas indicate other NaN conditions.

With an exponent of 0 there are two possibilities. The number zero is represented by all bits zero, whereas other values are de-normalised numbers with an exponent of -126.

Packed Decimal

Packed decimal numbers are stored is stored in memory as 12 bytes. The bit layout is:

Bit	Meaning
95	Sign of mantissa.
94	Sign of exponent.
93-92	If %11 (i.e. both bits set) then a NAN or infinity (°°). Otherwise 0. See below.
91-80	3 least significant digits of exponent in decimal.
76-79	Most significant digit of exponent in decimal on a FMOVE. P to memory if a fourth digit is required; otherwise don't care.
75-68	Don't care.
67-64	Most significant digit of the mantissa.
63-0	Remainder of digits of the mantissa.

If bits 93 and 92 are both one then bits 91-80 (the exponent) will be $FFF. If bits 63 to 0 are all zero then this represents infinity (bit 95 giving the sign) otherwise the value is Not-A-Number (NaN).

We will now discuss the floating point control registers.

FPCR Floating point control register

Although this is a 32 bit register only the bottom two bytes are defined as yet. The more significant byte is known as the *FPCR Exception Enable Byte* and controls whether particular conditions will cause an exception (if the corresponding bit is one) or whether the appropriate bit in the FPSR exception status byte is set. See below. The bits are as follows:

Bit	Name	Meaning
8	INEX1	Inexact decimal input
9	INEX2	Inexact operation
10	DZ	Divide by zero
11	UNFL	Underflow
12	OVFL	Overflow
13	OPERR	Operand error
14	SNAN	Signalling Not-A-Number (NaN)
15	BSUN	Branch/set on unordered

The least significant byte selects the rounding mode and rounding precision and is known as the *FPCR Mode Control Byte.* It is laid out as follows:

Bits	Name	Meaning
3-0		Zero
5-4	ROUND	Rounding direction. Towards: 00 nearest 01 zero 10 minus infinity 11 plus infinity
7-6	PREC	Rounding precision: 00 Extended 01 Single 10 Double 11 Reserved

FPSR Floating point status register

This is a 32 bit register, which is divided into four bytes:

31-25	24-17	16-8	7-0
condition code	quotient	exception status	accrued exception

The *FPSR Condition Code Byte* is updated after all the floating point instructions (other than FMOVEM) whose destination is a single floating point register FP0-7. The bits are as follows:

Bit	Name	Meaning
24	NAN	Not a number
25	I	Infinity
26	Z	Zero
27	N	Negative
31-28		Always 0

The quotient byte contains the sign of the quotient (bit 24) and 7 least significant bits (bits 23-17) of the quotient after an FMOD or FREM instruction. This is normally used as the first stage of performing approximations to trigonometric functions by taking the remainder after a division by a fraction of pi.

The FPSR *Exception Status Byte* (EXC) is updated after all the floating point instructions (other than FMOVEM) whose destination is a single floating point register FP0-7. The bits are as follows:

Bit	Name	Meaning
8	INEX1	Inexact decimal input
9	INEX2	Inexact operation
10	DZ	Divide by zero
11	UNFL	Underflow
12	OVFL	Overflow
13	OPERR	Operand error
14	SNAN	Signalling Not-A-Number (NAN)
15	BSUN	Branch/set on unordered

In the *FPSR Accrued Exception Byte* (AEXC) the bits are 'sticky' i.e. only cleared by an explicit move into the FPSR. It is updated after all the floating point instructions (other than FMOVEM) whose destination is a single floating point register FP0-7. In the table below, the Exception status bits column gives the condition in the FPSR Exception Status byte that will cause the appropriate bit to be set:

Bit	Name	Exception status bits	Meaning
2-0			Always 0
3	INEX	INEX1!INEX2!OVFL	Inexact
4	DZ	DZ	Divide by zero
5	UNFL	UNFL&INEX2	Underflow
6	OVFL	OVFL	Overflow
7	IOP	BSUN!SNAN!OPERR	Invalid operation

In the table above, ! means OR and & meaning AND. Thus bit 3 of the AEXC will be set after an instruction if it was already set or if the INEX1, INEX2 or OVFL bits in the EXC byte get set.

