ProAsm

Motorola 68000-series Professional Macro Assembler

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User's Manual

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NOTICE

This manual reflects version 1.92 of the ProAsm assembler.

Notices

Trademarks

Disclaimer

The information, the ProAsm program, and all the associated utilities are provided "as is" without warranty of any kind, either expressed or implied. The entire risk as to the accuracy of the information herein is assumed by you. Daniel Weber does not warrant, guarantee, or make any representations regarding the use of, or the results of the use of, the information, the ProAsm program, or the associated utilities in terms of correctness, accuracy, reliability, currentness, or otherwise. In no event will Daniel Weber be liable for direct, indirect, incidental, or consequential damages resulting from any defect in the information, the ProAsm program, or the associated utilities even if he has been advised of the possibility of such damages.

A Word about Backups and other Copying

You are encouraged to make up copies of the ProAsm software package for your own exclusive use. You do not have the right to distribute these duplicates, regardless of whether or not a fee is charged for such distribution. The disks are not copy protected, and may be installed on a hard disk at will. However, installation on multiple CPUs is specifically prohibited.

Remember, a program worth using, is worth buying.

Acknowledgments

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1 Introduction

> You know what your trouble is?
>
> You're the kind who always reads the handbook. Anything people build, any kind of technology, it's going to have some specific purpose. It's for doing something that somebody already understands. But if it's new technology, it'll open areas nobody's ever thought before. You read the manual, man, and you won't play around with it, not the same way. And you get all funny when somebody else uses it to do something you never thought of.
>
> William Gibson, the winter market 1985

1.1 Product Overview

Welcome to ProAsm!

The ProAsm assembler is a traditional two pass assembler that emits code for the entire Motorola MC68000 Family. ProAsm is a high performance, full-featured assembler with enough powerful features to make it appropriate for all assembly tasks. It produces native 68xxx code, and has special directives to enable the selection of the target processor and the appropriate code optimization for that processor. ProAsm supports both addressing mode syntaxes as defined by Motorola. Programmers find these capabilities of the new syntax mode particularly useful for handling advanced data structures common to sophisticated application and high level languages.

The output produced by ProAsm is either an executable file that can directly be run under AmigaDOS or the Workbench, object modules that are compatible with the Amiga standard linker and BLINK (the replacement linker from 'The Software Distillery'), binary output for ROM-able code (for example), pre-assembled files, or the Motorola S-record format. Besides the normal output files, ProAsm can also generate four types of auxiliary output files which reflect the results of the assembly process: the error file and the equate file, the source listing and the cross-reference listing.

ProAsm has a tremendous number of switchable optimizations including the multipass facility to gain an even more optimized code. ProAsm also has a very rich set of directives including a wide range of synonyms that allow source code written for other assemblers (Public Domain software for example) and the Commodore include files to be assembled. Included as well are directives to deal with structures, repeat loops and similar code elements very easily. Powerful macros with unlimited macro arguments and many macro directives are available to permit code to be easily and clearly arranged.

The rich set of available facilities allows exact control over the performance of the assembler. This control includes features such as optimization, case dependency for symbols, syntax control, and the default behaviour of ProAsm to name a few. More advanced control features such as precise code control and selectable symbol search algorithm are also included.

A valuable feature of ProAsm is the configuration file, which is automatically included in each assembly. You can customize ProAsm to suit your particular wishes by including commonly used macros, code and directives in the configuration file.

No program can be all things to all people. So all assemblers have limitations - ProAsm tries to put them as far as possible not to narrow your creativity. This results in the fact that the most limitations are just limited only by available memory (line length, macro body, macro nesting, macro arguments, nesting of macro directives, repeat and include file nesting,...).

However, ProAsm is an ideal assembler for the professional developer, as well as the high-level language programmer (such as C, Modula,...) who wants to integrate some assembly language code into his programs, and the beginner at assembly language programming.

1.2 The Manual

This manual is provided as a reference guide to ProAsm and its associated utilities. It contains information on the operation and the use of the directives, pseudo-opcodes, and other pertaining to the effective use of this software.

Two large indices, *Concept Index*, page 303, and *Directive Index*, page 301, allow you to find a specific topic quickly and easily.

Please note that this manual makes no effort to be a tutorial for M68000 Assembly Language Programming. For detailed information on the complete instruction set of the M68000 family we recommend the *M68000 Family Programmer's Reference Manual*, from Motorola Inc.

1.3 Conventions Used in this Manual

This manual refers to the entire Motorola 68000 series of microprocessors as the "M68000". It refers to individual chips as the "MC68000," "MC68010," etc.

M68000 instructions, register names, and symbols are printed in lower case. Assembler directives are printed in upper case to distinguish them from instructions. In reality, case does not matter for instructions, register names, or assembler directives, and only matters for symbols if you specifically request it.

Unless otherwise noted, square brackets '`[]`' are used to state that the arguments of a directive they enclose are optional.

1.4 Manual Updates

This documentation is updated with Change Pages and a '`read.me`' file.

Change Pages are issued for minor changes to the manual as pages or Postscript files or both. The date of issue is printed at the bottom of each page.

A '`read.me`' file is provided on the installation diskette. This file contains information about recent changes to the software that are not yet reflected in the manual.

1.5 System Requirements

ProAsm requires an Amiga with at least 512k of memory. Kickstart and Workbench 1.2 or higher are also required. ASX and ProOpts require Kickstart and Workbench 2.0 or higher (see Section 8.1 *ASX*, page 181 and Section 8.2.2 *ProOpts*, page 220). ProAsm is fully compatible with the entire Amiga family.

2 Getting Started

2.1 Making a Backup

Never run ProAsm from the original disk. Make a backup copy in case ProAsm's Program Disk is lost or destroyed. Use the new copy as your "work" disk. The original Program Disk should be stored in a safe place, away from heat or electromagnetic interferences etc. You can copy ProAsm files individually to any Workbench or other "system" disk you desire including hard disks and ram disks.

As mentioned earlier, you may retain a backup of this program for **personal use only**.

2.2 Installation

To install the ProAsm Package correctly, you simply have to copy the complete distribution into a directory (or to a partition) of your choice. The whole package requires about 1.7 MBytes of disk space.

This can be done using the given Installer script, this is also the recomended procedure. However, using the Installer script, you have also the possibility to do a partial installation. A double-click on 'Install_english' or 'Install_deutsch' to start the installation.

You can also install the package manually, by using the following command sequence:

```
makedir <your_directory>/ProAsm
copy ProAsm/ <your_directory>/ProAsm/ all
copy ProAsm.info <your_directory>
delete <your_directory>/ProAsm/install#?
```

Where '<your_directory>' is the path of your desired location where the ProAsm Package should be copied to (e.g: 'work:')

The following two commands copy the configuration files to env: or envarc: respectively:

```
copy ProAsm/env/ env: all
copy ProAsm/env/ envarc: all
```

To assure that the software will work correctly, the following lines should be added to your user-startup file. Use an editor to add these lines to the S:User-Startup :

```
path <your_directory>/ProAsm <your_directory>/ProAsm/c/ add
assign libs: <your_directory>/libs/ add
assign help: <your_directory>/ProAsm/Help add
```

If you intend to do a partial installation manually, you should take the following dependencies into account:

```
ProAsm Assembler:  proasm
                   libs/
                   Catalogs/

ASX             :  ASX
                   ASX.info
                   rexx/
                   env/

ProOpts         :  ProOpts
                   ProOpts.info

Utilities       :  c/

Documentation   :  Help/
                   Help.info

Examples        :  Examples/
                   Examples.info

BLink Archive   :  BLink.lha

Routine Files   :  routines/

Include Files   :  include/
```

3 Running ProAsm

3.1 Starting ProAsm from the Shell

ProAsm is driven by keyword options in any order indicating the action to be performed. The general command line format is as follows:

```
ProAsm <source file> [options]
ProAsm -M [options 1] <source file 1> [[options 2] <source file 2> [...]]
```

[options] specifies any optional parameters and <*source file*> the name of the file to be assembled. The second form allows you to assemble multiple source files in one invocation of ProAsm. If no extension is added to the <*source file*>, the assembler assumes '`.s`' as the extension.

3.1.1 Command-line Options

Following is the complete list of command-line options supported by ProAsm, in AmigaDOS command-line description format:

```
-A=ADDRESS/S,-B=BINARY/S,-D=DEFINE/K,-E=ERRFILE/K,-F=FILEREQ/S,
-G=CONFIGFILE/K,-H=HEADER/K,-I=INCDIR/K,-K=NOKEYWAIT/S,-L=LINKABLE/S,
-M=MULTISOURCE/S,-MA=MULTISOURCEA/S,-N=NOOBJ/S,-O=OBJFILE/K,
-P=LISTFILE/K,-Q=EQUFILE/K,-R=CREFFILE/K,-S=ADDSYM/S,-T=STRING/K,
-U=NOSTDOUT/S,-V0=V0/K,-V1=V1/K,-V2=V2/K,-V3=V3/K,-V4=V4/K,-V5=V5/K,
-V6=V6/K,-V7=V7/K,-V8=V8/K,-V9=V9/K,-W=WINDOW/S,-WS=WINDOWSIZED/K,
-X=EXPSYM/S
```

The meaning of these options is given below. All options can be supplied in either upper or lower case. Switch-style options ('`-A`', '`-B`', etc.) and keyword-style options ('`ADDRESS`', '`BINARY`', etc.) can be mixed arbitrarily. For options that take arguments, if the keyword style is used, the keyword must be separated from the argument by at least one space (e.g. '`HEADER foo.i`'). If the switch style is used, a space may be used but is not necessary (either '`-Hfoo.i`' or '`-H foo.i`' will work). Filename or path arguments that contain a whitespace must be enclosed in double or single quotes (e.g. '`HEADER "foo bar.i"`').

A sequence of switch-style options without an argument can be written all alone (e.g. '`-L -D`') or together (e.g. '`-LD`'). Even the following is a possible combination '`-LDE foo.err`' for '`-L -D -E foo.err`'.

'`ADDRESS` *address*'
'`-A` *address*'

This option causes ProAsm to assemble source code from an address in memory rather than from a file. The source code is assumed to start at *address*, which can be expressed in any base, in the same way that numeric constants are expressed in the source code itself (e.g. '`$1000`' is the same as '`4096`'). ProAsm assumes that the source text is a single null-terminated (C-style) string. This option is mainly provided to support text editors that can run an assembler from within the editor and provide the source code directly in memory rather than having to write it to a file first. If you use this option, no source file name may be specified in the command-line.

'`DEFINE` *symbol*=*expression*`[,`*symbol*=*expression*`[...]]`'
'`-D` *symbol*=*expression*`[,`*symbol*=*expression*`[...]]`'

This option defines the specified *symbol* with the result of the specified *expression* as if it had been defined with the `EQU` directive at the very beginning of the source code (see Section 5.5.1 *Equates*, page 71). Any amount of whitespace is accepted between the *symbol* and the equal sign, and between the equal sign and the *expression*. If more than one symbol definition is given, they can be separated by a comma ('`,`').

'`BINARY`'
'`-B`' This option tells the assembler to produce a "raw" binary file, containing only the data explicitly defined in the source code. No linking or debug information can be generated. See Section 5.9.2 *Output File Format*, page 129.

'`ERRFILE` *filename*'
'`-E` *filename*'

This option specifies the name of the error file to be used, and it overrides any `ERRFILE` directive specified in the actual source code. See Section 5.10 *Auxiliary Output Files*, page 145, for more information. You may also use a window specification instead of a filename, e.g.:

```
ProAsm mySource.s ERRFILE con:0/0/640/150/mySource_Errors
```

'`FILEREQ`'
'`-F`' This option causes ProAsm to open a file requester in which you can choose the source file to be assembled, rather than specifying its name on the command line. If you cancel the file requester, ProAsm will abort without assembling anything. If you use this option, no source file may be specified in the command-line, unless the `MULTISOURCE` or `MULTISOURCEA` option is also used. ProAsm uses the ASL file requester if you have Kickstart version 2.04 or later, or the REQ file requester on an earlier version of Kickstart.

'`CONFIGFILE` *filename*'
'`-G` *filename*'

This option tells ProAsm to use the file *filename* as ProAsm's configuration file, instead of the default file named '`ProAsm.config`'. This can be used, for example, to use a different configuration for individual projects. See Section 3.3 *Config File*, page 14, for more information.

