

# ASSEMBLER DEVELOPMENT KIT FOR THE QL

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Preface

Chapter 1: The Screen Editor

Metacomco's Assembler Development Kit for the QL is a powerful package incorporating a full screen editor and a macro assembler. This book is intended to be a guide for users of the kit and does not aim to be fully comprehensive on all related aspects of the QL or assembler programming. It assumes that the reader has knowledge of the QDOS operating system.

If further detailed information is required, a full specification of the Motorola 68008 microprocessor can be found in *MC68000 16/32 Bit Microprocessor Programmer's Reference Manual* (4th edition, ISBN 1-356-6795X) published by Prentice-Hall. An introduction to assembler programming can be found in various introductory texts such as *Programming the M68000* by Tim King and Brian Knight (ISBN 0-201-14635-5) published by Addison-Wesley. Further information about QDOS can be found in *QL Advanced User Guide* by Adrian Dickens (ISBN 0-947929-00-2) published by Adder Publishing.

## Assembler Development Kit for the QL

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### 1.1 Introduction

The screen editor ED) may be used to create a new file or to alter an existing one. The text is displayed on the screen, and can be scrolled vertically or horizontally as required. The size of the program is about 20K bytes and it requires a minimum workspace of 8K bytes.

The editor is invoked using EXEC or EXEC\_W as follows

```
EXEC_W mdv1_ed
```

The difference between invoking a program with EXEC or EXEC\_W is as follows. Using EXEC\_W means that the editor is loaded and SuperBasic waits until the editing is complete. Anything typed while the editor is running is directed to the editor. When the editor finishes, keyboard input is directed at SuperBasic once more.

Using EXEC is slightly more complicated but is more flexible. In this case the editor is loaded into memory and is started, but SuperBasic carries on running. Anything typed at the keyboard is directed to SuperBasic unless the current window is changed. This is performed by typing CTRL-C, which switches to another window. If just one copy of ED is running then CTRL-C will switch to the editor window, and characters typed at the keyboard will be directed to the editor. A subsequent CTRL-C switches back to SuperBasic. When the editor is terminated a CTRL-C will be needed to switch back to SuperBasic once more. More than one version of the editor can be run concurrently (subject to available memory) if EXEC is used. In this case CTRL-C switches between SuperBasic and the two versions of the editor in turn.

Once the program is loaded it will ask for a filename which should conform to the standard QDOS filename syntax. No check is made on the name used, but if it is invalid a message will be issued when an attempt is made to write the file out, and a different file name may be specified then if required. All subsequent questions have defaults which are obtained by just pressing ENTER.

The next question asks for the workspace required. ED works by loading the file to be edited into memory and sufficient workspace is needed to hold all the file plus a small overhead. The default is 12K bytes which is sufficient for small files. The amount can be specified as a number or in units of 1024 bytes if the number is terminated by the character K. If you ask for more memory than is available then the question is asked again. The minimum is 8K bytes.

You are next asked if you wish to alter the window used by ED. The default window is normally the same as the window used in the initialisation of ED although this may be altered if required. See Appendix B for details of how to do this. If you type N or just press ENTER then the default window is used. If you type Y then you are given a chance to alter the window. The current window is displayed on the screen and the cursor keys can be used to move the window around. The combination ALT and the cursor keys will alter the size of the window although there is a minimum size which may be used. Within this constraint you can specify a window anywhere on the screen, so that you can edit a file and do something else such as run a SuperBasic program concurrently. When you are satisfied with the position of the window press ENTER.

Next, an attempt is made to open the file specified, and if this succeeds then the file is read into storage and the first few lines displayed on the screen. Otherwise a blank screen is provided, ready for the addition of new data. The message "File too big" indicates that more workspace should be specified.

When the editor is running the bottom line of the screen is used as a message area and command line. Any error messages are displayed there, and remain displayed until another editor command is given.

Editor commands fall into two categories - immediate commands and extended commands. Immediate commands are those which are executed immediately, and are specified by a single key or control key combination. Extended commands are typed in onto the command line, and are not executed until the command line is finished. A number of

extended commands may be typed on a single command line, and any commands may be grouped together and groups repeated automatically. Most immediate commands have a matching extended version.

Immediate commands use the function keys and cursor keys on the QL, in conjunction with the special keys SHIFT, CTRL, and ALT. For example, delete line is requested by holding down the CTRL and ALT keys and then pressing the left arrow key. This is described in this document as CTRL-ALT-LEFT. Function keys are described as F1, F2 etc.

The editor attempts to keep the screen up to date, but if a further command is entered while it is attempting to redraw the display, the command is executed at once and the display will be updated later, when there is time. The current line is always displayed first, and is always up to date.

## 1.2 Immediate commands

### Cursor control

The cursor is moved one position in either direction by the cursor control keys LEFT, RIGHT, UP and DOWN. If the cursor is on the edge of the screen the text is scrolled to make the rest of the text visible. Vertical scroll is carried out a line at a time, while horizontal scroll is carried out ten characters at a time. The cursor cannot be moved off the top or bottom of the file, or off the left hand edge of the text.

The ALT-RIGHT combination will take the cursor to the right hand edge of the current line, while ALT-LEFT moves it to the left hand edge of the line. The text will be scrolled horizontally if required. In a similar fashion SHIFT-UP places the cursor at the start of the first line on the screen, and SHIFT-DOWN places it at the end of the last line on the screen.

The combinations SHIFT-RIGHT and SHIFT-LEFT take the cursor to the start of the next word or to the space following the previous word respectively. The text will be scrolled vertically or horizontally as required. The TAB key can also be used. If the cursor position is beyond the end of the current line then TAB moves the cursor to the next tab position, which is a multiple of the tab setting (initially 3). If the cursor is over some text then sufficient spaces are inserted to align the cursor with the next tab position, with any characters to the right of the cursor being shuffled to the right.

### Inserting text

Any letter typed will be added to the text in the position indicated by the cursor, unless the line is too long (there is a maximum of 255 characters in a line). Any characters to the right of the text will be shuffled up to make room. If the line exceeds the size of the screen the end of the line will disappear and will be redisplayed when the text is scrolled horizontally. If the cursor has been placed beyond the end of the line, for example by means of the TAB or cursor control keys, then spaces are inserted between the end of the line and any inserted character. Although the QL keyboard generates a different code for SHIFT-SPACE and SHIFT-ENTER these are mapped to normal space and ENTER characters for convenience.

An ENTER key causes the current line to be split at the position indicated by the cursor, and a new line generated. If the cursor is at the end of a line the effect is simply to create a new, empty blank line after the current one. Alternatively CTRL-DOWN may be used to generate a blank line after the current, with no split of the current line taking place. In either case the cursor is placed on the new line at the position indicated by the left margin (initially column one).

A right margin may be set up (using the command SR) so that ENTERs are automatically inserted before the preceding word when the length of the line being typed exceeds that margin. In detail, if a character is typed and the cursor is at the end of the line and at the right margin position then an automatic newline is generated. Unless the character typed was a space, the half completed word at the end of the line is moved down to the newly generated line. (Note that if a line has no spaces, i.e. it is completely full of characters, the whole line of text is considered to be one 'word' which is then moved down to a new line, leaving an empty line above). Initially there is a right margin set up at the right hand edge of the window used by ED. The right margin may be disabled by means of the EX command (see later).

### Deleting text

The CTRL-LEFT key combination deletes the character to the left of the cursor and moves the cursor left one position. If the cursor is at the start of a line then the newline between the current line and the previous is deleted (unless you are on the very first line). The text will be scrolled if required. CTRL-RIGHT deletes the character at the current cursor position without moving the cursor. As with all delete characters remaining on the line are shuffled down, and text which was invisible beyond the right hand edge of the screen may now become visible.

The combination SHIFT-CTRL-RIGHT may be used to delete a word or a number of spaces. The action of this depends on the character at the

cursor. If this character is a space then all spaces up to the next non-space character on the line are deleted. Otherwise characters are deleted from the cursor, and text shuffled left, until a space is found. The CTRL-ALT-RIGHT command deletes all characters from the cursor to the end of the line. The CTRL-ALT-LEFT command deletes the entire current line.

### Scrolling

Besides the vertical scroll of one line obtained by moving the cursor to the edge of the screen, the text may be scrolled 12 lines vertically by means of the commands ALT-UP and ALT-DOWN. ALT-UP moves to previous lines, moving the text window up; ALT-DOWN moves the text window down moving to lines further on in the file. The F4 key rewrites the entire screen, which is useful if the screen is altered by another program besides the editor. Remember that you can switch out of the editor window and into some other job by typing CTRL-C at any point, assuming that there is another job with an outstanding input request. SuperBasic will be available only if you entered the editor using EXEC rather than EXEC\_W. If there is enough room in memory you can run two versions of ED at the same time if you wish.

### Repeating commands

The editor remembers any extended command line typed, and this set of extended commands may be executed again at any time by simply pressing F2. Thus a search command could be set up as the extended command, and executed in the normal way. If the first occurrence found was not the one required, typing F2 will cause the search to be executed again. As most immediate commands have an extended version, complex sets of editing commands can be set up and executed many times. Note that if the extended command line contains repetition counts then the relevant commands in that group will be executed many times each time the F2 key is pressed.

## 1.3 Extended commands

Extended command mode is entered by pressing the F3 key. Subsequent input will appear on the command line at the bottom of the screen. Mistakes may be corrected by means of CTRL-LEFT and CTRL-RIGHT in the normal way, while LEFT and RIGHT move the cursor over the command line. The command line is terminated by pressing ENTER. After the extended command has been executed the editor reverts to immediate mode. Note that many extended commands can be given on a single command line, but the maximum length of the command line is 255 characters. An empty command line is allowed, so just typing ENTER after typing F3 will return to immediate mode.