FPIAR Floating point instruction address register

The floating point co-processor stores the current program counter in the floating point instruction address register when it starts to process an instruction, so that exception handlers

can determine the instruction that cause the exception. The handler cannot just look at its own program counter as most of the floating point instructions are executed concurrently with the main processor and so will refer to a later instruction.

Appendix F - Converting from other Assemblers

Most 68000 assemblers for TOS follow, to one degree or another, the Motorola standard. While the instructions themselves are thankfully standard, the syntax rules for labels, comments and directives can, and do, vary. This Appendix covers the changes most likely to be made when converting programs from another assembler, whether they are your old source files or a program listed in a magazine. It does not attempt to detail the differences in user interfaces or options between the different assemblers.

Atari MadMAC

Devpac does not require colons after labels or comments to be delimited with semicolons, but it does not allow instructions or directives to start in the label field.

The syntax and rules for local labels are the same, though $ and ? are not valid in Devpac symbols. The use of \ in quoted strings may have to be changed, and some arithmetic operators and priorities are different.

MadMAC allows directives to start with dot, if these are removed most directives are the same as Devpac. Those that differ, and their Devpac equivalents, are:

`ABS=OFFSET`, `ENDIF=ENDC`, `EXITM=MEXIT`, `GLOBL` and `EXTERN=XREF` or `XDEF`, `EJECT=PAGE`, `TITLE=TTL`, `NLIST=NOLIST`.

`INIT` can be converted to `DC` or `DCB` statements.

MadMAC s macro syntax is unique and its named parameters will need conversion, equivalents for its parameters are \ -= \ @ and \ ? can be emulated using `IFC` or `IFNC`. The 6502 options of MadMAC are not supported.

GST-ASM

GST-ASM labels are significant only to the first 8 characters and are case insensitive so `OPT C8-` may be required. Its rules for expression evaluation are very similar though $ is not allowed within a Devpac symbol.

Most directives are the same, those requiring name changes are `PAGEWID=LLEN` and `PAGELEN=PLEN`. Macro definitions will require conversion as will GST's unique form of local symbols.

Built-in functions and structure statements are not supported.

MCC Assembler

Very few changes are required, only the string operators are not supported and the need to add `.L` to `XREF` directives of absolutes.

K-Seka

Colons are not required after labels in Devpac though instructions or directives that start in the label field will need a tab added before them. Several Seka directives default to byte instead of word sizes for some reason. Equivalent directives names are:

`D=DC, BLK=DS, CODE=SECTION TEXT, IF=IFNE, ENDIF=ENDC`.

Macro syntax requires ?s to be changed to \s, except ?0 which should be replaced with \ @.

Fast ASM

The syntax of Fast ASM was designed around Gen 1.2 so few changes are required. Tokenised source files will need conversion to ASCII (using the Clipboard) before attempting to load them into the Devpac editor. The main change involves comment delimiters - Fast ASM lines starting with \ should be changed to start with * or ; - \ s used after instructions will not require any changes.

Appendix G - New Features

Summary of Version 3 Improvements

This section is intended as a quick guide to the main additional facilities that Devpac 3 provides for users who are familiar with version 2.2 of DevpacST. Users of earlier versions of DevpacST 2 should note that a considerable number of features were added during its life time.

We will give an overview of the new features here; for further details you should consult the relevant sections of this manual.

The Editor

This has been greatly enhanced, with multi-window editing, full mouse control, bookmarks, cut-and-paste, pop-up option menus, visual shell facilities, faster search and replace, different font sizes being some of the major highlights.

The Assembler

The assembler now fully supports all the 68000 to 68040 and 68332 processors, the 68881/2 maths co-processor and the 68851 MMU. It can also produce S-records & Lattice linkable code in addition to standard TOS executable and DRI/GST linkable code. To complement the production of S-records we supply an S-record splitter for use with EPROMs that are not the same width as the processor's bus.

The assembler can now generate and process pre-assembled include files. This increases the speed of assembly of programs that use the operating system include files.