'HEADER *filename*'
'-H *filename*'

The HEADER option tells ProAsm to assemble the file specified as *filename* before assembling the main source code, as if it had been included with INCLUDE at the very beginning of the source file. See Section 5.1.2 *Include Files*, page 47, for more information about include files. It is still processed after the configuration file, however.

'INCDIR *directory* [,*directory* [,..]]'
'-I *directory* [,*directory* [..]]'

This option adds the specified directory to the list of directories to search for include files. Directory names containing one or more whitespace must be enclosed in double or single quotes. You can specify more than one directory by separating each directory name with a comma (','). See Section 5.1.2.1 *Include Directories*, page 50, for more information.

'NOKEYWAIT'
'-K'

This option instructs ProAsm not to wait for a key to be pressed at the end of assembly. This only has an effect if the WINDOW or WINDOWSIZED option is also used.

'LINKABLE'
'-L'

This option tells ProAsm to create an object file which can be linked with other object files by a linker such as BLink. See Section 5.9.2 *Output File Format*, page 129, for more information.

'MULTISOURCE'
'-M'

This parameter keyword forces the assembler to accept more than just one source file on the command line. All source files will be assembled sequentially, in the order of their occurrence on the command line. Using this keyword the command line must be of the following syntax:

MULTISOURCE [*options 1*] <*source file 1*> [[*options 2*] <*source file 2*> [...]]

For example:

```
ProAsm MULTISOURCE BINARY BinImage.s  ADDSYM helloworld.s
```

First of all the source code *BinImage.s* is assembled to a binary image file according to the *BINARY* flag. Afterward the *helloworld.s* source file is processed using the *ADDSYM* keyword.

'MULTISOURCEA'
'-MA'

This is an extension of the above described MULTISOURCE keyword. MULTISOURCEA aborts assembly after the source file in which the first error occurred, instead of assembling all source files whether or not any errors occured.

'NOOBJ'

'-N' If this option is used, the assembler will not produce any output file at all. It is useful if you want to run a test assembly to check for syntax errors in the source code. This option overrides any other command-line options or directives in the source code specifying an output file to be produced. See Section 5.9.2 *Output File Format*, page 129, for more information on the `NOOBJ` directive and the different types of output files ProAsm can produce.

'OBJFILE *filename*'
'-O *filename*'
This option specifies the name of the object file to be produced. The actual format of this output file depends on the output file format selected; see Section 5.9.2 *Output File Format*, page 129, for more information. This option overrides any `OBJFILE` directive contained in the actual source code.

'LISTFILE *filename*'
'-P *filename*'
This option specifies the filename of the listing file; see Section 5.10 *Auxiliary Output Files*, page 145, for information about listing files. It also automatically enables listing generation, and overrides any `LISTFILE` directive present in the actual source code.

'EQUFILE *filename*'
'-Q *filename*'
This option directs ProAsm to generate an equate file in *filename*. It overrides any `EQUFILE` directive in the source code. See Section 5.10.2 *The Equate File*, page 147, for more information.

'CREFFILE *filename*'
'-R*filename*'
This option causes ProAsm to create a cross reference listing in *filename*. It overrides any `CREFFILE` directive in the source code; see Section 5.10 *Auxiliary Output Files*, page 145, for more information.

'ADDSYM'

'-S' This option tells the assembler to add symbol information to the output file (see Section 5.9.3.2 *Debugging Information*, page 138). This option is ignored unless you specify an `EXECUTABLE` or a `LINKABLE` output file.

'STRING *symbol*=*string*[,*symbol*=*string*[...]]'
'-T *symbol*=*string*[,*symbol*=*string*[...]]'
This option is used to assign the specified *string* to the *symbol*, as with the `EQUR` directive; see Section 4.2.4 *Textual Symbols*, page 31, and Section 5.5.1 *Equates*, page 71, for more information. Any number of whitespaces are accepted between the symbol name and the equal sign, and between the equal sign and the string. If the *string* contains whitespace it must be enclosed in double or single quotes, or between angle brackets ('<' and '>'). If more than one symbol definition is given, they can be separated

by a comma (‘`,`’). In this case, *strings* that contain a comma should be enclosed within angle brackets (‘`<`’ and ‘`>`’).

‘`NOSTDOUT`’

‘`-U`’ This tells ProAsm to perform assembly quietly; no output text will be displayed.

‘`V`*n*`=`*value*’

‘`-V`*n*`=`*value*’

Specifying one of these options will cause the specified *value* to be used as the definition of the special built-in symbol `__V`*n*, where *n* is between 0 and 9. For example, if you specify ‘`-V0=12345`’ on the command-line while assembling a particular program, the symbol `__V0` will be defined as if you had included the statement ‘`__V0 EQU 12345`’ at the beginning of the assembly language source file. See Chapter 6 *Special Symbols*, page 171, for more information on the `__V`*n* symbols.

‘`WINDOW`’

‘`-W`’ This option instructs the assembler to send all output text to a window instead to the standard output. This can be useful if you run ProAsm as a background process or from a script file. The window will be of the size of 640x200, or smaller if necessary. After assembly the message ‘Press a key to continue’ will be displayed in the window and ProAsm will wait for a key to be pressed before terminating, to give you a chance to see any errors or other messages generated during assembly. This behavior can be suppressed by using the `NOKEYWAIT` option. The `WINDOW` option overrides the `NOSTDOUT` option.

‘`WINDOWSIZED` *dimension*’

‘`-WS` *dimension*’

This is exactly the same as `WINDOW`, except that it allows you to specify the window dimensions. The *dimension* must be in the format ‘*x*`/`*y*`/`*width*`/`*height*’ (without the quotes), with coordinates in pixels.

‘`EXPSYM`’

‘`-X`’ This option tells the assembler to add only the information of the exported symbols to the output file; any `ADDSYM` option used previously will be overridden. It is only useful if `LINKABLE` output files are being generated (see Section 5.9.2 *Output File Format*, page 129).

3.2 Starting ProAsm from Workbench

To start ProAsm from the Workbench, double click on the ProAsm icon to load the assembler from disk. ProAsm will then display a file requester that is used to specify the filename of the source code to be assembled.

All output text is sent to a window of the size of 640x200, or smaller if necessary. After assembly the message 'Press a key to continue' will be displayed in the window and ProAsm will wait for a key to be pressed before terminating, to give you a chance to see any errors or other messages generated during assembly.

3.3 Configuration File

The ProAsm assembler supports a configuration file that allows you to set assembler options for a project. The configuration file itself can be regarded as an include file that is automatically loaded at the very beginning of each assembly (even before the header files). You can use it to customize ProAsm to suit your particular wishes. It is not restricted in its contents. This allows you to put any assembler directive and pieces of code that you want to have included each time (such as startup codes etc.) in the config file.

The default configfile name is '`proasm.config`'. The assembler first looks in the home directory of the main source code, and after that in the '`ENV:`' and '`S:`'[1] assigns. Searching this way through the directories gives you the possibility to have local and global configurations. Local configurations are stored in the same directory as your main source code and the global configurations in the '`ENV:`' assign. For permanent global configuration, copy your config file into the '`ENVARC:`' assign.

If you want to use another name than the default config file name, you may use the `-G/CONFIGFILE` command line option to specify a new name. For example:

```
pro helloworld.s CONFIGFILE asm:myconfig.i
```

The use of the configuration file can be suppressed if a name of file is given that does not exist. For example:

```
pro helloworld.s -G nil:
pro helloworld.s CONFIGFILE qwjhbciu
```

As mentioned above, the configuration file is an ASCII file that can be regarded as a variant of an include file. It can be edited using a texteditor or the ProOpts program (see Section 8.2.2 *ProOpts*, page 220, for more details). Remember that the use of a configuration file may have unwished side effects, by the presence of certain directives in the config file. An example to illustrate this is: if the config file contains any symbols, an error could be reported by the assembler, if it encounters an `OPT C-` or similar directives, that change the case dependency for symbols.

[1] Under Kickstart version 1.3 or earlier, '`ENV:`' and '`ENVARC:`' may not exist. Use '`S:`' instead.

Below you find two examples of configuration files which may give you an impression how they can look like.

Configuration file #1 is a simple config file, that just sets up often used include pathes:

```
EXEOBJ
INCDIR  include:
INCDIR  routines:
```

Configuration file #2 shows you a way how a startup code and a standard version string can be put into a config file:

```
EXEOBJ
INCDIR  include:
INCDIR  routines:

jmp     AutoDetach(pc)
dc.b    "$VER: ",progname," ",version," (",__date2,")",0
EVEN

INCLUDE startup4.r      ; the startup code
```

The 'startup4.r' startup code requires two symbol definitions in the main source code, `clistartup` and `wbstartup`, to work properly. `Progname` and `version` may be set by the `-T/STRING` command line option:

```
pro mySource.s -T progname="HelloWorld" -T version="1.00"
```

3.4 Hello World

Now that you have an idea how to run ProAsm, it is time to assemble the first program. The source code below shows the famous '`Hello World`'. If you are new to assembly programming, take a little time to look over this program.

```
*
*
* HelloWorld.s  - a small helloworld example in assembler
*
*

        OUTPUT  'ram:HelloWorld'        ; write executable to ram:HelloWorld
```

```
;
; exec function offsets
;
_LVOOpenLibrary         EQU     -552
_LVOCloseLibrary        EQU     -414
;
; dos function offsets
;
_LVOOutput              EQU     -60
_LVOWrite               EQU     -48

;
; program start
;
start:  lea     DosName(pc),a1
        moveq   #0,d0
        move.l  4,a6                    ; load execbase
        jsr     _LVOOpenLibrary(a6)     ; open dos.library
        move.l  d0,DosBase
        beq.s   NoDosLibrary            ; could not open library


        move.l  d0,a6
        jsr     _LVOOutput(a6)          ; get StdOut handle (handle in d0)

        move.l  d0,d1
        move.l  #Text,d2
        moveq   #TextLength,d3
        move.l  DosBase,a6
        jsr     _LVOWrite(a6)           ; write text to StdOut


Exit:   move.l  DosBase,a1
        move.l  4,a6
        jsr     _LVOCloseLibrary(a6)    ; close dos.library

NoDosLibrary:
        moveq   #0,d0                   ; set AmigaDOS return code
        rts                             ; exit program

;
; data
;
Text:           DC.B    "Hello World!",$a,0
TextLength      EQU     *-Text

DosName:        DC.B    "dos.library",0
                EVEN
```

```
DosBase:        DC.L    0

        END
```

To assemble the above program write the following line into the shell and press `RETURN`:

`ProAsm` HelloWorld.s

After a few ticks the output file is written to '`RAM:HelloWorld`' and ready to be executed. Run it by simply typing its name into the shell followed by a `RETURN`, and a nice '`Hello World!`' will be displayed.

4 Assembly Language Syntax

4.1 Source Line Format

An M68000 assembly language source code file is a normal ASCII text file containing an arbitrary number of lines. Each line has the following general layout:

label mnemonic operands comment

The following sections describe each of these four fields in detail.

4.1.1 Labels

The *label* field can have two slightly different formats. In the first format, The *label* starts at the first character of a line, with no *whitespace* (space or tab characters) in front of it, and is separated from the *mnemonic* field (if present) with at least one whitespace. In the second format, the label is followed immediately with a colon (':') character. In this case, whitespace may be used at the beginning of the line before the label. In addition, no whitespace is needed before the *mnemonic* field (the colon is sufficient to separate the two fields), although it may still be present.

For normal instructions and assembler pseudo-ops that generate data (such as `DC`), the *label* is optional, and is used to assign the address of the current position to a symbol. If you don't specify a label at all, then you must have at least one whitespace character at the beginning of the line before the *mnemonic* field.

You may also put a label on a line of its own. In this case, the current position is assigned to the label without doing anything else. You can assign the same position to several different labels by putting each on a separate, otherwise empty line.

To demonstrate how labels are defined, the following code fragments all do the same thing (they produce a program which loops forever uselessly):

```
loop    bra     loop
```

```
loop:   bra     loop
```

```
loop
        bra     loop

loop:
        bra     loop

loop:bra loop

 loop:  bra     loop

        loop:
        bra     loop
```

Many assembler directives make special use of the *label* field. For example, the `EQU` directive assigns a numeric value to the specified *label*, instead of the current position. In these cases, the label is usually (but not always) required, depending on the directive being used. In this case, a colon can still be used to separate the symbol from the assembler directive, but they must be on the same line.