Extended commands consist of one or two letters, with upper and lower case regarded as the same. Multiple commands on the same command line are separated from each other by a semicolon. Commands are sometimes followed by an argument, such as a number or a string. A string is a sequence of letters introduced and terminated by a delimiter, which is any character besides letters, numbers, space, semicolon or brackets. Thus valid strings might be

```
/happy/ 123 feet! :Hello! "1/2"
```

Most immediate commands have a corresponding extended version. See the table of commands for full details (section 1.4).

### Program control

The command X causes the editor to exit. The text held in storage is written out to file, and the editor then terminates. The editor may fail to write the file out either because the filename specified when editing started was invalid, or because the microdrive becomes full. In either case the editor remains running, and a new destination should be specified by means of the SA command described below. Alternatively the Q command terminates immediately without writing the buffer; confirmation is requested in this case if any changes have been made to the file. A further command allows a 'snapshot' copy of the file to be made without coming out of ED. This is the SA command. SA saves the text to a named file or, in the absence of a named file, to the current file. For example:

```
*SA /mdv2_savedtext/
or
*SA
```

This command is particularly useful in areas subject to power failure or surge. It should be noted that SA followed by Q is equivalent to the X command. Any alterations made between the SA and the Q will cause ED to request confirmation again; if no alterations have been made the program will be quitted immediately with the file saved in that state. SA is also useful because it allows the user to specify a filename other than the current one. It is therefore possible to make copies at different stages and place them in different files.

The SA command is also useful in conjunction with the R command. Typing R followed by a filename causes the editor to be re-entered editing the new file. The old file will be lost when this happens, so confirmation is requested (as with the Q command) if any changes to the

current file have been made. The normal action is therefore to save the current file with SA, and then start editing a new file with R. This saves having to load the editor into memory again, and means that once the editor is loaded the microdrive containing it can be replaced by another.

The U command "undoes" any alterations made to the current line if possible. When the cursor is moved from one line to another, the editor takes a copy of the new line before making any changes to it. The U command causes the copy to be restored. However the old copy is discarded and a new one made in a number of circumstances. These are when the cursor is moved off the current line, or when scrolling in a horizontal or vertical direction is performed, or when any extended command which alters the current line is used. Thus U will not "undo" a delete line or insert line command, because the cursor has been moved off the current line.

The SH command shows the current state of the editor. Information such as the value of tab stops, current margins, block marks and the name of the file being edited is displayed. Tabs are initially set at every three columns; this can be changed by the command ST, followed by a number n, which sets tabs at every n columns. The left margin and right margin can be set and reset by SL and SR commands, again followed by a number indicating the column position. The left margin should not be set beyond the width of the screen. The EX command may be used to extend margins; once this command is given, no account will be taken of the right margin on the current line. Once the cursor is moved off the current line, margins are enabled once more. To extend more than just the current line, use the SR command. The right hand margin may be set beyond the width of the window or screen. The maximum width is 255. (See also 1.2 Inserting text).

**Block control**

A block of text can be identified by means of the BS (block start) and BE (block end) commands. The cursor should be moved to the first line required in a block, and the BS command given. The cursor can then be moved to the last line wanted in the block, by cursor control commands or in any other way, such as searching. The BE command is then used to mark the end of the block. Note, however, that if any change is made to the text the block start and block end become undefined once more. The start of the block must be on the same line, or a line previous to, the line which marks the end of the block. A block always contains all of the line(s) within it.

Once a block has been identified, a copy of it may be moved into another part of the file by means of the IB (insert block) command. The previously identified block is replicated immediately after the current line. Alternatively a block may be deleted by means of the DC command, after which the block start and end values are undefined. It is not possible to insert a block within itself.

Block marks may also be used to remember a place in a file. The SB (show block) command resets the screen window on the file so that the first line in the block is at the top of the screen.

A block may also be written to a file by means of the WB command. The command is followed by a string which represents a file name. The file is created, possibly destroying the previous contents, and the buffer written to it. A file may be inserted by the IF command. The filename given as the argument string is read into storage immediately following the current line.

**Movement**

The command T moves the screen to the top of the file, so that the first line in the file is the first line on the screen. The B command moves the screen to the bottom of the file, so that the last line in the file is the bottom line on the screen if possible.

The commands N and P move the cursor to the start of the next line and previous line respectively. The commands CL and CR move the cursor one place to the left or one place to the right, while CE places the cursor at the end of the current line, and CS places it at the start.

It is common for programs such as compilers and assemblers to give line numbers to indicate where an error has been detected. For this reason the command M is provided, which is followed by a number representing the line number which is to be located. The cursor will be placed on the line number in question. Thus M1 is the same as the T command. If the line number specified is too large the cursor will be placed at the end of the file.

**Searching and Exchanging**

Alternatively the screen window may be moved to a particular context. The command F is followed by a string which represents the text to be located. The search starts at one place beyond the current cursor position and continues forwards through the file. If found, the cursor is placed at the start of the located string. To search backwards through the text use the command BF (backwards find) in the same way as F. BF will find the last occurrence of the string before the current cursor position. To find the earliest occurrence use T followed by F; to find the last, use B followed by BF. The string after F and BF can be omitted; in this case the string specified in the last F, BF or E command is used. Thus

\*F /wombat/

\*BF

will search for 'wombat' in a forwards direction and then in a reverse direction.

The E (exchange) command takes a string followed by further text and a further delimiter character, and causes the first string to be exchanged to the last. So for example

E /wombat/zebra/

would cause the letters 'wombat' to be changed to 'zebra'. The editor will start searching for the first string at the current cursor position, and continues through the file. After the exchange is done the cursor is moved to after the exchanged text. An empty string is allowed as the search string, specified by two delimiters with nothing between them. In this case the second string is inserted at the current cursor position. No account is taken of margin settings while exchanging text.

A variant on the E command is the EQ command. This queries the user whether the exchange should take place before it happens. If the response is N then the cursor is moved past the search string. If the response is Y or ENTER then the change takes place; any other response (except F2) will cause the command to be abandoned. This command is normally only useful in repeated groups; a response such as Q can be used to exit from an infinite repetition.

All of these commands normally perform the search making a distinction between upper and lower case. The command UC may be given which causes all subsequent searches to be made with cases equated. Once this command has been given then the search string "wombat" will match "Wombat", "WOMBAT", "WoMbaT" and so on. The distinction can be enabled again by the command LC.

**Altering text**

The E command cannot be used to insert a newline into the text, but the I and A commands may be used instead. The I command is followed by a string which is inserted as a complete line before the current line. The A command is also followed by a string, which is inserted after the current line. It is possible to add control characters into a file in this way.

The S command splits the current line at the cursor position, and acts just as though an ENTER had been typed in immediate mode. The J command joins the next line onto the end of the current one.

The D command deletes the current line in the same way as the CTRL-ALT-LEFT command in immediate mode, while the DC command deletes the character at the cursor in the same way as CTRL-RIGHT.

**Repeating commands**

Any command may be repeated by preceding it with a number. For example,

4 E /slithy/brillig/

will change the next four occurrences of 'slithy' to 'brillig'. The screen is verified after each command. The RP (repeat) command can be used to repeat a command until an error is reported, such as reaching the end of the file. For example,

RP E /slithy/brillig/

will change all occurrences of 'slithy' to 'brillig'.

Commands may be grouped together with brackets and these command groups executed repeatedly. Command groups may contain further nested command groups. For example,

RP ( F /bandersnatch/; 3 (B; N) )

will insert three copies of the current block whenever the string 'bandersnatch' is located.

Note that some commands are possible, but silly. For example,

RP SR 60

will set the right margin to 60 ad infinitum. However, any sequence of extended commands, and particularly repeated ones, can be interrupted by typing any character while they are taking place. Command sequences are also abandoned if an error occurs.

## 1.4 Command List

In the extended command list, /s/ indicates a string, /s/U indicates two exchange strings and n indicates a number.

### Immediate commands

|                  |                                   |
|------------------|-----------------------------------|
| F2               | Repeat last extended command      |
| F3               | Enter extended mode               |
| F4               | Redraw screen                     |
| LEFT             | Move cursor left                  |
| SHIFT-LEFT       | Move cursor to previous word      |
| ALT-LEFT         | Move cursor to start of line      |
| CTRL-LEFT        | Delete left one character         |
| CTRL-ALT-LEFT    | Delete line                       |
| RIGHT            | Move cursor right                 |
| SHIFT-RIGHT      | Move cursor to start of next word |
| ALT-RIGHT        | Move cursor to end of line        |
| CTRL-RIGHT       | Delete right one character        |
| CTRL-ALT-RIGHT   | Delete to end of line             |
| SHIFT-CTRL-RIGHT | Delete word to right              |
| UP               | Move cursor up                    |
| SHIFT-UP         | Cursor to top of screen           |
| ALT-UP           | Scroll up                         |
| DOWN             | Move cursor down                  |
| SHIFT-DOWN       | Cursor to bottom of screen        |
| ALT-DOWN         | Scroll down                       |
| CTRL-DOWN        | Insert blank line                 |

### Extended Commands

|         |  |
|---------|--|
| A /s/   | Insert line after current                            |
| B       | Move to bottom of file                               |
| BE      | Block end at cursor                                  |
| BF      | Backwards find                                       |
| BS      | Block start at cursor                                |
| CE      | Move cursor to end of line                           |
| CL      | Move cursor one position left                        |
| CR      | Move cursor one position right                       |
| CS      | Move cursor to start of line                         |
| D       | Delete current line                                  |
| DB      | Delete block   |
| DC      | Delete character at cursor                           |
| E /s/U  | Exchange s into t                                    |
| EQ /s/U | Exchange but query first                             |
| EX      | Extend right margin                                  |
| F /s/   | Find string s  |
| I /s/   | Insert line before current                           |
| IB      | Insert copy of block                                 |
| IF /s/  | Insert file s  |
| J       | Join current line with next                          |
| LC      | Distinguish between upper and lower case in searches |
| M n     | Move to line n                                       |
| N       | Move cursor to start of next line                    |
| P       | Move cursor to start of previous line                |
| Q       | Quit without saving text                             |
| R /s/   | Re-enter editor with file s                          |
| RP      | Repeat until error                                   |
| S       | Split line at cursor                                 |
| SA /s/  | Save text to file                                    |
| SB      | Show block on screen                                 |
| SH      | Show information                                     |
| SL n    | Set left margin                                      |
| SR n    | Set right margin                                     |
| ST n    | Set tab distance                                     |
| T       | Move to top of file                                  |
| U       | Undo changes on current line                         |
| UC      | Equate U/C and /c in searches                        |
| WB /s/  | Write block to file s                                |
| X       | Exit, writing text back                              |

## Chapter 2: The Macro Assembler

### 2.1 Introduction

The Sinclair QL contains a Motorola 68008 microprocessor which was designed to supersede the MC6800 and MC6809 processors. It is a byte-addressed machine with a 20 bit address bus, giving it an address space of 1 megabyte. It has at any one time 16 32-bit registers, 8 of which are specialised for arithmetic type operations (data registers, named D0-D7), and the other 8 of which are specialised for addressing operations (address registers, named A0-A7). A7 (synonymous to SP) is designated as the Stack Pointer.