LINE and HCLN debug hunks can be generated so that debuggers (including Mon version 3) can track the source code that corresponds to a given address and vice versa.

The range of options has been extended and options may now be specified by name rather than using cryptic letters. Command line support has been enhanced to allow the setting of labels and otherwise unavailable options. Options are also read from a default file and this can be created using the editor.

The assembler now gives an indication of where in a line an error was detected. The full range of relational operators are now supported.

Options have been added for listings on pass 1 and for tracing conditional assembly. The use of privileged instructions can now be controlled using the `SUPER` and `USER` options.

Further optimisation facilities are provided.

The `CARGS` and `RADIX` directives have been added.

`\#` may now be used as a synonym for `NARGS` in macros and the `macro .w` feature has been added for macros that must generate code on even boundaries. `\?` may be used to find the length of a macro parameter.

Default module names are more descriptive.

Compatibility Issues

Most source files should assemble with no changes although the new directive names may clash with existing macro names. Also `.b` may not be used as a local label.

If you are using shell scripts or make files you should note that the standalone version of the assembler is now called Gen.

The GEMMACRO.S file has been renamed GEMMACRO.I.

The Debugger

The front panel window display of Mon can now be organised as you wish. Windows can be split horizontally, vertically and also stacked in order to extend the number of available work areas. Each stacked window may be locked to an arbitrary expression allowing interactive monitoring of complex data structures.

Any number of source files may be loaded into each window along with any associated line number debugging information such as that output by Gen. Multi-module programs can thus be single stepped line by line from your original source file. Two powerful new operators are provided which convert a program address into a source line number and locate any part of the program from its position in the source.

Mon 'understands' the new video modes, 68030 and 68881 registers and instructions and the TT memory map. It also includes commands to read and write individual hardware ports via the Query Port and Transfer to Port commands, compare memory and dynamic symbol table loading. The full range of relational operators are now supported.

Integration

The integration of the package has been further enhanced so that the Next Error (Alt-J) command now works in multiple files and the assembler will read include files from memory without the need to save these to disk. The full range of assembly options is now available via the assembly option dialogs.

New tools

Devpac 3 also includes CLink, the Lattice C format linker, our reset-proof ramdisk, more include files for accessing the operating system and a utilities for splitting S-record files, SRSplit and removing debug information from files, Strip.

Features added to Devpac ST 2

This section indicates some of features that were added to DevpacST 2 before version 2.2 was released; if you are familiar with an early version of this product you should find it useful.

The operating system libraries have been expanded to cover the new calls that been

introduced.

Mon

Labels that are embedded in data areas, and full `MOVEM` register lists are now shown when disassembling to disk. The search command is now more flexible.

Gen

A number of new optimisations and error checking options were added. The `@` character is now allowed in symbols. Labels may be defined on the command line and this version of the assembler returns an appropriate GEMDOS return code. Local labels ending with a $ are now supported.

The GEMDOS header load bits by now be set using `COMMENT HEAD=`. The new directives `TEXT`, `DATA` and `BSS` are supported for increased compatibility. One line `IF`s (via the `IIF`) are also available.

LinkST

LinkST is very much faster than its original version.

Appendix H - Technical Support

HiSoft Devpac comes with 30 days free technical support, starting from the date of registration; therefore you should send in your registration card quickly. Technical support is available by telephone during our Technical Support Hour, by letter or by fax.

Should you wish to receive extended technical support, please complete the relevant sections on the registration card, indicating whether you would like to take up the *Silver* or the *Gold* service.

In addition to your name, address and postcode (very important for UK customers), we need payment details before we can accept your extended registration. You can pay by credit card (Mastercard, Eurocard, Access, Visa etc.), UK debit card (Switch, Connect etc.), Eurocheque, UK cheque or Postal Order.

You may have already registered another HiSoft product under our *Gold* or *Silver* service; in this case, there is no need to fill out the payment section.

Appendix I - Bibliography

This bibliography contains our suggestions for further reading on the subject of the Atari's operating system, 680x0 assembly language and programming in general. The views expressed are our own and as with all reference books there is no substitute for looking at the books in a good bookshop before making a decision.

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