A valid symbol name may contain up to 256 characters. The first character must be one of the following characters: '`A`' through '`Z`' (in either upper or lower case), a period ('`.`'), a backslash ('`\`'), an underscore ('`_`'), or an 'at' symbol ('`@`'). The rest of the symbol name can consist of the characters '`A`' through '`Z`' (also in upper or lower case), the digits '`0`' through '`9`', periods ('`.`'), and underscores ('`_`'). Symbols are normally case-sensitive, but can be made case-insensitive depending on an option you can set (see Section 5.5.3 *Case Sensitivity*, page 83). Names corresponding to M68000 registers such as '`D0`' are reserved (see Section 4.3 *Registers*, page 35), as well as the names of special assembler symbols (see Chapter 6 *Special Symbols*, page 171).

4.1.1.1 Local Labels

Local labels are a special form of labels that are strictly local to the block of assembly instructions and directives between two nonlocal (global) labels. Local labels provide a convenient means of generating labels for loops, branch instructions and such. The use of local labels reduces the possibility of multiply defined labels in a program, and it separates entry point labels from local references, such as the top of a loop.

Local labels cannot be referenced from outside the current assembly block.

Normally a local label begins with a dot ('`.`') or the slash character '`/`'. You can use an underscore ('`_`') to introduce a local label if the `OPT U+` option is turned on (see Section 5.5.3 *Local*

Label Introducer, page 83). The assembler also accepts local labels of the form *n*$, where *n* is any integer. Valid local labels include:

.local

/local

..label

2$

1994$

.2

Note that the local label '2$' is the same as '02$' or '0000002$' and so on (leading zeros are ignored).

4.1.1.2 Scope of Labels

The section of program text in which a label is defined is called its scope. An ordinary label which tags a location in the program or data is visible only within the current assembly, except otherwise declared by using the `XREF` directive that makes a label visible to other assembly units at link time.

A local label has a scope that extends between one nonlocal label and the next. Every time a non local label is defined, the previous span of local labels is discarded, and a new local label scope is created. Consider the following example that illustrates the scopes of the different kinds of labels:

```
FirstLabel:                      ; a new local label scope is created
        moveq  #15,d7
.loop:  move.b  (a0)+,(a1)+      ; first appearance of the local label
'.loop'
        dbra d7,.loop
SecondLabel:                     ; the above local label scope has gone away,
        move.l  a2,a1            ; and a new scope is created
.loop:  cmp.b (a1)+,d0           ; another (different) local label '.loop'
        bne.s   .loop            ; branches to '.loop' above
ThirdLabel:                      ; the above local label scope has gone away,
        move.l a1,d0             ; and a new scope is created
        beq.s   .loop            ; generates an error message - no '.loop'
symbol found
FourthLabel:
```

The scope of the first local label '`.loop`' spans from the '`FirstLabel`' to the '`SecondLabel`' label. The second appearance of the local label '`.loop`' has a scope which extends between the '`SecondLabel`' and the '`ThirdLabel`' label. After the definition of the '`ThirdLabel`' label, the branch to '`.loop`' will generate an error message because that label is no longer defined within this scope.

4.1.2 Mnemonic

The *mnemonic* field contains the name of an instruction (also known as an *opcode*) or a special assembler directive (a *pseudo-opcode*) defining exactly what ProAsm is supposed to do with this line. Mnemonics are always case-insensitive: for example, '`move`', '`Move`', and '`MOVE`' are the same.

This manual does not describe the instructions ProAsm understands; these can be found in any M68000 assembly language book such as the *M68000 Programmer's Reference Manual*, published by Motorola, Inc. However, ProAsm accepts a large number of pseudo-opcodes which make assembly language programming easier; these are described in Chapter 5 *Directives*, page 47. Finally, you can defined your own mnemonics with ProAsm's powerful *macro* facility (see Section 5.2 *Macros*, page 52, for more information).

4.1.3 Operands

The *operands* field contains any additional data needed by the selected mnemonic. The field may contain multiple operands separated by commas. In general, whitespace may be used within the operands field, but only within quoted strings (e.g. '`"Hello world!"`'). In this case, the whitespace is considered to be part of the string. As a special case, the `DC` and related directives also allow whitespace immediately after a comma (e.g. '`1, 2, 3`'). This type of whitespace is merely padding and is ignored by ProAsm.

For M68000 instructions, the operands themselves have special formats dictated by the *addressing modes* in use. The addressing modes are described later in Section 4.4 *Addressing Modes*, page 36. For assembler directives, the operands are usually symbolic constants, numeric expressions, or text strings.

4.1.4 Comment

At the end of any line may be placed a *comment*, which is completely ignored: comments are purely for the benefit of humans reading the source code. Comments are usually separated from the rest of the source line with a semicolon (‘;’) or asterisk (‘*’), which explicitly tells ProAsm to ignore everything on the rest of the line starting with the semicolon or asterisk. However, ProAsm automatically considers the contents of a line after a mnemonic and its operands as “comment,” so in this case you do not need to use a semicolon at the beginning of the comment. However, for clarity we recommend that you still use one.

You can also reserve a whole line for a comment by making the first non-whitespace character a semicolon or an asterisk.

You can create comments that span many lines by preceding it with ‘/*’ and terminating it with ‘*/’. Note that this is the standard comment format in the C language. However, unlike in C, the initial ‘/*’ sequence must be first on a line (like ‘*’ comments). Additionally, ProAsm ignores all text up to and including the *entire* line on which the ‘*/’ appears.

Here are some examples of lines containing valid comments, although we do not recommend the last three examples to be used as comments:

```
* This is a comment.
; This is a comment.

                        * This is a comment.
                        ; This is a comment.

foo                     * This is a comment.
foo:                    ; This is a comment.

        nop             * This is a comment.
        move.l  d0,a0   ; This is a comment.

        nop             This is a comment.
        move.l  d0,a0   This is a comment.

/* This is
   one big
   comment.  */
```

4.2 Expressions

An expression is a combination of symbols, constants, numbers, labels, and algebraic operations. The expression is used to specify a value which is to be used as an operand.

4.2.1 Constants

There are two forms of integer constants supported by ProAsm, namely numeric integer constants and string constants. All integer constants are considered absolute quantities when they appear in an expression.

4.2.1.1 Integer Constants

ProAsm accepts numeric quantities in decimal (base 10), hexadecimal (base 16), octal (base 8), or binary (base 2) radices, or ASCII string. Integer constants can represent quantities up to 32 bits.

`Decimal numbers`
: Decimal numbers consist of between one and ten decimal digits (in the range 0 through 9). The range of decimal numbers is between -2147483648 and 2147483647.

`Hexadecimal numbers`
: Hexadecimal constants are preceded by the dollar character ('`$`') and can then have between one and eight hexadecimal digits. The hexadecimal digits consist of the decimal digits from 0 to 9 and the letters 'a' to 'f' (case does not matter).

`Octal numbers`
: Octal numbers are preceded by the atSign ('`@`') and can then have one to eleven octal digits. Octal digits consist of the decimal digits from 0 to 7. Note that eleven octal digits can have 33 bits, thus the largest octal number is `@`37777777777.

`Binary numbers`
: Binary numbers are indicated by the presence of the percent sign ('`%`') and can then have between one and 32 binary digits. The binary digits are the decimal digits 0 and 1.

`ASCII strings`
: The ASCII string in an expression is a non-numeric constant. The string data is represented by a sequence of characters enclosed by a pair of matching single or double quotes ('`'`' or '`"`'). Strings of one to four characters will generate a valid 32 bit numeric value. This can be used as any other integer constant within an expression.

: For example, the following strings generate the indicated hexadecimal integer values:

```
'a'     = $00000061
'ab'    = $00006162
```

```
'abc'  = $00616263
'abcd' = $61626364
```

The following example shows all integer constants within an expression:

```
move.l  #1994+$7f347+@47946+%100111011101101+"gh&",d0
; ⇒ move.l #523064,d0
```

4.2.1.2 Floating-point Constants

ProAsm accepts two notations for floating-point numbers: the pure fractional number and the engineering (exponential) notation. The fractional notation should already be familiar to you; the decimal-point method of writing numbers:

```
3.1415926
0.1994
32145.1123
-46.732
and so on.
```

The engineering notation includes a fractional part and an exponential part. Taking the same numbers from above, they could be written as:

```
3.1415926E0
1.994E-1
3.21451123E4 (or 3.21451123E+4)
-4.6732E1
```

The '`E`', meaning exponent, can be either written in upper- or lowercase. An exponent of *n* effectively "moves" the decimal point *n* places to the right if *n* is positive and to the left if negative, preserving the correct value of the number.

Notice that when you write a floating-point number in the source code, the assembler also accepts numbers without a fractional part:

```
foo     FEQU    3
; is the same as
foo     FEQU     3.0
```

(The assembler automatically recognizes the integer value (`3`) as a floating-point number because `FEQU` was used instead of `EQU`.)

4.2.2 Numeric Symbols

A *numeric symbol* is a symbol that represents a number. The exact value that a numeric symbol actually represents, however, is not always known by the assembler. There are three types of numeric symbols: absolute, relocatable, and external.

4.2.2.1 Absolute Symbols

An absolute symbol has an exact, known value. It can be used anywhere a numeric constant can be used, and works in exactly the same way. Absolute symbols are commonly defined with the `EQU` directive, like this:

```
the_answer      EQU     42
```

4.2.2.2 Relocatable Symbols

A relocatable symbol refers to the address of a specific position within the output file the assembler is producing: for example, the address of a specific instruction or data item. However, the assembler may not know exactly where in the computer's address space the output it is producing will be loaded. In such cases, relocatable symbols are used.

While ProAsm does not know exactly where a relocatable symbol will fall in memory, it *does* know where the symbol will fall relative to other symbols in the same segment. If one relocatable symbol is subtracted from another one in the same segment, they "cancel out" into a known value as if an absolute symbol had been used. In the following example, ProAsm knows the value to put into the last `DC.L` statement because the two relocatable symbols cancel each other out in the expression:

```
start:
        DC.L    1,2,3
finish:
        DC.L    finish-start    ; ⇒ 12
```

An implicit form of "cancelling out" occurs when a relocatable symbol is used as an operand in a PC-relative addressing mode. In the following example, ProAsm knows the exact value to use in the `LEA` instruction, because the relocatable symbol "cancels out" with the (relocatable) address of the `LEA` instruction:

```
somewhere:
        ...
        LEA     (somewhere,pc),a0
```

Note that branch instructions (B*cc*) are always PC-relative.

If ProAsm is generating a `BINARY` or otherwise non-relocatable output file, but no `ORG` directive is used, "cancelling out" is the *only* way relocatable references may be used. (If an `ORG` directive is used, then ProAsm knows exactly where its output will be loaded, so it always uses absolute symbols instead of relocatable symbols.)

If ProAsm is generating a relocatable output file, such as an AmigaDOS executable or a linkable object module, then relocatable symbols can also be used when defining longwords in instructions or data. This causes ProAsm to include in the output file a *fixup* for the longword in question, which instructs the linker or loader to "fix" the value once the address is known exactly. For example, the following statements are valid only when producing a relocatable file:

```
foo:
        ...
        jmp     foo
        ...
        DC.L    bar+10
        ...
bar:
```

Only one relocatable symbol may be used in an expression this way; all other parts of the expression must be known values (or pairs of relocatable symbols cancelling each other out, which amounts to the same thing). Also, no special arithmetic may be applied to such a relocatable symbol. For example, '`bar*2`' or '`-bar`' would not work in the `DC.L` above.

4.2.2.3 External Symbols

External symbols are symbols declared by the `XREF` directive, meaning that the symbol is actually defined in a different module to be linked later with the module being generated. In this case, ProAsm does not even know where the symbol is located relative to other symbols: all it knows is that the symbol exists. Because of this, external symbols are the most restrictive type, and can only be used at all when ProAsm is generating a linkable object file (see Section 5.9.2 *Output File Format*, page 129).

Since the relative positions of symbols are not known to ProAsm, external symbols cannot "cancel out" like relocatable symbols, and a fixup is produced every time one is used. There are three ways an external symbol can be used:

32-bit Absolute

In instructions or data definitions that expect full 32-bit addresses, ProAsm can generate 32-bit absolute *fixups* (external symbol information), which are "fixed" once the exact address of the symbol is known. These examples use 32-bit absolute fixups:

```
XREF    foo,bar
...
jmp     foo
...
DC.L    bar-15
```

Note that this is the easiest way to use external symbols, and you only need to worry about the other two if you are worried about the size or efficiency of your program.