It has two operating states (User and System), the second of which is privileged, and has its own, separate stack pointer. This means that there are in fact 9 address registers, only 8 of which are visible at any one time. In addition to the general purpose registers, there is a 24-bit Program Counter (PC), and a 16-bit Status Register (SR) incorporating the 8-bit Condition Code register (CCR).

Like the MC6809, the MC68008 has a large collection of addressing modes, and addresses are specified by using one of the 12 Effective Address types, the assembler code syntax of which is described later. The MC68008 is capable of performing 8, 16 and 32 bit arithmetic, and most instructions have a size qualifier, specifying the size of the operation to be performed.

### 2.2 Running the Assembler

The assembler consists of three overlays, and will normally require most of the available memory of an unexpanded QL. Thus it is not possible to run the assembler with a large SuperBasic program and the editor in memory unless the QL has expansion RAM fitted. It may be possible to load the first assembler overlay with little spare RAM, but the assembler will not be able to load the second (and largest) overlay in this case. It is run using the EXEC or EXEC\_W command as follows:

```
EXEC_W ndvl_asm
```

See the description of the editor for a fuller discussion of the difference between EXEC and EXEC\_W. Once the program has loaded it will ask for the name of the source file. This file should contain a suitable assembly language program. This will consist of a mixture of instruction opcodes and directives, symbolic names and labels, operators and other special symbols. This file must be provided and must exist. Note that the assembler will require access to the microdrive from which it was loaded whilst it runs, so the normal course of action is to keep the source on one microdrive and the assembler on another. The assembler can be loaded from either drive.

The assembler then proceeds to ask a number of further questions, all of which have a default value which is used if just ENTER is pressed. The first of these is to determine whether an assembly listing is required, and if so where it is to be produced. The initial question asks if a listing is needed; the default is N which means that no listing will be produced. In this case if any error is detected the line in error and the error message will be displayed in the window. If the reply is Y then a further question is asked concerning the destination for the listing. The default is to produce the listing on the screen, and if ENTER is pressed then this is assumed. When the listing is produced on the screen, then no page headings are printed. If a file name is specified then this will be used. The file may refer to a microdrive file or to a serial line device such as ser1 to which a printer is connected. In this case page headings are produced at the top of each page, and directives such as PAGE (see below) will cause a page throw. Note that in order to copy a listing saved on a microdrive to a printer COPY\_N rather than just COPY should be used.

Assembly listings contain all the lines in the input file which are not disabled from being printed by either a NOLIST directive or because the line contains a directive which is not echoed. The output provides the address or relative offset followed by the code generated. This is followed by a space or an E if the line is in error. The line number and the reflection of the input text makes up the rest of the line. If the line is the result of a macro expansion then the line number will be followed by a plus sign (+). If there are any errors then a new page is given at the end of the listing detailing the error, with a full English error message and a reference to the line number.

The next question concerns the code file. This will contain the object code produced by the assembler. The default is that no code output is required, so none will be produced; this is useful if a simple check on the syntax of a program is required, or perhaps just an assembly listing is needed. If a file name is given then an attempt is made to open it, and the question is asked again if this fails.

The final stage is to determine whether the window used by the assembler is to be changed. The reply ENTER or N means that the default window is to be used. The default window is normally the same as the initial window, but this may be changed. See Appendix B for details. If Y is typed then the window is cleared and it may be moved or changed in size by means of the cursor keys. The cursor keys by themselves move the window, while ALT pressed in conjunction with the cursor keys will alter the window size. Once the window is suitably defined, ENTER will proceed with the assembly.

The output file may be in one of four different formats, depending on the assembler program. The formats may not be mixed. The first format is position independent code. In this case the output will be binary code which can be loaded anywhere in memory. In order to produce code which can be EXECed the file must be position independent, as there is no way to determine where in memory the code will be loaded. It is normally good style to write programs as position independent if at all possible. Code will be produced as position independent if ORG is not specified and if no relocation information is generated.

The second case is relocatable code. This is produced when ORG has not been specified but when relocation information is generated. Relocation information is produced when a reference is made to a label which cannot be computed while the assembler is running, but which will only be known when the program is loaded. For example,

```
DC.L FRED
```

```
:
```

```
FRED BSR.S MARY
```

In this case the value of the label FRED cannot be specified relative to the program counter as MARY is, and the address represented by FRED will not be known until the program is loaded into memory. The reference to FRED requires relocation. This is performed by the assembler in the following fashion. The output file is produced in a special format which contains the code and the relocation information. This is preceded by a small section of code (a relocater) produced automatically from the assembler. When the code is run, execution will start at the first instruction, which is part of the relocater. The relocater will use the relocation information to modify the program so the reference to FRED above does indeed refer to the instruction required. Once all such relocation information is dealt with, the first instruction of the user's code is jumped to. The effect of this is that relocatable code should execute as expected, but if the path of the code is traced with a debugger then the relocater will be seen to run before the main user program. Relocatable code can be run via EXEC or CALL.

The assembler can also produce code in absolute format. Absolute code will only run in one region of memory and will not work anywhere else. It is specified by using the ORG directive which is followed by a reference to the first location to be used. For example, space might be allocated via the RESPR SuperBasic command, and a note taken of the value returned. The program could then be assembled using the base of the resident area as the argument to the ORG directive. The resulting absolute code should be loaded into the resident area via LBYTES and CALLED. The program may not be EXECed and will not run at any other location. If possible absolute format should be avoided because of these restrictions. The two previous formats may be CALLED or EXECed and are hence much more flexible.

The final format is used if any external names are used, either as an external reference or an external definition. These will be used to link sections of code written in assembler or in high level languages. The output is not directly executable but must be passed through a linker to be combined with other code sections. This format is produced if XDEF or XREF are used.

The assembler is a two pass assembler, reading the source text twice, firstly to construct a symbol table and macro definitions, and secondly, to produce a source listing and object module.

Finally, once the assembler has finished, it asks

More files to assemble [Y/N] ?

If Y is replied, the whole series of questions at the beginning of this section is repeated. A reply of N ends assembly and takes the user out of the assembler. There is no default, i.e. a reply of ENTER leads to the question being repeated until Y or N is given. However, if the last assembly fails from a fatal error, the question is not asked. The assembler will not continue after a fatal error.

## 2.3 Program encoding

A program acceptable to the assembler takes the form of a series of input lines that are:

- Comment or Blank lines
- Executable Instructions
- Assembler Directives

### Comments

Comments are introduced into the program in one of two ways. If the first character on the line is an asterisk ("\*"), then the whole line is treated as comment. Also, text after an instruction or assembler directive is treated as comment, provided it is preceded by at least one blank character. Blank lines are also treated as comments by the assembler.

Examples of Comments:

\* This entire line is a comment

FRED MOVEQ.L #10,D0 Comment following instruction

PAGE Move to the top of a new page

### Executable Instructions

The specification of the executable instructions is given in full in the references provided in the preface and is not covered here. The source statements have the general overall format:

[LABEL] OPCODE [OPERAND(s)] [COMMENT]

each field being separated from the next by at least one blank character.

### Label Field

A label is a user symbol which either

- Starts in the first column, terminated by at least one blank character or a newline, or
- Starts in any column, and is terminated with a colon (":").

If a label is present, then it must be the first non-blank item on the line. The label is assigned the value and type of the program counter, i.e. the memory address of the first byte of the instruction or data being referenced. Labels are allowed on all instructions, and some directives. See the specification of individual directives for whether a label field is allowed. Opcodes which are uses of a macro may not have a label field, although the same effect is obtained by placing the label by itself on the line before.

N.B. Labels must not be Instruction names, Directives or Register names, and must not be multiply defined.

### Opcode Field

The Opcode field follows the Label field, and is separated from it by at least one blank character. Entries in this field are of two types. Firstly, the MC68000 operation codes, as defined in the MC68000 User Manual, and secondly, Assembler Directives. For instructions and directives which can operate on more than one data size, there is an optional Size-Specifier subfield, which is separated from the opcode by the period (".") character. Possible size specifiers are:

- B - Byte sized data (8 bits)
- W - Word sized data (16 bits)
- L - Long Word sized data (32 bits)
- or Long Branch specifier
- S - Short Branch specifier

The size specifier must match with the instruction or directive type being used.

### Operand Field

If present, this field contains the one or more operands to the instruction or directive, and must be separated from it by at least one blank character. Where two or more operands occur in this field, they must be separated by the comma character (","). The operand field is terminated by the blank or newline characters, so no blank characters are allowed in this field.

### Comment Field

If present, anything after the terminating blank character of the operand field is ignored, and hence can be treated as comment.

## 2.4 Expressions

An expression is a combination of symbols, constants, algebraic operators and parentheses, and can be used to specify the operand field to instructions or directives. Relative symbols may be included in expressions, but they can only be operated on by a subset of the operators.

### Operators

The operators available, in decreasing order of precedence are:

- Monadic Minus ("-")
- Left Shift, Right Shift ("<<" and ">>")
- And, Or ("&" and "|")
- Multiply, Divide ("\*" and "/")
- Add, Subtract ("+" and "-")

The precedence of the operators can be over-ridden by enclosing sub-expressions in parentheses. Operators of equal precedence are evaluated from left to right. Note that there should not normally be any spaces in an expression, as the space will be regarded as a delimiter between one field and another.

### Operand Types for Operators

In the following table, absolute symbols are represented by "A", and relative symbols by "R". The possible operator/operand combinations are shown, with the type of the resulting value. "x" indicates an error. The Monadic minus operator is only valid with an absolute operand.

| Operators | Operands |        |        |        |
|-----------|----------|--------|--------|--------|
|           | A op A   | R op R | A op R | R op A |
| +         | A        | x      | R      | R      |
| -         | A        | x      | x      | R      |
| *         | A        | x      | x      | x      |
| /         | A        | x      | x      | x      |
| &         | A        | x      | x      | x      |
| !         | A        | x      | x      | x      |
| >>        | A        | x      | x      | x      |
| <<        | A        | x      | x      | x      |

## Symbols

A symbol is a string of characters, the first of which must be alphabetic ("A"-"Z"), "@", or period (".") and the rest of which can be any of these characters or also numeric ("0"-"9") or the underline character ("\_"). In all symbols, the lower case characters ("a"-"z") are treated as synonymous with their upper case equivalents. Symbols can be up to 30 characters in length, all of which are significant. The assembler will take symbols longer than this, and truncate them to 30 characters, giving a warning that it has done so. The instruction names, Directive names, Register names, and special symbols CCR, SR, SP and USP cannot be used as user symbols. A symbol can have one of three types:

### Absolute

- a) The symbol was SET or EQUated to an Absolute value
- b) An ORG statement preceded the definition of the symbol

### Relative

- a) The symbol was SET or EQUated to a Relative value
- b) A RORG statement preceded the definition of the symbol
- c) Neither ORG nor RORG was used (Default is RORG \$0)

### Register

- a) The symbol was set to a register name using EQU (This is an extension from the MOTOROLA specification).

There is a special symbol "\*", which has the value and type of the current program counter, i.e. the address of the current instruction or directive being dealt with.

## Numbers

A number may be used as a term of an expression, or as a single value. Numbers ALWAYS have absolute values, and can take one of the following formats:

### Decimal (a string of decimal digits)

Example: 1234

### Hexadecimal ("\$" followed by a string of hex digits)

Example: \$89AB

### Binary ("% followed by zeros and ones)

Example: %10110111

### ASCII Literal (Up to 4 ASCII characters within quotes)

Examples: 'ABCD' '\*' 'lan's

Strings of less than 4 characters are justified to the right, with NUL being used as the packing character.

To obtain a quote character in the string, two quotes must be used.

## 2.5 Addressing modes

The effective address modes define the operands to instructions and directives, and there is a detailed description of them in the references above. Addresses refer to individual bytes, but instructions, Word and Long Word references access more than one byte, and the address for these must be word aligned.

In the following table, "Dn" represents one of the data registers (D0-D7), "An" represents one of the address registers (A0-A7 and SP), "a" represents an absolute expression, "r" represents a relative expression, and "Xn" represents An or Dn, with an optional ".W" or ".L" size specifier. The syntax for each of the modes is as follows:

| Address Mode | Description and Examples                       |
|--------------|--|
| Dn           | Data Register Direct<br>e.g. MOVE D0,D1        |
| An           | Address Register Direct<br>e.g. MOVEA A0,A1    |
| (An)         | Address Register Indirect<br>e.g. MOVE D0,(A1) |

|          |  |
|----------|--|
| (An)+    | Address Register Indirect Post Increment<br>e.g. MOVE (A7)+,D0   |
| -(An)    | Address Register Indirect Pre Decrement<br>e.g. MOVE D0,-(A7)  |
| a(An)    | Address Register Indirect with Displacement<br>e.g. MOVE 2(A0),D1  |
| a(An,Xn) | Address Register Indirect with Index<br>e.g. MOVE 0(A0,D0),D1<br>MOVE 12(A1,A0.L),D2<br>MOVE 120(A0,D3.W),D4 |

## Address Mode

| Address Mode           | Description and Examples   |
|------------------------|--|
| a                      | Short absolute (16 bits)<br>e.g. MOVE \$1000,D0                                  |
| a                      | Long absolute (32 bits)<br>e.g. MOVE \$10000,D0                                  |
| r                      | Program Counter Relative with Displacement<br>e.g. MOVE ABC,D0 (ABC is relative) |
| r(Xn)                  | Program Counter Relative with Index<br>e.g. MOVE ABC(D0.L),D1(ABC is relative)   |
| #a                     | Immediate data<br>e.g. MOVE #1234,D0   |
| USP )<br>CCR )<br>SR ) | Special addressing modes<br>e.g. MOVE A0,USP<br>MOVE D0,CCR<br>MOVE D1,SR        |

## 2.6 Directives

All assembler directives (with the exception of DC) are instructions to the assembler, rather than instructions to be translated into object code. They are first listed by function, and then described individually.

Note that labels are only allowed on directives where shown. For example, EQU is allowed a label, it is optional for ORG but not allowed for LLEN or TTL.

### Assembly Control

|      |                    |
|------|--------------------|
| ORG  | Absolute origin    |
| RORG | Relocatable origin |
| SIZE | Size of data area  |
| END  | Program end        |

### Symbol Definition

|      |                                 |
|------|---------------------------------|
| EQU  | Assign permanent value          |
| EQU* | Assign permanent register value |
| SET  | Assign temporary value          |

### Data Definition

|    |                  |
|----|------------------|
| DC | Define constants |
| DS | Define storage   |

### Listing Control

|              |                                  |
|--------------|----------------------------------|
| PAGE         | Page-throw to listing            |
| LIST         | Enable listing                   |
| NOLIST (NOL) | Disable listing                  |
| SPC n        | Skip n blank lines               |
| NOPAGE       | Disable paging                   |
| LLEN n       | Set line length (60 <= n <= 132) |
| PLEN n       | Set page length (24 <= n <= 100) |
| TTL          | Set program title (max 40 chars) |
| NOOBJ        | Disable object code output       |
| FAIL         | Generate an assembly error       |

### Conditional Assembly

|      |                               |
|------|-------------------------------|
| CNOP | Conditional NOP for alignment |
| IFEQ | Assemble if equal             |
| IFNE | Assemble if not equal         |
| ENDC | End of conditional assembly   |

Macro Directives

|       |                          |
|-------|--------------------------|
| MACRO | Define a macro name      |
| ENDM  | End of macro definition  |
| MEXIT | Exit the macro expansion |

External Symbols

|      |                         |
|------|-------------------------|
| XDEF | Define external name    |
| XREF | Reference external name |

General Directives

|              |                           |
|--------------|---------------------------|
| GET "<file>" | Insert file in the source |
|--------------|---------------------------|

Assembly Control

ORG Set Absolute Origin

Format: [label] ORG absexp

The ORG directive changes the program counter to the value specified by the absolute expression in the operand field. Subsequent statements are assigned absolute memory locations, starting with the new program counter value. The optional symbol "label" will be assigned the value of the program counter AFTER the ORG directive has been obeyed.

RORG Set Relative Origin

Format: [label] RORG absexp

The RORG directive changes the program counter to be of relocatable type, and to have the value given by "absexp". Subsequent statements will be assigned relocatable memory locations, starting with the value assigned to the program counter. Addressing in relocatable sections is done using the "program counter relative with displacement" addressing mode.

If neither an ORG nor a RORG directive is specified, relative mode is assumed, and the program counter will start as if a "RORG 0" were present. Assembler modules which are to run via EXEC must be relocatable, so this default value is normally correct. The label value assignment is the same as for ORG.

SIZE Size of data area

Format: SIZE number

The SIZE directive tells the assembler the size of the data area to write into the code file, and which will hence be allocated to you when the job is run via EXEC. A job initiated in this way will be started with register A6 pointing to the base of the code, (A6,A4.L) will point to the base of the data area and (A6,A5.L) will point to the end of the data area. The stack pointer will normally run down from the top of the area towards the bottom; any other space can be allocated from the bottom upwards. Jobs should normally make use of the data area for memory storage by setting up suitable offsets on (A6,A4.L) or some other register initialised to this value. The default size of the data area if the SIZE directive is not given is 500 bytes. The number specified after the SIZE directive is the new value specified in bytes.

END End of program

Format: [label] END

The END directive tells the assembler that the source is finished, and subsequent source statements are ignored. The END directive encountered during the first pass of the assembler causes it to begin the second pass. If the end of file is detected before an END directive a warning message is given. If the label field is present, then the value of the current program counter is assigned to the label, before the END directive is executed.

Symbol Definition

EQU Equate symbol value

Format: label EQU exp

The EQU directive assigns the value of the expression in the operand field to the symbol in the label field. The value assigned is permanent, so the label may not be defined anywhere else in the program. The expression must not contain forward references.

EQR Equate register value

Format: label EQR register

This directive allows the user to equate one of the processor registers with a user symbol. Only the Address and Data registers are valid, so special symbols like SR, CCR and USP are illegal here. The register assigned is permanent, so the label cannot be defined anywhere else in the program. The register must not be a forward reference to another EQR statement.

SET Set symbol value

Format: label SET exp

The SET directive assigns the value of the expression in the operand field to the symbol in the label field. SET is identical to EQU, apart from the fact that the assignment is temporary, and can be changed later on in the program. The expression cannot contain forward references, and no forward references are allowed to symbols which are defined using SET.