PC-Relative

In instructions expecting PC-relative values, ProAsm can create *PC-relative fixups* which will be reduced to constants by the linker. Most PC-relative external references are 16-bit, but 8-bit and 32-bit external references are also possible. 8-bit references are not very useful due to their severely limited range, and 32-bit PC-relative references only work in code for 68020 and higher processors, since earlier processors do not have any 32-bit PC-relative addressing modes.

To generate PC-relative references, ProAsm must assume that the segment containing the reference will be merged by the linker into the same segment as the one in which the symbol is actually defined. If this assumption is not satisfied, the linker will produce an error while linking the object files together.

Here are examples that generate 16-bit PC-relative fixups:

```
XREF    foo,bar
...
move.w  (bar+10,pc),d0
jmp     (foo,pc)
```

Base-Relative

In instructions expecting 16-bit *non*-PC-relative values, ProAsm creates *16-bit base-relative fixups*. It makes the assumption that the symbol will reside in a special "global data segment" produced by the linker, containing *all* data accessed this way. The linker creates a special symbol called `_LinkerDB`, which is the *base address* of all global data. You reference this data by loading the address of `_LinkerDB` into an address register with 32-bit absolute mode, then use this register as the base address for referencing 16-bit base-relative data. Here are some examples of how this is done:

```
            XREF    _LinkerDB
            XREF    foo,bar
            ...
            ; Load base register
            lea     _LinkerDB,a5
            ...
            ; 16-bit access to foo
            move.w  (foo,a5),d0
            ...
            ; 16-bit indirect access to bar
            move.w  (indirect,pc),d0
            move.l  (d0.w,a5),d1

    indirect:
            DC.W    bar
```

4.2.3 Operators

Operators can be used in expressions to combine the values of constants and symbols into a final result based on arithmetic or logical operations. An expression is evaluated according to the precedence of operators and truth values detailed below. Operators higher in the table are evaluated first. You may have to use parentheses to ensure that expressions are evaluated in the desired order.

7	()	parentheses
6	-	unary minus
	$\sim$	complement (logical NOT)
5	<<	logical shift left
	>>	logical shift right
	$\ll$	arithmetical left shift
	$\gg$	arithmetical right shift
	$\ll\ll$	rotate left
	$\gg\gg$	rotate right
4	*	multiplication
	/	division
	\	modulo
3	&	logical AND
	$\vert$	logical OR
	!	logical EOR
2	+	addition
	-	subtraction
1	<>	not equal
	><	not equal
	=	equal
	<=	lower or same
	>=	greater or equal
	>	less
	<	greater

Absolute, relocatable, and external symbol operations are limited in their combinations. The table below shows all possible combinations, with their type of the resulting value.

Operator	**AA**	**AR**	**AX**	**RA**	**RR**	**RX**	**XA**	**XR**	**XX**
unary minus	A	○	○	○	○	○	○	○	○
complement	A	○	○	○	○	○	○	○	○
shift/rotate operations	A	○	○	○	○	○	○	○	○
multiplication	A	○	○	○	○	○	○	○	○
division	A	○	○	○	○	○	○	○	○
modulo	A	○	○	○	○	○	○	○	○
bit operations	A	○	○	○	○	○	○	○	○
addition	A	R	A+X	R	○	○	X+A	○	○
subtraction	A	○	○	R	A	○	X−A	○	○
relations	A	○	○	○	A	○	○	○	○

A: absolute symbol, R: relocatable symbol, X: external reference, ○: illegal

The comparison operators (`=`, `<>`, `><`, `<`, and `>`, `<=`, `>=`) always use signed comparisons and yield boolean results. The constituents of a boolean expression are the truth values denoted by -1 for TRUE and 0 for FALSE.

```
1<2                     ; ⇒ TRUE
1990>1994               ; ⇒ FALSE
5=(4+1)                 ; ⇒ TRUE
```

Excessively complex relocatable and external expressions will generate an error. For instance:

```
dc.l    relocatable-relocatable                 ; is allowable
dc.l    relocatable-relocatable-relocatable     ; is not
```

All expressions are evaluated as signed 32 bit values, may have any length, and my have parenthesis nesting up to 255 levels.

4.2.4 Textual Symbols

A *Textual symbol* is a special type of symbol which may be used in expressions and by certain other assembler constructs such as `\*STRING` (see Section 5.2.1 *Substituting textual symbols in symbol names*, page 58). A textual symbol represents not a number, but merely a piece of text that is inserted in place of the symbol and assembled as if you had typed that text into the source file in the first place. Textual symbols are defined with the `EQUR` directive (see Section 5.5.1 *Equates*, page 71), and usually represent ASCII strings such as '`"hello there"`', or register lists for MOVEM instructions such as '`d2-d7/a2-a6`'.

```
dregs   EQUR    d0-d7
msg     EQUR    "Hello world"

        movem.l dregs,-(sp)       ; Push d0-d7 on the stack

        DC.B    msg,0             ; ⇒ Null-terminated "Hello world"
```

Textual symbols are substituted even when their names occur within quoted strings. For example, the following two code fragments are equivalent:

```
foo     EQUR    "Hello there"
        dc.b    foo

foo     EQUR    <Hello there>
        dc.b    "foo"
```

4.2.5 Forward References to Numeric and Textual Symbols

Both numeric and textual symbols can be referenced before they are defined. For example, the following code fragment works as expected:

```
        dc.l    foo
        dc.b    bar

foo     EQU     123
bar     EQUR    "hello"
```

However, forward referencing is not unlimited. The *expression* in an `EQU` directive may contain forward references to symbols not defined yet, *or* the symbol defined may be forward-referenced from earlier parts of the program, *but not both*. In other words, an `EQU` that makes forward references must not itself be forward referenced. This is because ProAsm performs only two passes on a program, and resolving symbols defined through multiple forward-reference "hops" would require more than two passes. If you attempt to use symbols that would need more than two passes to resolve, ProAsm will generate an '`abuse of forward referenced symbol`' error.

While `EQU` cannot forward-reference symbols in its *expression* and at the same time have its *symbol* forward-referenced by earlier parts of the program, this restriction does not apply to textual symbols and `EQUR`. This is because `EQUR`'s operand does not get evaluated until it is actually used.

For example, the following code fragment does not work:

```
        DC.L    foo+1           ; Does not work!
foo     EQU     bar+1
bar     EQU     1
```

However, this one does:

```
        DC.L    foo+1           ; Works!
foo     EQUR    bar+1
bar     EQU     1
```

Why does the second example work? In the first pass, ProAsm sees the symbol `foo` and, since it is not defined yet, assumes (correctly) that it is a forward reference. Then it sees the second line, which defines the symbol `foo`. However, since it is an `EQUR` instead of an `EQU`, ProAsm does not try to evaluate the text '`bar+1`' at this point. Instead it simply stores it as a text string. In the last line, `bar` gets defined. On the second pass, when ProAsm sees the first line, it first substitutes '`bar+1`' for '`foo`', generating the line '`DC.L bar+1+1`'. Finally, it computes the numeric value, using the value of `bar` defined in the first pass.

In general, it is good programming practice to put equates near the top of a program, before they are used, so these strange forward reference situations should not occur often.

However, if you use `EQUR` to get around limitations on forward referencing, be careful of other subtle side-effects of the difference between the way `EQU` and `EQUR` work. For example:

```
foo     EQU     5+5
bar     EQUR    5+5
        DC.L    foo*3           ; ⇒ 30
        DC.L    bar*3           ; ⇒ 20
```

The reason for the different result is because of the way the replacement value is handled. `EQU` calculates its numeric value immediately, and later in the `DC.L` directive, `foo` is treated as a single numeric value. On the other hand, `EQUR` does *not* evaluate its argument immediately—it simply attaches the string of text to the symbol `bar`. Later, the line '`DC.L bar*3`' gets expanded into the line '`DC.L 5+5*3`' *before* the numeric expression is evaluated. When the value actually is evaluated, the '`5*3`' is evaluated first, because multiplication has higher precedence than addition.

For this reason, if you want to use EQUR for numeric expressions, you should always enclose their values in parentheses, like this:

```
bar     EQUR    (5+5)
```

This will force `bar` to behave as if it had been defined with `EQU`.

4.2.6 Assembly Location Counter

The assembly location counter is the asterisk character '*'. When used in any statement in the operand field the asterisk represents the offset from the start of assembly to the first byte of the statement. Even used in assembler directives the asterisk represents the offset to the first byte of the statement. Consider the following example:

```
programstart:
        ...
foo:    move.l  *,a0        ; load offset of foo into the register a0
bra:    dc.l    *,*          ;  = dc.l bar-programstart,bar-programstart+4
```

You can also define a symbol by advancing the asterisk character. For example:

```
foo     EQU     *       ; assign current offset to foo
```

This is an equivalent to the normal symbol definition, except the benefit of defining global symbols between local symbols without interrupting the scope of labels.

```
GlobalSymbol:
        ...
.local:
        ...
        beq     .local
foo     EQU     *
        bne     .local
        ...
AnotherGlobalSymbol:
        bcs     .local1
        bne     foo
```

4.3 Registers

All M68000 processors contain the following basic set of registers, which are the ones primarily used during normal programming:

`D0–D7` General-purpose 32-bit data registers, normally used to hold integer values, counters, etc.

`A0–A6` General-purpose 32-bit address registers, normally used to hold pointers into main memory.

`A7` or `SP` The last address register is the *Stack Pointer*, and may be referred to by either '`A7`' or '`SP`'.

`CCR` The 8-bit *Condition code Register* holds condition codes generated during test and comparison instructions, and is used by conditional branch instructions.

`SR` The 16-bit *Status Register* holds various processor status and configuration bits. It is actually a superset of the `CCR`, which is contained in the lower 8 bits of the `SR`.

In addition, different members of the M68000 family support various extended registers, listed in the following table. Many of the registers can only be accessed using special instructions. All of the M68000 registers are described fully in the *M68000 Family Programmer's Reference Manual.*

Basic Registers

MC680x0, MC68EC030, MC68EC040, MC68LC040	D0-D7, A0-A7, CCR, SR, USP

Control Registers

MC68000, MC68008	None
MC68010	SFC, DFC, VBR
MC68020	SFC, DFC, VBR, CACR, CAAR
MC68030	SFC, DFC, VBR, CACR, CAAR, CRP, SRP, TC, TT0, TT1, MMUSR
MC68EC030	SFC, DFC, VBR, CACR, CAAR, ACR0, ACR1, ACUSR
MC68040, MC68LC040	SFC, DFC, VBR, CACR, URP, SRP, TC, DTT0, DTT1, ITT0, ITT1, MMUSR
MC68040	SFC, DFC, VBR, CACR, DACR0, DACR1, IACR0, IACR1

Stack Pointer

MC68000, MC68008, MC68010	USP, SSP
MC68020, MC68030, MC68040, MC68060	USP, SSP (MSP, ISP)

Floating-Point Registers

MC68881, MC68882, MC68040, MC68060	FP0-FP7, FPCR, FPIAR, FPSR

MMU Registers

MC68851	AC, BAC0-BAC7, BAD0-BAD7, CRP, CAL, DRP, PCSR, PSR, SCC, VAL
MC68030	CPR, SRP, TC, MMUSR, TT0, TT1
MC68040, MC68LC040	URP, SRP, TC, MMUSR, DTT0, DTT1, ITT0, ITT1

4.4 Addressing Modes

With the release of the 68020 microprocessor special attention was given to increasing the addressing capabilities. Whereas offsets (address displacements) were limited to values that can be defined with 8- or 16- bits with the 68000/10 microprocessors, the 68020 and higher microprocessors allow you also the use of offsets defined with 32-bits.

Compared with the 68000 and 68010 microprocessors the 68020, 68030, and 68040 microprocessors have several extra addressing modes in addition. The new addressing modes fall under two general categories:

- Indirect addressing modes,
- Program counter (PC) relative addressing modes.

Due to these extensions of the addressing modes Motorola had to develop a new syntax, since the improvements did not fit in the old syntax. In this new syntax all elements of the above mentioned addressing modes are now enclosed within parentheses ('(' and ')'). Another advantage of this new syntax standard is that it is more logical and thus simpler to understand.

The new addressing modes are designed specifically to provide many additional options for addressing data in tables flexibly. Programmers find these capabilities particularly useful for handling advanced data structures common to sophisticated application and high level languages.

ProAsm supports both addressing mode syntax as defined by Motorola for the M68000 Family. Below you will find a description of all addressing modes.