Data Definition

DC Define Constant

|         |         |      |      |
|---------|---------|------|------|
| Format: | [label] | DC.B | list |
|         | [label] | DC.W | list |
|         | [label] | DC.L | list |

The DC directive defines a constant value in memory. It may have any number of operands, separated by commas (","). The values in the list must be capable of being held in the data location whose size is given by the size specifier on the directive. If no size specifier is given, a default of "W" is assumed. If the size is "B", then there is one other data type which can be used; that of the ASCII string. This is an arbitrarily long series of ASCII characters, contained within quotation marks. As with ASCII literals, if a quotation mark is required in the string, then two must be entered. If the size is "W" or "L", then the assembler aligns the data onto a word boundary.

DS Define Storage

|         |         |      |        |
|---------|---------|------|--------|
| Format: | [label] | DS.B | absexp |
|         | [label] | DS.W | absexp |
|         | [label] | DS.L | absexp |

The DS directive is used to reserve memory locations, but does not initialise them in any way. The amount of space allocated depends on the data size (given by the size specifier on the directive), and the value of the expression in the operand field. This is interpreted as the number of data items of that size to allocate. As with DC, if the size specifier is "W" or "L", the space is aligned onto a word boundary; thus "DS.W 0" will have the effect of aligning to a word boundary only. See CNOP for a more general way of handling alignment. If no size specifier is given, a default of "W" is assumed.

Listing Control

PAGE Page Throw

Format: PAGE

Unless paging has been inhibited, advance the assembly listing to the top of the next page. The PAGE directive does not appear on the output listing.

LIST Enable Listing

Format: LIST

The LIST directive enables the production of the assembly listing file. Listing continues until either an END or a NOLIST directive is encountered. This directive is only active if a listing file is being produced. The LIST directive does not appear on the output listing.

NOLIST Disable Listing

Format: NOLIST  
NOL

The NOLIST directive (for which NOL is a synonym), disables production of the assembly listing file. Listing ceases until either an END or a LIST directive is encountered. The NOLIST directive does not appear on the program listing.

SPC      Space Blank Lines  
Format:            SPC          number

The SPC directive outputs the number of blank lines given by the operand field, to the assembly listing. The SPC directive does not appear on the program listing.

---

NOPAGE    Disable Paging

Format:            NOPAGE

The NOPAGE directive disables the printing of page throws and title headers on the assembly listing. It is on by default if listing is to a file or device, and off by default if the listing is to the screen.

---

LLEN      Set Line Length

Format:            LLEN          number

The LLEN directive sets the line length of the assembly listing file, to the value given in the operand field. The value must lie between 60 and 132, and can only be set once in the program. The LLEN directive is not listed. The default is 132.

---

PLEN      Set Page Length

Format:            PLEN          number

The PLEN directive sets the page length of the assembly listing file, to the value given in the operand field. The value must lie between 24 and 100, and can only be set once in the program. The default is 60.

---

TTL        Set Program Title

Format:            TTL            title string

The TTL directive sets the title of the program to the string given in the operand field. This string is used as the page heading in the assembly listing. The string starts at the first non-blank character after the TTL, and continues until the end of line. It must not be longer than 40 characters in length. The TTL directive does not appear on the program listing.

---

NOOBJ     Disable Object Code Generation

Format:            NOOBJ

The NOOBJ directive disables the production of the object code file at the end of assembly. This directive disables the production of the code file even if a file name was specified when the assembler was started.

---

FAIL      Generate a user error

Format            FAIL

The FAIL directive causes the assembler to flag an error for this input line.

---

#### Conditional Assembly

---

CNOP      Conditional NOP

Format:    [label]    CNOP    number, number

This directive is an extension from the Motorola standard and allows a section of code to be aligned on any boundary. In particular, it allows any data structure or entry point to be aligned to a long word boundary.

The first expression represents an offset, while the second expression represents the alignment required for the base. The code is aligned to the specified offset from the nearest required alignment boundary. Thus

CNOP      0,4

will align code to the next long word boundary while

CNOP      2,4

will align code to the word boundary 2 bytes beyond the nearest long word aligned boundary.

IFEQ      Assemble if Equal  
IFNE      Assemble if Not Equal

Format:            IFEQ          absexp  
                     IFNE          absexp

The IFEQ and IFNE directives are used to enable or disable assembly, depending on the value of the expression in the operand field. The value is assumed to be EQUAL if it is zero, and NOT EQUAL otherwise. Thus the assembly is disabled if the operand is non zero for IFEQ, or zero for IFNE. The conditional assembly switch remains active until a matching ENDC statement is found. Conditional assembly switches can be nested arbitrarily, and each level of nesting must be terminated by a matching ENDC.

---

ENDC      End conditional assembly

Format:            ENDC

The ENDC directive is used to terminate conditional assembly, set up using the IFEQ and IFNE directives. ENDC matches the most recently encountered IFEQ or IFNE.

---

#### Macro Directives

---

MACRO     Start a macro definition

Format:    label      MACRO

This introduces a macro definition, which is terminated by ENDM. The macro is given the name of the label, and subsequent uses of that label as an operand will cause the contents of the macro to be expanded and inserted into the source code. A macro can contain any opcode, most assembler directives or any previously defined macro. When a macro label is used as an operand it may not have a label field on the same line, although an otherwise blank line containing a label may be placed before the line to get the required effect. Code generated by macro expansion is marked with a '+' sign in the listing. When a macro name is used it may be followed by a number of arguments, separated by commas. If the argument is to contain a space (for example, a string containing a space) then the entire argument must be enclosed by '<' (less than) and '>' (greater than) symbols.

The source code entered after a MACRO directive and before an ENDM directive is stored up and saved as the contents of the macro. The code can contain any normal source code; in addition the symbol '\ (backslash) has a special meaning. Backslash followed by a number n indicates that the value of the nth argument is to be inserted into the code. If the nth argument is omitted then nothing is inserted. Backslash followed by the symbol '@' will cause the text '@nnn' to be generated, where nnn is the number of times the \@ combination has been encountered. This is normally used to generate unique labels within a macro.

Macro definitions may not be nested, i.e. a macro cannot be defined within a macro, although a previously defined macro may be called. There is a limit to the level of nesting of macro calls which is currently set at ten.

Macro expansion stops when the end of the stored macro text is encountered, or when an MEXIT directive is found (see below).

---

ENDM      Terminate a macro definition

Format:            ENDM

This terminates a macro definition introduced by a MACRO directive.

---

MEXIT     Exit from macro expansion

Format:            MEXIT

This directive is used to exit from macro expansion mode. It is normally used in conjunction with the IFEQ and IFNE directives, and allows conditional expansion of macros. Once the directive is executed, the assembler stops expanding the current macro as though there was no more stored text to include.

---

#### External Symbols

---

XDEF      Define an internal label as an external entry point

Format:            XDEF          label[,label]



One or more labels may follow the XDEF directive; they may be absolute or relocatable but the name must be less than 8 characters. Each label defined here will generate an external symbol definition. References to the symbol can be made in other modules (possibly from a high level language) and the references satisfied by a linker. If this directive or the next is used then the code produced by the assembler is not directly executable.

XREF Define an external name

Format: XREF label[,label]

One or more labels which must not have been defined elsewhere in the program follow the XREF directive. Subsequent uses of the label must be at locations aligned to a word boundary and will cause an external reference to be generated for that label. The label will be used as if it referred to an absolute value, and the actual value used will be filled in from another module by the linker. The value may only be used where a 32 bit or 16 bit value would be valid. The linker will also generate any relocation information that may be required in order for the resulting code to be relocatable.

External symbols are normally used as follows. A routine in one program segment is specified as an external definition by placing a label at the start of the routine and quoting the label after an XDEF directive. Another program may call that routine by declaring a label via the XREF directive and then jumping to the label so declared. Data areas may be accessed in the same way so long as the values are either 32 or 16 bits.

General Directives

GET insert an external file

Format: GET "file name"

The GET directive allows the inclusion of external files into the program source. The file which is inserted is given by the string descriptor in the operand field. GET directives can be nested to a depth of three. The file name must be enclosed in quotes as shown. This is especially useful when a standard set of macro definitions or EQUs are required in several programs; the definitions are placed in a single file and other programs reference them by means of a suitable GET. It is often convenient to place NOLIST and LIST directives at the head and tail of files intended to be included via GET.

2.7 Example programs

Example Program 1

A simple program to read and write a string.

```

*
* QDOS Request codes
*
MT_FRJOB EQU $05
IO_OPEN EQU $01
IO_CLOSE EQU $02
IO_FLINE EQU $02
IO_SSTRG EQU $07
*
* Macros
*
QDOS MACRO
MOVEQ #\1,D0
TRAP #\2
ENDM
*
TIDYUP MACRO
QDOS IO_CLOSE,2 Close channel
MOVEQ #-1,D1
MOVEQ #0,D3 Cancel this job
QDOS MT_FRJOB,1
*
* In case CALLED
MOVEQ #0,D0 Return code - all OK
RTS
ENDM
*
* Main program
*
* Open stream
MOVEQ #-1,D1 Current Job
MOVEQ #2,D3 Exclusive Device
LEA.L DEVNAME,A0 Pointer to device name
QDOS IO_OPEN,2 Open stream
*
* Main Loop
*
* Loop
MOVEQ #-1,D1 Current Job
MOVEQ #2,D3 Exclusive Device
LEA.L DEVNAME,A0 Pointer to device name
QDOS IO_OPEN,2 Open stream

```

```

* Print prompt
MOVEQ #18,D2 Length of string
MOVEQ #-1,D3 Infinite timeout
LEA.L PROMPT,A1 Pointer to string
QDOS IO_SSTRG,3 Print prompt
*
* Read reply
LEA.L BUFFER,A3 Pointer to buffer
LEA.L 2(A3),A1 Skip first word
MOVEQ #30,D2 Length of buffer
QDOS IO_FLINE,3 Read input,D1 gets set to nbytes read
MOVE.W D1,(A3) Save no. of bytes read
*
* Print message
MOVEQ #6,D2 Length of text
MOVEQ #-1,D3 Infinite Timeout
LEA.L MESS,A1 Pointer to message
QDOS IO_SSTRG,3 print message
MOVEQ #0,D2 Clear D2
MOVE.W (A3),D2 Length of name
LEA.L 2(A3),A1 Pointer to name
QDOS IO_SSTRG,3 Print name
*
* Tidy up
*
TIDYUP
*
* Data Section
*
BUFFER DS.W 1
DS.B 30
DEVNAME DC.W 4
DC.B 'CON'
MESS DC.B 'Hello'
PROMPT DC.B 'Enter your name : '
*
END

```

Example Program 2

A routine to examine the contents of a part of memory.

```

*
MT_FRJOB EQU $05
IO_OPEN EQU $01
IO_CLOSE EQU $02
IO_SBYTE EQU $05
IO_SSTRG EQU $07
NADDR EQU 100
*
* Macro
*
QDOS MACRO
MOVEQ #\1,D0
TRAP #\2
ENDM
*
TIDYUP MACRO
QDOS IO_CLOSE,2 Close channel
MOVEQ #-1,D1
MOVEQ #0,D3 Cancel this job
QDOS MT_FRJOB,1
*
* In case CALLED
MOVEQ #0,D0
RTS
ENDM
*
* Main program
*
* Open stream
MOVEQ #-1,D1 Current Job
MOVEQ #2,D3 Exclusive Device
LEA.L DEVNAME,A0 Pointer to device name
QDOS IO_OPEN,2 Open stream
*
* Start address
LEA.L $28000,A4 Start address
MOVEQ #(NADDR-1),D4 (No. of addresses to be examined -1)
*
* Main Loop
*
* Loop
*print Address as 8 hex digits
MOVEQ #10,D2 Length of string
MOVEQ #-1,D3 Infinite timeout
LEA.L MESS1,A1 Pointer to string
QDOS IO_SSTRG,3 Print string

```

```

MOVE.L A4,D1      Address into D1
BSR     WRITE32BITS Print address
*
* Print contents of address
MOVEQ   #14,D0    Length of text
MOVEQ   #-1,D3    Infinite Timeout
LEA.L   MESS2,A1  Pointer to string
QDOS    IO_3STRG,3  Print string
*
MOVE.L   (A4)+,D1  Contents to D1 & inc
                    pointer
BSR     WRITE32BITS Print contents
*
* Output L/F
MOVEQ   #0A,D1    L/F into D1
BSR     WRITECHAR  Write the character
*
* All addresses examined? Loop if not
DBRA    D4,LOOP
*
* Tidy up
TIDYUP
*
WRITE32BITS
SWAP    D1
BSR.S   WRITE16BITS  Write top 16 bits
SWAP    D1          and drop through to
                    write out the low
                    16 bits
*
WRITE16BITS
ROR.W   #8,D1
BSR.S   WRITE8BITS   Write top 8 bits
ROL.W   #8,D1        (of 16) and drop
                    through to write out
                    the low 8 bits
*
WRITE8BITS
ROR.B   #4,D1
BSR.S   WRITE4BITS   Write top 4 bits
ROL.B   #4,D1        (of 8) and drop
                    through to write
                    out the low 4 bits
*
WRITE4BITS
MOVE.L   D1,-(SP)    Save D1 on stack
ANDI.B   #0F,D1      Mask to retain
                    low 4 bits
ADDI.B   #'0',D1     Add character
                    code for zero
CMPI.B   #'9',D1     Is it > character
                    nine
BLS.S    WRITE4BITS1 No, so write
                    character out
ADDI.B   #'A'-'9'-1,D1 Yes, so convert
                    to range A-F
*
WRITE4BITS1
BSR.S   WRITECHAR
MOVE.L   (SP)+,D1    Restore D1
RTS
*
WRITECHAR
MOVEM.L  D0/D3/A1,-(SP) Stack registers
                    used/corrupted
MOVE.W   #-1,D3      Infinite Timeout
MOVEQ    #IO_SBYTE,D0 Code to send
                    1 byte
TRAP #3             Byte to be sent
                    in D1
MOVEM.L  (SP)+,D0/D3/A1 Restore
                    registers
RTS
*
* Data Section
DEVNAME  DC.W   #
DC.B     'CON '
MESS1    DC.B   'Address : '
MESS2    DC.B   'Contents : '
END

```

### Example Program 3

A program to pan a string inside a window which can be increased/decreased in size as well as moved around the screen.

\* Constant section

TTL Demonstration - Constants

\* QDOS requests

\* Trap #1 codes

```

MT_FRJOB EQU 5
* Trap #2 codes
IO_OPEN  EQU 1
IO_CLOSE EQU 2

```

```

* Trap #3 codes
IO_FBYTE EQU 1
IO_SBYTE EQU 5
SD_BORDER EQU $C
SD_WDEF   EQU $D
SD_CURE   EQU $E
SD_PXNP   EQU $17
SD_PAN    EQU $18
SD_CLEAR  EQU $20
SD_SETIN  EQU $29
SD_SETSZ  EQU $2D

```

\* Colours

```

C_GREEN EQU 4
C_WHITE EQU 7
C_CHAR1 EQU C_GREEN
C_CHAR2 EQU C_WHITE

```

\* Key Codes

```

K_ENTER EQU $0A
K_SPACE EQU $20
K_UP     EQU $D0
K_DOWN   EQU $D8
K_LEFT   EQU $C0
K_RIGHT  EQU $C8
K_ALT_UP EQU $D1
K_ALT_DOWN EQU $D9
K_ALT_LEFT EQU $C1
K_ALT_RIGHT EQU $C9

```

\* A few useful constants

```

CHWIDTH EQU 16
CHHEIGHT EQU 20
MINH EQU CHHEIGHT+1
MINW EQU CHWIDTH*6+4
MAXX EQU 512-CHWIDTH-4
MAXY EQU 256-CHHEIGHT-2
BWIDTH EQU 1           Width of window border
WIDTH EQU MINW
HEIGHT EQU MINH
X EQU 304
Y EQU 300

```

\* Names for registers

```

MW EQU D4      Current window width
WH EQU D5      .. and height
WX EQU D6      X position of top left
                    corner
WY EQU D7      .. and Y position

```

```

PAGE
TTL Demonstration - Macros
SPC 2

```

\* Macros

```

SPC 2

```

\* A generalised call for cursor positioning, scrolling, panning etc. Timeout is infinite and A1 is assumed to contain channel to screen.

```

SCROPS MACRO
MOVEQ #\1,D1
MOVEQ #\2,D2
MOVEQ #\3,D0           Opcode into D0
MOVEQ #-1,D3          Timeout
LEA.L WINDOW,A1       Address of window block
TRAP #3               Do it
ENDM
SPC 2

```

\* A generalised call for QDOS requests

```

QDOS MACRO
MOVEQ #\1,D0           Trap code
TRAP #\2               Do it
ENDM

```

```

TIDYUP MACRO
QDOS IO_CLOSE,2       Close console channel
MOVEQ #-1,D1
MOVEQ #0,D3           Cancel this job
QDOS MT_FRJOB,1       Terminate this job

```

\* In case CALLED

```

MOVEQ #0,D0           Return code - all OK
RTS
ENDM

```

\* PAGE

TTL Demonstration - Main program

\* Main Program

```

INIT
* Open Console stream
    MOVEQ    #-1,D1          Current Job
    MOVEQ    #2,D3          Exclusive device
    LEA.L    DEVNAME,A0     Pointer to Device name
    QDOS    IO_OPEN,2      Open channel, ID in A0
*
* Set default window
    SCROPS   3,1,SD_SETSZ   Large chars
    SCROPS   0,0,SD_CURE    Enable cursor
*
* Initialise window section
    MOVE.W   (A1)+,WM       Width
    MOVE.W   (A1)+,WH       Height
    MOVE.W   (A1)+,WX       X
    MOVE.W   (A1)+,WY       Y
    LEA.L    LOGO,A4        Use A4 to point to
                                current character
    LEA.L    LOGOE,A5       And A5 to hold end
    BRA     SETWIN9         Display window and enter
                                loop
*
* Main loop
SETWINDOW
    BSR     VDU_RDCH        Get character or timeout
    BEQ.S   SETWIN0        Character ready, so
                                handle that case
*
* No character typed yet, so handle scrolling of name
    SCROPS   -CHWIDTH,0,SD_PAN
    MOVE.B   10(A4),D1     Get colour for this char
    QDOS     SD_SETIN,3    Change colour
    MOVE.B   (A4)+,D1     Get char
    QDOS     IO_SBYTE,3    Print character (A0 has
                                channel ID)
    BSR     SETCURSOR      Set the cursor back
    CMPA.L   A4,A5         Reached end?
    BNE.S   SETWINDOW      No, wonderful
    LEA.L   LOGO,A4        Yes, reset ptr
*
* Handle window movement
SETWIN0
    CMPI.B   #K_ENTER,D1   Was it ENTER ?
    BEQ     FINISH         End program
    CMPI.B   #K_SPACE,D1   Was it SPACE ?
    BEQ     SETWIN9        Yes, so redraw window
SETWIN1
    CMPI.B   #K_UP,D1      Up arrow?
    BNE.S   SETWIN2
    CMPI.W   #CHHEIGHT,WY  Check for y <= CHHEIGHT
    BLT.S   SETWINDOW      If so, don't alter it -
                                Wait for next char
    SUBI.W   #CHHEIGHT,WY  Otherwise take CHHEIGHT
                                away
    BRA     SETWIN9        Redraw window
SETWIN2
    CMPI.B   #K_DOWN,D1    Down arrow ?
    BNE.S   SETWIN3
    MOVE.W   WH,D3         D3 = Height
    ADD.W   WY,Q3          Add Y to it
    CMPI.W   #MAXY,D3      Is Y + Height >= MAXY
    BGE     SETWINDOW      Yes - Wait for next char
    ADDI.W   #CHHEIGHT,WY  No so add CHHEIGHT to Y
    BRA     SETWIN9        Redraw window
SETWIN3
    CMPI.B   #K_LEFT,D1    Left arrow ?
    BNE.S   SETWIN4
    CMPI.L   #CHWIDTH,WX   Is X < chsize
    BLT     SETWINDOW      Yes, so ignore
    SUBI.W   #CHWIDTH,WX   X=X-chsize
    BRA.S   SETWIN9        Redraw window
SETWIN4
    CMPI.B   #K_RIGHT,D1   Right arrow ?
    BNE.S   SETWIN5
    MOVE.W   WM,D3         Width
    ADD.W   WX,D3          plus X
    CMPI.W   #MAXX,D3      Are we at end of screen
    BGE     SETWINDOW      Yes, so ignore
    ADD.W   #CHWIDTH,WX   X=X+chsize
    BRA.S   SETWIN9        Redraw window
SETWIN5
    CMPI.B   #K_ALT_UP,D1  ALT Up arrow ?
    BNE.S   SETWIN6
    CMPI.W   #MINH,WH      Is Height <= MINH
    BLE     SETWINDOW      Yes, so ignore
    SUB.W   #CHHEIGHT,WH   Height-Height-CHHEIGHT
    BRA.S   SETWIN9        Redraw window
SETWIN6
    CMPI.B   #K_ALT_DOWN,D1 ALT Down arrow ?
    BNE.S   SETWIN7