The following notation conventions are used in this section:

`D`*n*	Any data register (Example: `D4` is data register 4)
`A`*n*	Any address register (Example: `A1` is address register 1)
`X`*n*	Either an address register or a data register
`PC`	Program Counter
`ZD`*n*	Pseudo register that represents the suppressed data register *n*. Only valid for the program counter and address register relative addressing modes.
`ZA`*n*	Pseudo register that represents the suppressed address register *n*. Only valid for the address register relative addressing modes.
`ZSP`	Pseudo register that represents the suppressed address register A7. Only valid for the address register relative addressing modes.
`ZPC`	Pseudo register that represents the suppressed program counter. Only valid for the program counter relative addressing modes.
d8	Signed displacement up to 8 bits wide (-128–127)
d16	Signed displacement up to 16 bits wide (-32768–32767)
d32	Signed displacement up to 32 bits wide
bd	Base Displacement up to 32 bits wide
od	Outer Displacement up to 32 bits wide
`.`*size*	Size of an index: either `.W` for 16 bits or `.L` for 32 bits
`.B`, `.W`, `.L`	Fixed size specifiers: byte, word, or long word, respectively
`*`*scale*	Scale factor for an index: 1,2,4, or 8, for no scaling, word, long word, or quad word scaling, respectively
imm	An immediate value up to 32 bits wide
`()`	Identifies first-level indirect addressing
`[]`	Identifies second-level indirect addressing

D*n* Data Register Direct

The operand is one of the eight data registers numbered from 0 to 7, and the operation is performed on the contents of the register. For example, '`D3`' specifies that the contents of data register 3 is the operand.

A*n* Address Register Direct

The operand is one of the eight address registers numbered from 0 to 7, and the operation is performed on the contents of that register. For example, '`A5`' specifies that the contents of address register 5 is the operand.

(A*n***)** Address Register Indirect

The operand is the memory location whose address is the contents of address register *n*. For example, if '`(A0)`' is specified and register `A0` contains 1000, then the operand is the byte, word, or longword at memory address 1000.

(A*n***)+** Address Register Indirect with Postincrement

In the Address Register Indirect with Postincrement Mode, the operand is in the memory, and the address of the operand is specified in the address register. After the operand address is used, the address stored in the address register is incremented by one, two, or four depending on the size of the operand: byte, word, or long word. Coprocessors may support auto-increment addressing for any size of operand.

Example:

`(A1)+`	`A1` is a pointer to the operand, and is automatically incremented after use.

-(A*n***)** Address Register Indirect with Predecrement

In the Address Register Indirect with Predecrement Mode, the operand is in the memory, and the address of the operand is specified in the address register. Before the operand address is accessed, it is decremented by one, two, or four depending on the operand size: byte, word, or long word. Coprocessors may support decrementing for any operand size.

Example:

`-(A4)`	`A4` is a pointer to the operand, and is automatically decremented before use.

(*d16***,A***n***)** Address Register Indirect with Displacement
*d16***(A***n***)** (old syntax)

In the Address Register Indirect with Displacement Mode, the operand is in memory. The address of the operand is the sum of the address in the address register plus the sign extended 16 bit displacement. The effective address is: (An) + displacement.

Examples:

`16(A5)`	The operand is 16 bytes past the address in `A5`.
`(8,A3)`	The operand is 8 bytes past the address in `A3`.

(*d8*.B,A*n*,X*n*.*size*scale*)** Address Register Indirect with Index (8 Bit Displacement)
d8*(A*n*,X*n*.*sizescale*)** (old syntax)

In this addressing Mode, the operand is in memory and its address is the sum of the address register plus the sign extended 8 bit displacement plus the (possibly scaled) contents of the index register. The scale factor can be 1 (default if not specified, or for a MC68000/10 processor), 2, 4, or 8. The index can be either data or address register. The size of the index register may be word or long word. If word or no size is specified then the low order word is sign extended before use. The effective address is: displacement + (An) + (Xn.SIZE*SCALE)

Examples:

`20(A3,D0.W)`	Register `A3` is a pointer with constant displacement (20) and variable index (in the lower 16 bits of `D0`).
`10(A4,A2.L*4)`	Register `A4` is a pointer with constant displacement (10) and variable index (four times the contents of `A2`)

(*bd*.*size*,A*n*,X*n*.*size*scale*)** Address Register Indirect with Index (Base Displacement)

In this addressing mode, the operand is in memory. The address of the operand is the sum of the contents of the address register, the sign extended and scaled contents of the index register plus the sign extended 16 or 32 bit base displacement. The size of the index register may be word or long word. If word or no size is specified then the low order word is sign extended to 32 bit before use. The base displacement size can be word or long word, if not specified then word is used. All three user-specified values are optional. Any not specified values are considered to be zero in the effective address calculation.

The assembler supplies the "ZAn" (zero value is taken for the address register n) notation to indicate that the address register is not used. This allows the memory access without using the base address register in calculating the effective address. This mode is only for the MC68020 or later processors. The effective address is: base displacement + (An) + (Xn.SIZE*SCALE)

Example:

```
($1234.W,A3,D4.L*8)
```

([*bd*.*size*,**A***n*],**X***n*.*size***scale*,*od*.*size***)** Memory Indirect Postindexed

In the Memory Indirect Postindexed Mode, the operand and its address are in memory. The processor calculates the memory address by adding the base displacement (bd), and the base address register (An) together. It then fetches the 32 bit address at this memory address and adds the scaled index register (Xn.SIZE*SCALE) and then the outer displacement (od) to yield the effective address.

In the syntax for this mode, the square brackets ('[]') enclose the value used to calculate the memory address. All four user-specified values are optional. Any not specified values are considered to be zero in the effective address calculation. Both displacements and the index register contents are sign extended to 32 bits. The base and outer displacement may be null (suppressed), word, or long word; if not specified, the size of the displacement is word. The "ZAn" and "ZDn" (zero value is taken for the address or data register n) notations are supplied by the assembler to indicate that the register is not used. This allows the memory access without using the base address register or the index register in calculating the effective address. This mode is only for the MC68020 or later processors. The effective address is: (bd + An) + Xn.SIZE*SCALE + od

Examples:

```
([$44900,A3],D4.W*4,20)
([$40,ZA2],ZD7,4)
([$87620,ZA0],D0,96)
```

([*bd*.*size*,**A***n*,**X***n*.*size***scale*],*od*.*size***)** Memory Indirect Preindexed

In the Memory Indirect Preindexed Mode, the operand and its address are in memory. The processor calculates the memory address by adding the base displacement (bd), the base address register (An), and scaled index register (Xn.SIZE*SCALE) together. It then fetches the 32 bit address at this memory address and adds the outer displacement (od) to yield the effective address.

In the syntax for this mode, the square brackets ('[]') enclose the value used to calculate the memory address. All four user-specified values are optional. Any not specified values are considered to be zero in the effective address calculation. Both displacements and the index register contents are sign extended to 32 bits. The base and outer displacement may be null (suppressed), word, or long word; if not specified, the size of the displacement is word. The "ZAn" and "ZDn" (zero value is taken for the address or data register n) notations are supplied by the assembler to indicate that the register is not used. This allows the memory access without using the base address register or the index register in calculating the effective address. This mode is only for the MC68020 or later processors. The effective address is: (bd + An + Xn.SIZE*SCALE) + od

Example:

```
([$44100,A2,D3.L*2],16.L)
([$1480,ZA3,D5.W*4],12)
```

(*d16*,PC) Program Counter Indirect with Displacement
***d16*(PC)** (old syntax)

In this mode, the operand is in memory. The address of the operand is the sum of the address in the program counter (PC) and the sign extended 16 bit displacement.

If the displacement is not an absolute expression then the assembler calculates the displacement as being relative to the current program counter (offset calculated from the current PC). The effective address is: (PC) + displacement

Examples:

```
20(PC)
(16,PC)
```

(*d8*.B,PC,X*n*.*size*scale*)** Program Counter Indirect with Index (8 Bit Displacement)
d8*(PC,X*n*.*sizescale*)** (old syntax)

This mode is similar to the address register indirect with index (8 bit displacement) mode described in Section 4.4 *Address Register Indirect with Index (8 Bit Displacement)*, page 39, but the program counter (PC) is used as the base register.

In this addressing Mode, the operand is in memory and its address is the sum of the program counter plus the sign extended 8 bit displacement plus the (possibly scaled) contents of the index register. The scale factor can be 1 (default if not specified, or for a MC68000/10 processor), 2, 4, or 8. The index can be either data or address register.

The size of the index register may be word or long word. If word or no size is specified then the low order word is sign extended before use.

If the displacement is not an absolute expression then the assembler calculates the displacement as being relative to the current program counter (offset calculated from the current PC).

This mode is only allowed for reads. The effective address is: displacement + (PC) + (Xn.SIZE*SCALE)

Examples:

```
12(PC,D0.L)
(20,PC,A0.W)
```

(*bd*.*size*,PC,X*n*.*size*scale*)** Program Counter Indirect with Index (Base Displacement)

This mode is similar to the address register indirect with index (base displacement) mode described in Section 4.4 *Address Register Indirect with Index (Base Displacement)*, page 39, but the program counter (PC) is used as the base register.

In this addressing mode, the operand is in memory. The address of the operand is the sum of the contents of the program counter, the sign extended and scaled contents of the index register plus the sign extended 16 or 32 bit base displacement. The size of the index register may be word or long word. If word or no size is specified then the low order word is sign extended before use. The base displacement size can be word or long word, if not specified then word is used. All three user-specified values are optional. Any not specified values are considered to be zero in the effective address calculation.

If the displacement is not an absolute expression then the assembler calculates the displacement as being relative to the current program counter (offset calculated from the current PC).

This mode is only allowed for reads. The assembler supplies the "ZPC" (zero value is taken for the PC), "ZAn", and "ZDn" notations to indicate that the PC or index register is not used. This allows the memory access without using the PC or index register in calculating the effective address. This mode is only for the MC68020 or later processors. The effective address is: base displacement + (PC) + (Xn.SIZE*SCALE)

Examples:

```
($5678.W,PC,D3.W*2)
($144,ZPC,D4.W)
```

([*bd.size*,PC],X*n.size*scale*,*od.size*)** Program Counter Memory Indirect Postindexed

This mode is similar to the memory indirect postindexed mode described in Section 4.4 *Memory Indirect Postindexed*, page 40, but the program counter (PC) is used as the base register. Both the operand and its address are in memory. The processors calculates the memory address by adding the base displacement (bd), and the program counter contents together. It then fetches a long word at this memory address and adds the scaled index register (Xn.SIZE*SCALE) and then the outer displacement (od) to yield the effective address.

In the syntax for this mode, the square brackets (‘`[]`’) enclose the value used to calculate the memory address. All four user-specified values are optional. Any not specified values are considered to be zero in the effective address calculation. Both displacements and the index register contents are sign extended to 32 bits. The base and outer displacement may be null (suppressed), word, or long word; if not specified, the size of the displacement is word.

If the displacement is not an absolute expression then the assembler calculates the displacement as being relative to the current program counter (offset calculated from the current PC).

This mode is only allowed for reads. The assembler supplies the "ZPC" (zero value is taken for the PC), "ZAn", and "ZDn" notations to indicate that the PC or index register is not used. This allows the memory access without using the PC or index register in calculating the effective address. This mode is only for the MC68020 or later processors. The effective address is: (bd + PC) + Xn.SIZE*SCALE + od

Examples:

```
([$4414.L,PC],D0,14)
([$40,ZPC],D4,4)
```

([*bd.size*,PC,X*n.size*scale*],*od.size*)** Program Counter Memory Indirect Preindexed

This mode is similar to the memory indirect preindexed mode described in Section 4.4 *Memory Indirect Preindexed*, page 40, but the program counter (PC) is used as the base register. Both the operand and its address are in memory. The processor calculates the memory address by adding the base displacement (bd), the program counter contents, and scaled index register (Xn.SIZE*SCALE) together. It then fetches a long word at this memory address and adds the outer displacement (od) to yield the effective address.

In the syntax for this mode, the square brackets ('`[]`') enclose the value used to calculate the memory address. All four user-specified values are optional. Any not specified values are considered to be zero in the effective address calculation. Both displacements and the index register contents are sign extended to 32 bits. The base and outer displacement may be null (suppressed), word, or long word; if not specified, the size of the displacement is word. This mode is only for the MC68020 or later processors.

If the displacement is not an absolute expression then the assembler calculates the displacement as being relative to the current program counter (offset calculated from the current PC).