```

```

    MOVE.W   WH,D3         Height
    ADD.W   WY,D3          Add Y
    CMPI.W   #MAXY,D3      Is Height+Y >= MAXY
    BGE     SETWINDOW      Yes, so ignore
    ADD.W   #CHHEIGHT,WH  Height=Height+CHHEIGHT
    BRA.S   SETWIN9
SETWIN7
    CMPI.B   #K_ALT_LEFT,D1 ALT Left Arrow ?
    BNE.S   SETWIN8
    MOVE.W   WM,D3         Width
    SUB.W   #CHWIDTH,D3   Minus CHWIDTH
    CMPI.W   #MINW,D3      Is it <= MINW
    BLT     SETWINDOW      Yes, so ignore
    SUB.W   #CHWIDTH,WX   Reduce width
    BRA.S   SETWIN9        Redraw window
SETWIN8
    CMPI.B   #K_ALT_RIGHT,D1 ALT Right arrow ?
    BNE     SETWINDOW
    MOVE.W   WM,D3         Width
    ADD.W   WX,D3          Plus X
    CMPI.W   #MAXX,D3      Is it >= MAXX
    BGE     SETWINDOW      Yes, so ignore
    ADD.W   #CHWIDTH,WX   Increase Width
    BRA.S   SETWIN9
SETWIN9
    SCROPS   0,1,SD_BORDER Remove old border
    SCROPS   0,0,SD_CLEAR  And clear old window
    LEA.L    WINDOW,A1     Get address of buffer
    MOVE.W   WM,(A1)+      Restore Width
    MOVE.W   WH,(A1)+      Restore Height
    MOVE.W   WX,(A1)+      Restore X
    MOVE.W   WY,(A1)+      Restore Y
    SCROPS   C_WHITE,WIDTH,SD_WDEF Redefine
                                window
    SCROPS   0,0,SD_CLEAR  Clear screen
    BSR.S   SETCURSOR      Set the cursor correct
    LEA.L    LOGO,A4        Reset character pointer
    BRA     SETWINDOW      Go back and get next ke
*
* Tidy up
FINISH
    TIDYUP
*
* Position cursor to standard place (PIXP specified
* relative to window)
SETCURSOR
    MOVEQ    #0,D2         Cursor at top position
    MOVE.W   WM,D1         Right hand edge x-coord
    SUBI.W   #CHWIDTH*2+5,D1 Less two chars width
                                and allow for border
    MOVEQ    #-1,D3        Timeout
    QDOS     SD_PIXP,3     Position cursor
    RTS
*
* Read one char from the keyboard
VDU_RDCH
    MOVEQ    #30,D3        Some timeout
    QDOS     IO_FBYTE,3    Get a character in D1.B
                                (A0 has channel ID)
    TST.L   D0             Check for timeout = 0 if
                                char typed
    RTS
*
* Data area
* Window co-ordinates
WINDOW    DC.W   WIDTH
          DC.W   HEIGHT
          DC.W   X
          DC.W   Y
*
DEVNAME   DC.W   22
          DC.B   'CON_100x22a304x200_128'
LOGO      DC.B   'MetaConCo'
LOGOE     DC.B   C_CHAR1,C_CHAR2,C_CHAR2,C_CHAR2
          DC.B   C_CHAR1,C_CHAR2,C_CHAR2
          DC.B   C_CHAR1,C_CHAR2,C_CHAR2
*
END

```

## Appendix A: The 68000 instruction set

The address modes are represented as follows:

|   |   |
|---|---|
| An<br>Dn<br>Rn  | Any address register<br>Any data register<br>Any register   |
| (An)<br>d(An)<br>-(An)<br>(An)+                               | Address register indirect<br>with displacement<br>with predecrement<br>with postincrement   |
| <ea><br><aea><br><cea><br><dea><br><caea><br><daea><br><maea> | Any address mode<br>Alterable address mode<br>Control address mode<br>Data address mode<br>Control alterable address mode<br>Data alterable address mode<br>Memory alterable address mode |
| <rl><br><imm>   | Register list<br>Immediate data   |

The different categories of effective address are classified in the following table:

| Addressing modes                             | Data                  | Memory                | Control               | Alterable             |
|--|-----------------------|-----------------------|-----------------------|-----------------------|
| Dn<br>An                                     | X<br>-                | -<br>-                | -<br>-                | X<br>X                |
| (An)<br>-(An)<br>(An)+<br>d(An)<br>d(Rn,An)  | X<br>X<br>X<br>X<br>X | X<br>X<br>X<br>X<br>X | X<br>-<br>-<br>X<br>X | X<br>X<br>X<br>X<br>X |
| Absolute<br>PC relative<br>PC relative index | X<br>X<br>X           | X<br>X<br>X           | X<br>X<br>X           | X<br>-<br>-           |
| Immediate                                    | X                     | X                     | -                     | -                     |

The sizes for each instruction are given as B for byte, W for word and L for long. Under the column 'Modes' are listed examples of the various forms of address modes. If a number of instructions have the same form, then only the first one is used in the examples. Where the syntax differs for different instructions, all possible variations are included.

| Description             | Name                                | Modes   | Size                           |
|-------------------------|-------------------------------------|---|--------------------------------|
| Add binary              | ADD<br>ADDA<br>ADDI<br>ADDQ<br>ADDX | <ea>, Dn<br>Dn, <maea><br><ea>, An<br>#<imm>, <daea><br>#<imm>, <cea><br>Dn, Dn<br>-(An), -(An) | BWL<br>WL<br>BWL<br>BWL<br>BWL |
| Add decimal             | ABCD                                | Dn, Dn<br>-(An), -(An)  | B                              |
| Arithmetic shift left   | ASL                                 | Dn, Dn<br>#<imm>, Dn<br><maea>  | BWL                            |
| Arithmetic shift right  | ASR                                 |   | BWL                            |
| Bit test and change     | BCHG                                | Dn, <daea><br>#<imm>, <daea>  | B L                            |
| Bit test and clear      | BCLR                                |   | B L                            |
| Bit test and set        | BSET                                |   | B L                            |
| Bit test                | BTST                                | Dn, <dea><br>#<imm>, <dea>  | B L                            |
| Branch on condition     | Bcc                                 | <label>   | BW                             |
| Branch unconditionally  | BRA                                 |   | BW                             |
| Branch to subroutine    | BSR                                 |   | BW                             |
| Check and possibly TRAP | CHK                                 | <dea>, Dn   | W                              |
| Compare                 | CMP<br>CMPA<br>CMPI<br>CMPM         | <ea>, Dn<br><ea>, An<br>#<imm>, <daea><br>(An)+, (An)+  | BWL<br>WL<br>BWL<br>BWL        |
| Compare with zero       | TST                                 | <daea>  | BWL                            |
| Decrement test & branch | DBcc                                | Dn, <label>   | W                              |
| Decrement & branch      | DBRA                                |   | W                              |

| Description            | Name                                     | Modes  | Size                 |
|------------------------|--|--|----------------------|
| Division - signed      | DIVS                                     | <dea>, Dn  | W                    |
| Division - unsigned    | DIVU                                     |  | W                    |
| Exchange registers     | EXG                                      | Rn, Rn   | L                    |
| Jump                   | JMP                                      | <cea>  | -                    |
| Jump to subroutine     | JSR                                      |  | -                    |
| Load effective address | LEA                                      | <cea>, An  | L                    |
| Logical AND            | AND<br>ANDI<br>ANDI to CCR<br>ANDI to SR | <dea>, Dn<br>Dn, <maea><br>#<imm>, <daea><br>#<imm>, CCR<br>#<imm>, SR | BWL<br>BWL<br>B<br>W |
| Logical exclusive OR   | EOR<br>EORI<br>EORI to CCR<br>EORI to SR | Dn, <daea><br>#<imm>, <daea><br>#<imm>, CCR<br>#<imm>, SR              | BWL<br>BWL<br>B<br>W |
| Logical OR             | OR<br>ORI<br>ORI to CCR<br>ORI to SR     | <dea>, Dn<br>Dn, <maea><br>#<imm>, <daea><br>#<imm>, CCR<br>#<imm>, SR | BWL<br>BWL<br>B<br>W |
| Logical shift left     | LSL                                      | Dn, Dn<br>#<imm>, Dn<br><maea>   | BWL                  |
| Logical shift right    | LSR                                      |  | BWL                  |

| Description            | Name             | Modes  | Size |
|------------------------|------------------|--|------|
| Move data              | MOVE             | <ea>,<daea>  | BWL  |
| Move multiple          | MOVEA            | <ea>,An  | WL   |
|                        | MOVEM            | <rl>,-(An)<br><rl>,<caea><br>(An),<rl><br><cea>,<rl> | WL   |
| Move to peripheral     | MOVEP            | Dn,d(An)<br>d(An),Dn                                 | WL   |
|                        | MOVEQ            | #<imm>,Dn  | L    |
|                        | MOVE to CCR      | <daea>,CCR   | W    |
|                        | MOVE to SR       | <daea>,SR  | W    |
|                        | MOVE from SR     | SR,<daea>  | W    |
| MOVE USP               | USP,An<br>An,USP | L  |      |
| Multiply - signed      | MULS             | <daea>,Dn  | W    |
| Multiply - unsigned    | MULU             |  | W    |
| Negate binary          | NEG              | <daea>   | BWL  |
|                        | NEGX             |  | BWL  |
| Negate decimal         | NBCD             | <daea>   | B    |
| No operation           | NOP              |  |      |
| Logical complement     | NOT              | <daea>   | BWL  |
| Push effect address    | PEA              | <cea>  | L    |
| Reset                  | RESET            |  | -    |
| Return from exception  | RTE              |  | -    |
| Return and restore CCR | RTR              |  | -    |
| Return from subroutine | RTS              |  | -    |

Conditional tests

The following may be specified as the conditional test in the branch to condition (Bcc), decrement test and branch (DBcc) and set from condition (Scc) instructions. Also T and F may be used to indicate True and False in Bcc and Scc instructions.