This mode is only allowed for reads. The assembler supplies the "ZPC" (zero value is taken for the PC), "ZAn", and "ZDn" notations to indicate that the PC or index register is not used. This allows the memory access without using the PC or index register in calculating the effective address. This mode is only for the MC68020 or later processors. The effective address is: (bd + PC + Xn.SIZE*SCALE) + od

Examples:

```
([$4415,PC,D4],14)
([$150,ZPC,D4])
```

(*d16*).W Absolute Short Addressing
***d16*.W** (old syntax)

In this addressing mode, the operand is in memory, and the address of the operand is in *d16*. The 16 bit address is sign extended to 32 bit before it is used. This gives a useful range of 0 through $7FFF and $FFFF8000 through $FFFFFFFF.

Examples:

`($4).W` Absolute address 4.
(Under the Amiga operating system,
this happens to be a very popular address,
containing a pointer to ExecBase and all
other operating system structures.)

`$4.W` (old syntax)

(*d32*) Absolute Long Addressing
(*d32*).L
d32 (old syntax)
***d32*.L**

In the Absolute Long Addressing Mode the operand is in memory, and the address of the operand is in *d32*.

Examples:

`($DFF000)`	Absolute address $DFF000 (the base address of the Amiga's custom chips)
`($DFF000).L`	
`$DFF000`	

#*imm* Immediate Data

In this addressing mode, the operand is in one or two extension words depending on the size of the operand: byte, word or long word; and its value is specified by the expression following the pound sign ('`#`'). Coprocessor instruction can support immediate data of any size.

Example:

`#4418`	The operand is the number 4418.
`#'A'`	The operand is the ASCII code of the letter '`A`', or 65.

4.5 Instruction Set

ProAsm supports the instruction set of the complete M68000 family. For a complete overview refer to Appendix D *Instruction Set Summary*, page 289. This section discusses some peculiarities of the assembler and the instructions:

- Some instructions have variant forms that can be specified by the user or will be automatically used by the assembler. The `ADD` and `SUB` instructions have `ADDA`, `SUBA`, `ADDI`, `SUBI`, `ADDQ`, SUBQ as variants. The CMP instruction has CMPA and CMPM as variants. The AND, OR, and EOR instructions have their immediate variant (ANDI, ORI, and EORI).

The assembler will automatically use the appropriate form if possible. Note that the correct forms are always assembled faster than if the "stubs" have to be converted by the assembler.

- A Bcc.**B** is equivalent to Bcc.**S**.
- If a short branch is specified to the following instruction, the branch will be replaced by a NOP instruction to avoid an execution error. A warning will be reported if such a conversion is made.

  Example:

```
        bra.s   foo     ; ⇒ converted to NOP
foo:    ...
```

- There are two extensions to the standard condition codes: HS (higher or same – unsigned) and LO (lower – unsigned). They are equivalent to CC (carry clear) and CS (carry set).

  For branch instructions BHS is equivalent to BCC, and BLO is equivalent to BCS. This will also work for the DBcc and the Scc instructions.
- If a MOVEQ instruction is used with an immediate source operand from 128–255 a warning is issued. The MOVEQ instruction expects an 8-bit (-128–127) immediate value that, during execution, is sign-extended to long (32-bit). Thus any 8-bit number greater than 127 will automatically become negative when sign-extended to long.

  To suppress this warning you have to add a longword size specifier ('.L').
- A LINK instruction with a positive or odd integer value as second argument reports a warning.
- The BTST instruction is the only bit manipulating instruction that allows program counter relative addressing modes.

  BTST allows also an immediate addressing mode as destination if a data register is taken as source.

  Consider the following example:

```
        btst    d0,#%111100000011101
        bne.s   foo
```

  This example jumps to 'foo' if the data register d0 contains a value of zero, a value from 2–4, or from 11–14.

5 Directives

5.1 Source Code Input

5.1.1 Terminating the Input File

END Stop reading the input file
ENDSRC

The `END` directive indicates the logical end of the source, and the assembler ignores the remainder of the file. This directive is optional; the end-of-file will be detected if no `END` directive is given. If the assembler detects an unexpected end-of-file (for example within an expression) an error will be issued.

The `END` directive may also be used to indicate the end of an included file. If `END` is encountered in an include file, instead of stopping assembly entirely, ProAsm merely "drops out" of the include file and resumes with the source file that included it.

5.1.2 Include Files

INCLUDE *filename* Include source from file

The `INCLUDE` directive allows you the inclusion of external files into the program source. The loaded files must be either source or preasm files.

The *filename* must be in normal AmigaDOS format and must be enclosed in double or single quotes if it contains any whitespaces.

If no explicit path is given (e.g. '`DF0:...`') the assembler will first search in the current directory for the requested file, and after that in each of the directories defined by the `INCDIR/INCPATH` directives, and the `-I/INCDIR` command line option.

The included files have no restrictions on their content. They are only read in the first pass, but processed on all passes.

The `INCLUDE` directive can be nested as deeply as available memory allows.

Example:

```
        INCLUDE "exec/types.i"
        INCLUDE "exec/memory.i"
```

OPT Y+ Ignore multiple includes (default)
OPT NOINCONCE
OPT Y- Do not ignore multiple includes
OPT INCONCE

These options control the inclusion of files. The first two forms force the assembler to ignore multiple file inclusion. A file can be included as many times as you like to.

The last two forms tell the assembler to do not ignore multiple includes. The files are only allowed to be included once. Any further inclusion will be skipped by the assembler.

These options work together with the following directives: `INCLUDE`, `INCEQU`, `MACLIB`, and `HEADER`.

By default, multiple includes are ignored.

INCBIN *filename*[,*size*[,*seek*]] Include a binary file
IBYTES *filename*[,*size*[,*seek*]]

These directives are used to include raw binary data (such as graphic data, sound samples, sprite data, etc.) directly into the object code at the current position. The program counter is updated accordingly.

The *filename* must be in normal AmigaDOS format and must be enclosed in double or single quotes if it contains any whitespaces.

If no explicit path is given (e.g. '`DF0:...`') the assembler will first search in the current directory for the requested file, and after that in each of the directories defined by the `INCDIR/INCPATH` directives, and the `-I/INCDIR` command line option.

Normally the complete file is loaded into the object code, except one of the optional parameters *size* or *seek* is given.

Size represents the number of bytes that are maximally read of the file *filename*. To avoid complications, the smaller size of both sizes (*size* and the file size) is taken into account for reading the data. If no size is given, the file size is taken instead.

The *seek* value defines the position in the file to start the reading. A positive value sets the position relative to the start of the file, and a negative value relative to its end. For example, 20 is the position 20 bytes forward from start, -20 is 20 bytes back from the end of file. If *seek* is set to zero, reading begins at the first byte of the file.

Consider the following example:

```
INCBIN "TheImage1.raw"           ; include the whole file
INCBIN "TheImage2.raw",1024      ; include max. the first 1024 bytes
INCBIN "TheImage3.raw",512,-512  ; include the last 512 bytes of the file
INCBIN "TheImage3.raw",,-512     ; same as above
INCBIN "TheImage4.raw",117,25    ; read 117 bytes from byte 25
```

INCEQU *filename* Include source from file in the first pass only

The `INCEQU` directive allows you the inclusion of external files into the program source so they are processed in the first pass only. The loaded files must be either source or preasm files.

Files included using `INCEQU` have restrictions on their content, because they are read and processed in the first pass only. Only symbol and macro definitions should be used in a file loaded by the `INCEQU` directive, since that is the only time ProAsm evaluates symbols and macro definitions. Code or data generating directives and temporary symbols are not allowed in such a file. An error is reported if any M68000 instruction or illegal directive is found in the included file.

The *filename* must be in normal AmigaDOS format and must be enclosed in double or single quotes if it contains any whitespaces. The `INCEQU` directive can be nested as deeply as available memory allows.

If no explicit path is given (e.g. '`DF0:...`') the assembler will first search in the current directory for the requested file, and after that in each of the directories defined by the `INCDIR`/`INCPATH` directives, and the `-I`/`INCDIR` command line option.

HEADER *filename* Include source from file at the very beginning

The `HEADER` directive allows you the inclusion of external files into the program source before assembling the main source code. The loaded files must be either source or preasm files. This directive must be used before any code or data generating directive, or an error will be reported by the assembler. Note that it is still processed after the configuration file, however.

The *filename* must be in normal AmigaDOS format and must be enclosed in double or single quotes if it contains any whitespaces.

If no explicit path is given (e.g. '`DF0:...`') the assembler will first search in the current directory for the requested file, and after that in each of the directories defined by the `-I/INCDIR` command line option.

The included files have no restrictions on their content. They are read in the first pass only, but processed on all passes.

MACLIB *filename* Include preasm file

The `MACLIB` is a special variant of the `INCLUDE` directive. It allows you only the inclusion of preassembled (preasm) files into the program source.

The *filename* must be in normal AmigaDOS format and must be enclosed in double or single quotes if it contains any whitespaces.

If no explicit path is given (e.g. '`DF0:...`') the assembler will first search in the current directory for the requested file, and after that in each of the directories defined by the `INCDIR/INCPATH` directives, and the `-I/INCDIR` command line option.

The file that is to be included using the `MACLIB` directive must be a preasm file, otherwise an error will be reported.

This directive is not the only one that allows the inclusion of preasm files. Alternative directives are `INCLUDE`, `INCEQU`, and `HEADER`.

5.1.2.1 Specifying Include Directories

INCDIR *path*[,*path*[,...]] Define include search path
INCPATH *path*[,*path*[,...]]

This directives add the specified directory names to the list of directories that tell the assembler where to look for files to be included by the `INCLUDE` or `INCBIN` directives, or their synonyms. The assembler normally looks for includes in the current directory, then in the first directory in the search path, then in the second, and so on.

The `INCDIR` directive takes as its parameter a sequence of directory names separated by commas (‘`,`’). Directory names containing whitespaces or commas must be enclosed in double or single quotes.

If you find yourself frequently referring to files with the same directory name, it might be worthwhile adding a line like the following to the top of your source code:

```
INCDIR "horribly/long/directory/name"
```

This way you can refer to the files like this:

```
INCLUDE "myIncludeFile.i"
```

instead of:

```
INCLUDE "horribly/long/directory/name/myIncludeFile.i"
```

We also recommend using multiple `INCDIR` directives each with just one search path, instead of multiple comma-separated directories in one directive, to provide a better overview of the entire search path.

Example:

```
INCDIR "Include:"                    ; specify first search path,
INCDIR "asm:myInclude/"              ; specify another search path

INCLUDE "exec/memory.i"              ; Definitions used by the
INCLUDE "intuition/intuition.i"      ; operating system.
INCLUDE "project1/myDefinitions.i"   ; Definitions for my project
```

5.2 Macros

Identical of similar instruction sequences may often be repeated in different place in a program. Writing a sequence of instructions repeatedly can be tedious if the sequence is long or must be used many times.

A macro is a shorthand notation for something else. That "something else" may be much longer than the macro name itself, difficult to type, or it can be made more readable by using a macro for it.

A macro can contain M68000 instructions, assembler directives, and other macro calls. Thus, macro substitution is a process of replacing the macro name by its defined substitution code, called the macro body. A macro body is not limited in its size (limited only by available memory).

The example:

```
myMacro         MACRO
                lea     \1,a0
                bsr     WriteStr        ; write string
                ENDM

                ...
                myMacro titletext
```

will be assembled to:

```
                ...
                lea     titletext,a0
                bsr     WriteStr        ; write string
```

This example illustrates the fact that everything in the macro body (including the comments you may write in the definition) replaces the macro name when the macro is invoked.

Typical uses for macros include also the definition of structure elements and structures themselves. For example you want to expand the PSTRING directive (see PSTRING, page 119) in a way that it supports strings longer than 255 characters:

```
PSTRING_        MACRO
                dc.w    \*STRLEN(\1)
                dc.b    "\1"
                EVEN
                ENDM

        ...
        PSTRING_ <Strings up to 65535 characters allowed>
        ; ⇒ DC.W 38 / DC.B "Strings up to 65535 characters allowed"
```

While defining a macro, you must take care of the two following important points:

- You can call macros within macros, but you cannot define macros in macros.
- If you want to use local symbols within a macro body, then use the '.' ('.symbol') or a double backslash ('\\'). The '\\' will be assembled to a single backslash.

```
foo     MACRO
        ...
        tst.l   d0
        beq.s   \\bar
        moveq   #0,d0
        bra.s   .out
\\bar:  ...
.out:
        ENDM
```

CAUTION: When you use macros, you should carfully document them. Macros can impair the readability of a program if they are used indiscriminately and unnecessarily. This can make it extremely difficult to understand and to follow the program logic.

symbol **MACRO** Begin macro definition
ENDM End macro definition
ENDMAC

The block of code between the `MACRO` and the matching `ENDM` directive is the contents of the macro, called the macro body, and may contain parameters. The provided `symbol` is used as macro name. When the assembler finds the macro name in the opcode field of the source code, the contents of the macro is expanded and inserted into the source code at the point of the macro name. Together with the macro name in the opcode field, you may supply any number of arguments in the operand field.

Arguments supplied in the operand field must be separated by commas. If an argument contains whitespaces or a comma then the argument should be enclosed in a matching set of angle brackets ('`<`' and '`>`').

Consider the following example:

```
foo   MACRO
      DC.B     "\1","\2"
      ENDM

      foo      Argument1,Argument2 ; ⇒ DC.B "Argument1","Argument2"
      foo      <A,B,C>,<D,E,F>     ; ⇒ DC.B "A,B,C","D,E,F"
      foo      <Hello World>,!     ; ⇒ DC.B "Hello World","!"
```

See Section 5.2.1 *Symbols and Keywords for Macros*, page 54, for more information about macro arguments and macro directives.

MEXIT Exit from macro

This directive can be used to terminate the current macro call prematurely (as thought there were no more source code in the macro body). Usually this directive is used in association with a conditional directive. This allows you to have more control over a macro:

```
foo     MACRO
        move.l  \1,d0
        IFEQ    NARG-1              ; just one argument given?
                MEXIT               ; ⇒ exit macro.
        ENDC
        move.\0 \2,d1
```

5.2.1 Symbols and Keywords for Macro Definitions

This section describes a number of special symbols and keywords which can be used within macro definitions to build more powerful macros.

Keywords start with a backslash character ('\') and can be used *anywhere* in a line, even embedded within a symbol name, while special symbols such as `NARG` can only be used where ordinary symbols could be used. The `\*S(`*symbol*`)` keyword can be used to embed special (or even ordinary) symbols anywhere in the source text; see Section 5.2.1 *Substituting textual symbols in symbol names*, page 58, for more information.

\\n — Argument n to macro
\\(n)

Macro invocations can take parameters just like M68000 instructions and assembler directives. A symbol consisting of a backslash and a number greater than zero is substituted with the nth argument to the macro. For example, the following macro generates a synonym for the '`moveq #0,`*reg*' instruction:

```
clrd    MACRO
        moveq   #0,\1
        ENDM
```

After this macro is defined, you can use, for example, '`clrd d0`' instead of '`moveq #0,d0`'.

With the `\`n form, n can be a single digit from '`1`' to '`9`' to indicate one of the first nine parameters, or a lowercase letter from '`a`' to '`z`' to indicate parameters 10–35, respectively. With the `\(`n`)` form, n can be any number or constant numeric expression (e.g. `\(16+i)`, `\(34)`, ...).

Macro arguments are *textually substituted* before they are evaluated, so be careful of possible side-effects. For example, this code sequence does not have the result that was probably intended:

```
times2  MACRO
        moveq   #\1*2,d0
        ENDM

        times2  2+4             ; ⇒ moveq #10,d0
```

This is because the text '`2+4`' is substituted for '`\1`' *before* the expression is evaluated. The expression that actually gets evaluated is '`2+4*2`', which ends up as 10 because of arithmetic precedence rules.

To avoid situations like this, you may want to surround any `\`n symbols used in arithmetic expressions with parentheses. For example, the above piece of code could be fixed like this:

```
times2  MACRO
        moveq   #(\1)*2,d0
        ENDM
```

```
        times2  2+4             ; ⇒ moveq #12,d0
```

You can take advantage of textual substitution to dynamically construct symbol names within a macro. For example, the following macro, when invoked with part of a symbol name as a parameter, defines three new symbols with names based on the one supplied:

```
one_two_three   MACRO
\1_plus_one     EQU     (\1)+1
\1_plus_two     EQU     (\1)+2
\1_plus_three   EQU     (\1)+3
                ENDM
```

\0 Size tag used to invoke macro

This symbol is replaced by the single-letter size tag used on the macro invocation. If the macro is invoked without any size specifier, word size ('.w') is assumed.

For example, this macro definition clears a byte, word, or longword at a0, and post-increments a0 appropriately:

```
stuff0  MACRO
        clr.\0  (a0)+
        ENDM

        stuff0.b        ; stuff a byte with 0
        stuff0.w        ; stuff a word with 0
        stuff0          ; (same as above)
        stuff0.l        ; stuff a longword with 0
```

\# Unique number

\@ Unique number prefixed with '_'

These symbols are replaced with some arbitrary number which is guaranteed to be unique for every macro invocation. The **\@** form prefixes the number with an underscore, while the **\#** form generates the number alone.

These symbols are generally used to generate unique labels within macros that can be used many times. For example, this macro stores the value in d0 into 'somewhere', but only if d0 is not zero:

```
foo     MACRO
        tst.l   d0
        beq.b   lab
        move.l  d0,somewhere
lab:
        ENDM
```

Unfortunately, this macro can be used only once—if you try to use it more than once, ProAsm will generate a '`Symbol defined twice`' error, because `lab` gets defined once in each macro invocation. This can be fixed by changing the code to look like this:

```
foo     MACRO
        tst.l   d0
        beq.b   lab\@
        move.l  d0,somewhere
lab\@:
        ENDM
```

In this case, each time the macro is invoked, a new symbol of the form '`lab_`*n*' is generated, so multiple invocations of the macro do not conflict with each other.

Unfortunately, this macro definition still is not perfect. It will cause problems if it is used in code that defines local symbols, as in the following fragment:

```
        tst.l   d1
        bne.b   .nearby
        foo
.nearby
```

In this example, the global label generated in the invocation of `foo` will "chop" all local labels at that point, and ProAsm will generate an '`Undefined symbol`' error. The macro can be fixed once and for all by making its internal symbol local, like this:

```
foo     MACRO
        tst.l   d0
        beq.b   .lab\@
        move.l  d0,somewhere
.lab\@:
        ENDM
```

VAL(expression***)** Value of *expression* as decimal text
VALOF(expression***)**
V(expression***)**
D(expression***)**
HEX(expression***)** Value of *expression* as hexadecimal text
HEXOF(expression***)**
H(expression***)**
BIN(expression***)** Value of *expression* as binary text
BINOF(expression***)**
B(expression***)**
OCT(expression***)** Value of *expression* as octal text
OCTOF(expression***)**
O(expression***)**

When ProAsm sees one of these symbols, it first calculates *expression*, which must evaluate to a numeric constant, and then it textually substitutes the computed value of that expression in place of the original symbol. The `\*D(`*expression*`)` and `\*V...(`*expression*`)` forms substitute the number in decimal, the `\*H...(`*expression*`)` forms substitute the value in hexadecimal, the `\*B...(`*expression*`)` forms in binary, and the `\*O...(`*expression*`)` forms in octal.

For example, the following macro can be used to automatically generate a linked list:

```
counter SET     1                       ; Initial value

defnode MACRO
node_\*D(counter):                      ; This node's label
        DC.L    node_\*D(counter+1)     ; Pointer to next node
counter SET     counter+1               ; Bump node counter
        ENDM
```

Each invocation of `defnode` will then define a new node in a linked list, with the first longword containing a pointer to the next node.

STRING(textual symbol***)** Text contained in *textual symbol*
S(textual symbol***)**

This keyword allows textual symbols such as those defined by the `EQUR` directive (see `EQUR`, page 73) to be used in places where such a symbol could not normally be used; for example, as part of a symbol name. ProAsm first expands the *textual symbol*, then substitutes it directly into the source code.

Example:

```
foo             EQUR    bar

bar_one         EQU     1
bar_two         EQU     2

                DC.B    \*S(foo)_one,\*S(foo)_two      ; 1, 2
```

***STRLEN(*string*)** Decimal value of string length

When ProAsm encounters this macro directive, it first evaluates the length of the given *string*, and then it textually substitutes the decimal value of resulting string length in place of the original macro directive.

For example, the following macro can be used to automatically generate a linked list of given strings:

```
counter SET     1                       ; Initial value

defstring MACRO
node_\*D(counter):                      ; This node's label
        DC.L    node_\*D(counter+1)     ; Pointer to next node
counter SET     counter+1               ; Bump node counter

        DC.B    \*STRLEN(\1)            ; insert string length
        DC.B    '\1'                    ; insert given string
        EVEN
        ENDM


        defstring Count
        defstring Zero
```

***LEFT(*string*,*expr*)** Specified number of characters from left
***L(*string*,*expr*)**
***RIGHT(*string*,*expr*)** Specified number of characters from right
***R(*string*,*expr*)**

These macro directives determine the substring out of the given *string* argument. *Expr* specifies the number of characters that are taken from left (`\*LEFT()`) or from right (`\*RIGHT()`) respectively of *string* as substring. *Expr* is taken as unsigned value, and zero will be similar to an empty string.

Is *string* shorter than the requested length for the substring, the complete *string* is taken.

The substring then is textually substituted in place of the original macro directive.

Consider the following example:

```
foo     MACRO
        DC.B    "\*LEFT(\1,\2)","\*RIGHT(\1,\2)"
        ENDM

        foo     ABCDEF,2
        ; ⇒ DC.B "AB","EF"
        foo     ABCDEF,4
        ; ⇒ DC.B "ABCD","CDEF"
        foo     ABCDEF,6
        ; ⇒ DC.B "ABCDEF","ABCDEF"
        foo     ABCDEF,8
        ; ⇒ DC.B "ABCDEF","ABCDEF"
```

MID(string*,*n*,*m***)** Specified number of characters, starting at position n
M(string*,*n*,*m***)**

This macro directive textually substitutes the substring, defined by the given arguments, in place of the macro directive.

This substring is ascertained by *m* characters starting at position *n*. If there are less than *m* characters left to the right of position *n*, the remainder of the *string* is taken as substring.

The expressions *n* and *m* are taken as unsigned values, and at least one expression resulting in zero will produce an empty substring.

For example:

```
        ...
        DC.B    "\*MID(ABCDEF,3,2)"
        ; ⇒ DC.B "CD"
        DC.B    "\*MID(ABCDEF,4,8)"
        ; ⇒ DC.B "DEF"
        ...
```

***UPPER(*string*)** *string* converted to uppercase
***LOWER(*string*)** *string* converted to lowercase

These macro directives allow *strings* to be converted in upper or lowercase, and then the converted strings are textually substituted in place of the original macro directive.

For example, the following macro can be used to generate a list with zero terminated upercased strings:

```
Upper_  MACRO
        dc.b    "\*UPPER(\1)",0
        ENDM

        Upper_  Appleseed       ; ⇒ dc.b "APPLESEED",0
        Upper_  Rumpelstiltskin ; ⇒ dc.b "RUMPELSTILTSKIN",0
        Upper_  Orion           ; ⇒ dc.b "ORION",0
```

5.3 Conditional Assembly

The purpose of conditional assembly directives is to determine whether a section of source code is to be assembled or not.

These directives commonly are used in include files containing symbol and macro definitions to determine if the file has already been included.

This mechanism works like this (the example is taken from the Commodore '`exec/types.i`' include file):

```
IFND EXEC_TYPES_I
EXEC_TYPES_I SET 1

... ; definition body

ENDC ; EXEC_TYPES_I
```

But what does this code fragment? This code fragment first checks if the symbol `EXEC_TYPES_I` has already been defined. If it has been defined, the whole part between the `IFND` and the `ENDC` directive will be skipped by the assembler. The other way round if the symbol has not been defined, the next line defines the symbol and the definition body gets assembled. The `ENDC` directive informs the assembler that this conditional directive is completed.

This construction prevents multiple definitions of the include file body, while enabling you to include '`exec/types.i`' wherever and whenever you feel you have to.

All the following described conditional directives have two things in common: they all end with an `ENDC` directive (or by its synonym), and they all control the inclusion or exclusion of one or more groups of code lines. Conditional assembly directives may be nested up to 2147483647 ($= 2^{31-1}$) times.

IFD *symbol* Assemble if symbol defined
IFND *symbol* Assemble if symbol not defined

Depending on whether or not the symbol in question has been defined, the assembler will include or exclude the source code lines until a matching `ENDC` or `ELSE` directive is found.

Symbol may relate to a symbol of any type.