In the following table, C indicates that the C status bit must be set, and C' means that the bit must be unset for the condition to be true. Two symbols, & and |, are used to connect conditions. & means that both must be true; | means that either may be true.

| Condition             | Name | Test                        |
|-----------------------|------|-----------------------------|
| Carry clear           | CC   | C'                          |
| Carry set             | CS   | C                           |
| Equal                 | EQ   | Z                           |
| Not equal             | NE   | Z'                          |
| Plus                  | PL   | N'                          |
| Minus                 | MI   | N                           |
| Overflow clear        | VC   | V'                          |
| Overflow set          | VS   | V                           |
| High                  | HI   | C' & Z'                     |
| Low or same           | LS   | C   Z                       |
| High or same          | HS   | C'                          |
| Low                   | LO   | C                           |
| Greater than          | GT   | (N & V & Z') (N' & V' & Z') |
| Greater than or equal | GE   | (N & V) (N' & V')           |
| Less than or equal    | LE   | Z (N & V) (N' & V')         |
| Less than             | LT   | (N & V) (N' & V)            |

Appendix B: Installation

Changing the default window

Both the editor and the assembler allow the window which is to be used to be altered as part of the initialisation sequence. If this option is not required then the default window is used. This is initially the same as the window used during the start of the program, but if required the default window may be altered permanently by patching the programs. This is useful where a certain window size and position is always required and means that the window does not have to be positioned correctly each time the program is run.

Changing the default drive name

For those users who upgrade their QLs with disc drives, there is the possibility of changing the default drive to something other than mdv1. This option will not be given when installing the editor ED since it can be EXECed from any device.

The INSTALL program

The program INSTALL is supplied on the distribution microdrive to perform both of the above tasks. It is run by the command

```
LRUN mdv1_install
```

The program starts by asking whether the default window is to be set up for TV or monitor mode. The minimum window size is greater in TV mode because the characters used are larger. You should answer T if you are setting the default for use with TV mode and M if you are setting it for use with monitor mode. Note that the current mode in use is of no consequence.

The standard window will appear on the screen and can be moved by means of the cursor keys and altered in size by means of ALT cursor keys. This is similar to the mechanism used when altering the window during normal program initialisation. Once the window is in the right place and of the desired size, press ENTER.

The program now asks for the name of the file which is to be modified. If you wished to alter the editor then the file would probably be something like 'mdv1\_ed'. The next item requested is the name of the program. When a new job such as the editor or the assembler is running on the QL, it has a name associated with it. This can be inspected by suitable utilities. The name is six characters long, and whatever is typed here is used as the name and forced to the correct length. The name is of little importance except for job identification.

In the case of the assembler the program will then go on to ask for a default drive name where it should look for its overlays. If you do not wish to change the default drive name the reply should be

```
MDV1
```

(Note - the reply must not be MDV1\_). If you do wish to change the default drive name the reply should be the device name, for example

| Description           | Name  | Modes                | Size |
|-----------------------|-------|----------------------|------|
| Rotate left           | ROL   | Dn,Dn<br>#<imm>,Dn   | BWL  |
| Rotate right          | ROXL  | <daea>               | BWL  |
|                       | ROR   |                      | BWL  |
|                       | ROXR  |                      | BWL  |
|                       |       |                      | BWL  |
| Set from condition    | Scc   | <daea>               | B    |
| Set to zero           | CLR   | <daea>,Dn            | BWL  |
| Sign extend           | EXT   | Dn                   | WL   |
| Stop execution & wait | STOP  | #<imm>               | -    |
| Subtract binary       | SUB   | <ea>,Dn<br>Dn,<daea> | BWL  |
|                       | SUBA  | <ea>,An              | WL   |
|                       | SUBI  | #<imm>,<daea>        | BWL  |
|                       | SUBO  | #<imm>,<daea>        | BWL  |
|                       | SUBX  | Dn,Dn<br>-(An),-(An) | BWL  |
| Subtract decimal      | SBCD  | Dn,Dn<br>-(An),-(An) | B    |
| Subroutine link       | LINK  | An,#<imm>            | -    |
| Subroutine unlink     | UNLK  | An                   | -    |
| Swap register halves  | SWAP  | Dn                   | W    |
| Test bit and set      | TAS   | <daea>               | B    |
| Trap exception        | TRAP  | #<imm>               | -    |
|                       | TRAPV |                      | -    |

In this latter case the assembler will append 'FLP1\_\_' to its overlays before attempting to load them.

The INSTALL program will then modify the file specified. INSTALL can be run as many times as you like to alter the default window of the editor or the assembler. It is unlikely to be useful with programs other than those distributed by Metacomco that provide user selection of an initial window such as Metacomco's Assembler, LISP and BCPL.

## Appendix C: The Linker Program

The commands XDEF and XREF make it possible for an assembler program to refer to labels not defined within the program itself, but defined elsewhere in another quite separate assembler program.

When a program containing XDEFs and/or XREFs is assembled, the output module produced is in a special format (Sinclair Relocatable Binary Object File Format). This file cannot be directly EXECed but must be linked with the module(s) in which the external labels are defined. The linker program supplied on the microdrive will link such modules together to produce an EXECable file.

Note that the linker is only capable of linking two or more modules produced by the Metacomco assembler. It is not suitable for linking Assembler modules to modules produced by compiling a high level language program.

To run the linker one types

```
EXEC MDV1_LINKER
```

or

```
EXEC_W MDV1_LINKER
```

The linker first asks for a workspace size. The reply given should be a number (of bytes) optionally followed by a 'K' which converts the requested number to Kilobytes. The minimum size which can be asked for is 1K. If no number is typed the linker will use its default workspace size (10K).

It will then go on to ask for each of the Binary files (up to a maximum of 20 code files produced by the assembler) in turn and, having read each file, will report the file's length. This length does not include all the extra bytes put in the file by the assembler to create the special file format. When just ENTER is typed in reply to the request for a binary file the linker will start its second pass which entails re-reading each file in turn.

After processing all the files, the linker will ask for a name for an output file and then a stack size (in bytes) which will be used with the program when it is run.

An example containing external references now follows. The program has been split into four separate programs which must be assembled separately and the resulting code files linked together.

### Program a

\* Program a

```
MT_FRJOB EQU $05
IO_OPEN EQU $01
IO_CLOSE EQU $02
```

```
QDOS MACRO
MOVEQ #1,D0
TRAP #12
ENDM

XREF PRINTP,PRINTM
```

\* Open stream

```
OPENFL MOVEQ #1,D1 Current job
MOVEQ #2,D3 Exclusive device
LEA.L DEVNAME,A0 Point to device name
QDOS IO_OPEN,2
```

\* Print prompt

```
JSR PRINTP
```

\* Print message

```
JSR PRINTM
```

\* Tidy up

```
QDOS IO_CLOSE,2
MOVEQ #1,D1
MOVEQ #0,D3 Cancel this job
QDOS MT_FRJOB,1
```

\* In case called

```
MOVEQ #0,D0 Return code = all OK
RTS And home
```

\* Data Section

```
DEVNAME DC.W 4
DC.B 'CON_'
END
```

### Program b

\* Program b

```
IO_SSTRG EQU $07
```

```
QDOS MACRO
MOVEQ #1,D0
TRAP #12
ENDM

XREF READREP,MESS,PROMPT,BUFFER
XDEF PRINTP,PRINTM
```

\* Print prompt

```
PRINTP MOVEQ #18,D2 Length of text
MOVEQ #1,D3 Timeout
LEA.L PROMPT,A1 Message
QDOS IO_SSTRG,3
```

\* Read reply

```
JSR READREP Get reply
RTS Return to calling program
```

\* Print message

```
PRINTM MOVEQ #6,D2 Length of text
MOVEQ #1,D3 Timeout
LEA.L MESS,A1 Message
QDOS IO_SSTRG,3
MOVEQ #0,D2 Clear B2
LEA.L BUFFER,A3 Pointer to name
MOVE.W (A3),D2 Length of name
LEA.L 2(A3),A1 Ptr to name
QDOS IO_SSTRG,3
RTS
```

END

### Program c

\* Program c

```
IO_PLINE EQU $02
```

```
XREF BUFFER
XDEF READREP
```

\* Read reply

```
READREP LEA.L BUFFER,A3 Ptr to buffer
LEA.L 2(A3),A1 Skip first word
MOVEQ #30,D2 Length of buffer
TRAP #13
MOVE.W D1,(A3) Save number of bytes read
RTS
```

END

### Program d

\* Program d

```
XDEF BUFFER,MESS,PROMPT
```

\* Data Section

```
BUFFER DS.W 1
DS.B 30
MESS DC.B 'Hello '
PROMPT .B 'Enter your name : '
```