Consider the following example:

```
IFND DefaultValue
DefaultValue EQU 10
ENDC
```

IFEQ *expression* Assemble code if expression is equal to zero
IFNE *expression* Assemble code if expression is not equal to zero
IF *expression* Assemble code if expression is not equal to zero
IFGE *expr.* Assemble code if expression is greater than or equal to zero
IFGT *expression* Assemble code if expression is greater than zero
IFHI *expression* Assemble code if expression is higher than zero
IFLE *expression* Assemble code if expression is less than or equal to zero
IFLS *expression* Assemble code if expression is lower or same as zero
IFLT *expression* Assemble code if expression is less than zero
IFMI *expression* Assemble code if expression is minus
IFPL *expression* Assemble code if expression is plus

The *expression* is evaluated and its result is used to determine whether or not the following code lines will be assembled (up until an `ENDC` or `ELSE`).

For example:

```
IFD SymbolA      ; SymbolA defined?
IFMI SymbolA      ; if so, check if its value is negative.
neg.l d0           ; if TRUE, add this code line.
ENDC
ENDC
```

Even more fancy *expressions* are possible:

```
IFNE    (Counter1<>0)&(FlagB) ; IFNE = "IF TRUE"
...
ENDC
```

IFEQ *e,e* Assemble code depending on the comparison of both expression
IFNE *expression,expression*
IF *expression,expression*
IFCC *expression,expression*
IFHS *expression,expression*
IFCS *expression,expression*
IFLO *expression,expression*
IFGE *expression,expression*
IFGT *expression,expression*
IFHI *expression,expression*
IFLE *expression,expression*
IFLS *expression,expression*
IFLT *expression,expression*
IFMI *expression,expression*
IFPL *expression,expression*
IFVC *expression,expression*
IFVS *expression,expression*

Both *expressions* are evaluated and the comparison of their results is used to determine whether or not the following code lines will be assembled (up until an `ENDC` or `ELSE`).

Both *expressions* are compared before the condition is checked. If the comparison of the *expressions* is not true according to the defined condition, assembly is disabled.

Example:

```
IFLE foo,bar
PRINTX 'bar' is less or equal than 'foo'
ENDC
```

The tests for the conditions are equal to the ones for the conditional branch instructions of the M680x0 family:

`CC`	carry clear
`CS`	carry set
`EQ`	equal
`GE`	greater or equal
`GT`	greater than
`HI`	higher
`HS`	carry clear (synonym to `CC`)
`LE`	less or equal
`LO`	carry set (synonym to `CS`)
`LS`	lower or same
`LT`	less than
`MI`	minus
`NE`	not equal
`PL`	plus
`VC`	overflow clear
`VS`	overflow set

Note that `IF` is an abridgement for `IFNE`.

IFC *string,string* Assemble code if strings are the same
IFNC *string,string* Assemble code if strings are not the same

These directives compare the two given *strings*. Depending on whether or not the *strings* are identical, the assembler will include or exclude the source code lines until a matching `ENDC` or `ELSE` directive is found.

If a *string* contains any whitespaces or comma then it must be enclosed within single or double quotes.

Note that the *strings* are compared case dependently.

These directives are often used within macro bodies to check the validity of a macro parameter, as shown in the following example:

```
MyMacro MACRO
IFC '','\1' ; first is a null string
FAIL *** MyMacro: no parameter given!
ENDC
...
ENDM
```

IF1 Assemble code if within the first pass
IF2 Assemble code if within the last pass

These directives can be used to let the assembler do certain operations only in the first or last pass of the assembly.

For example:

```
IF1
SymbolA EQU 1
SymbolB EQU 12
ENDC

IF2
PRINTX *** Pass 2 in progress...
ENDC
```

Please note: Never ever put any code within these two directives, it may cause a difference in the object code size produced between the passes!

IFU *macro* Assemble code if macro is used
IFNU *macro* Assemble code if macro is not used

These directives can be used to determine whether the macro in question has been used until now, the assembler will include or exclude the source code lines till a matching `ENDC` or `ELSE` directive is found.

For example:

```
MyMacro MACRO
...
ENDM

...
```

```
IFU MyMacro
INCLUDE "MyMacro_Routines.s" ; include additional routines
ENDC                         ; used by the MyMacro macro.
```

ELSE Toggle assembly condition
ELSEIF

These directives reverse the condition whether the code is assembled or not from the last `IF` condition. The `ELSE/ELSEIF` directive matches the most recent `IF` directive.

Consider the following example:

```
IFEQ number
PRINTX 'number' is zero.
ELSE
PRINTX 'number' is not zero.
ENDC
```

ELSEIF *expression* Toggle assembly condition and check expression

The use of the `ELSEIF` directive together with an *expression* is an extension to the standard `ELSE/ELSEIF` directive.

The `ELSEIF` *expression* statement is an abbreviation for

```
ELSE
IFNE    expression
```

It reverses whether the code is assembled or not from the last `IF` condition. If the toggles to `TRUE` (the previous condition was `FALSE`) and the *expression* is unequal to zero the assembler will include the source code lines until a matching `ENDC` or `ELSE` directive is found.

For example:

```
IFND    bar
PRINTX  *** bar not defined!
ELSEIF  bar
add.l   #bar,d0              ; this line is only assembled if the
ENDC                         ; symbol bar is defined and not zero.
```

ENDC Terminate conditional assembly
ENDIF

Returns the assembly status to what it was before the last `IF` condition. An `ENDC/ENDIF` directive is required for each `IF` directive. It matches the most recent `IF` directive.

IIF *expression instruction* Immediate IFNE

This is the immediate form of the `IFNE` directive and it is only effective on *instruction*. Neither the `ENDC` nor the `ELSE` can be used together with this directive.

`IIF` enables the assembly of *instruction* if the result of the given *expression* is unequal to zero.

For example:

```
IIF foo PRINTX *** foo is unequal to zero.
```

The preceding example is similar to the following:

```
IFNE foo
PRINTX *** foo is unequal to zero.
ENDC
```

ENDASM Break assembly
ASM Continue assembly

The `ENDASM` and `ASM` directives are a special form of conditional assembly directives. They can be used to explicitly exclude the source code lines between the `ENDASM` and the next `ASM` directive.

```
...
ENDASM
; this source code line will not be assembled.
ASM
...
```

A similar construction can be obtained by using one of the standard conditional directives, for example:

```
...
IFEQ 1
; these source code lines will not be assembled,
```

```
; since the condition of the IF directive
; is always FALSE.
ENDC
...
```

This can be useful if you want to have old code fragments to be included in the source code but not being assembled, for example as comment or for archive reasons.

These directives can not be nested.

5.4 Repeating Text

Frequently the same sequence of instructions has to be repeated several times in the same source file, for example if you are generating data tables or some kind of routine that consists of similar parts. To make it easier to define repeated sections of code or data, ProAsm features two kinds of repeat loops: the `REPT - ENDR` loop and the `REPEAT - UNTIL`*cc* loop. The assembler will repeat the block between the repeat loop introducer and the matching repeat terminator. After assembling this block the repeat condition will be checked and then the assembly will be recommenced at the beginning of the repeat or the repeat will be terminated.

REPT *expression* Begin repeat loop
ENDR End repeat loop

The block of code between the `REPT` and the matching `ENDR` directive will be repeated *expression* number of times. If *expression* evaluates to zero the assembler will skip the instructions within this loop.

Example:

```
REPT 4
move.l d0,(a0)+
ENDR
; the statement above is the same as the lines below
move.l d0,(a0)+
move.l d0,(a0)+
move.l d0,(a0)+
move.l d0,(a0)+
```

REPEAT Begin repeat loop

UNTIL*cc* *expression*[,*expression*] End repeat loop

The block of code between the `REPEAT` and the matching `UNTIL`*cc* directive will be repeated as long as the result of the *expression* satisfies the condition *cc*.

The `UNTIL`*cc* directive marks the end of the repeat loop and has two or three parameters: a condition and one or two expressions. The given *expression* is evaluated and according to the *cc* condition the loop is recommenced or terminated. If two *expressions* are given the results of both *expressions* are compared before the condition is checked. The *cc* may specify the following conditions:

`CC`	carry clear
`CS`	carry set
`EQ`	equal
`GE`	greater or equal
`GT`	greater than
`HI`	higher
`LE`	less or equal
`LS`	lower or same
`LT`	less than
`MI`	minus
`NE`	not equal
`PL`	plus
`VC`	overflow clear
`VS`	overflow set

The advantage of this loop is that the *expressions* may involve variables that are undefined when the repetition started. For example, a counting loop may be expressed as:

```
i       EQU     0
REPEAT
...
i       SET     i+1      ; increment the loop counter
UNTILEQ  j,n             ; process loop n times
```

The termination condition is checked each time *after* the source sequence within the loop. As a consequence, the sequence is assembled at least once. The `REPEAT` loop introduces the danger of a nonterminating loop. Evidently, such loops must be used with care. Consider, for example:

```
REPEAT
i       EQU     i-2
UNTILEQ i
```

It is easy to realize that the above loop only terminates if *i* is higher than zero and even (divisible by two).

Since ProAsm supports also comparison operators within an expression, `UNTIL`*cc* directives with two given arguments may be reduced into a more obvious statement:

```
UNTILLE   i,n
; can be reduced to
UNTILEQ   i<=n
```

See Section 4.2.3 *Operators*, page 30, for more information about the comparison operators.

REXIT Exit from a repeat loop

This directive can be used to terminate the current repeat loop prematurely. Usually this directive is used in association with a conditional directive. This allows you to have more control over a repeat loop:

```
REPT -1              ; loop forever!
IFNE  i>=n
   REXIT             ; ...except we can break out here
ENDC
; ...
i SET i+1
ENDR
```

This is a quite similar to a `REPEAT-UNTIL`*cc* construct, except that this loop will terminate immediately if *i* is already greater or equal to *n* before the repeat loop started. The block of code within a `REPEAT-UNTIL`*cc* loop will be assembled at least once.

A counting loop may be expanded as:

```
        i EQU 0
        REPEAT
        ...
        i SET i+1
        UNTILEQ j=n
; or
        REPT n
        ...
        ENDR
```

5.5 Defining Symbols

5.5.1 Equates

symbol **EQU** *expression* Define numeric symbol
symbol **EQUATE** *expression*
symbol = *expression*
symbol == *expression*
DEFINE *symbol* = *expression*

Equates *symbol* to the value of the result of *expression*. The *expression* is calculated immediately, and must resolve to a numeric constant or a relocatable address. *symbol* can then be used in place of the value of *expression*. The *symbol* may be a forward reference to a symbol defined later in the program, subject to the rules explained in Section 4.2.5 *Forward References to Numeric and Textual Symbols*, page 32.

symbol **SET** *expression* Define numeric symbol
symbol **SETVAL** *expression*

These directives assign the result of *expression* to the *symbol*. The *expression* is calculated immediately, and must resolve to a numeric constant or a relocatable address. *symbol* can then be used in place of the value of *expression*. These directives are identical to the `EQU` directives, with the exception that the assignment is temporary and the *symbol* may be redefined. You can always change the value of a numeric *symbol* later in the program.

The *symbol* may be a forward reference to a symbol defined later in the program, subject to the rules explained in Section 4.2.5 *Forward References to Numeric and Textual Symbols*, page 32.

Consider the following example:

```
foo SET 1994
move.l #foo,d0
foo SET 1995
move.l #foo,d1

will be assembled to:

move.l #1994,d0
move.l #1995,d0
```

symbol **FEQU** *expression* Define numeric floating-point symbol

Equates *symbol* to the floating-point value of the result of *expression*. The *expression* is calculated immediately, and must consist of valid floating-point numbers and resolve to a numeric floating-point constant. *symbol* can then be used in place of the value of *expression*.

The *symbol* may be a forward reference to a symbol defined later in the program, subject to the rules explained in Section 4.2.5 *Forward References to Numeric and Textual Symbols*, page 32.

Example:

```
pi      FEQU    3.14159265359
        ...
        fmove.d #pi,fp0
```

symbol **FSET** *expression* Define numeric floating-point symbol

Equates *symbol* to the floating-point value of the result of *expression*. The *expression* is calculated immediately, and must consist of valid floating-point numbers and resolve to a numeric floating-point constant. *symbol* can then be used in place of the value of *expression*. This directive is identical to the `FEQU` directive, with the exception that the assignment is temporary and the *symbol* may be redefined. You can always change the value of a numeric floating-point *symbol* later in the program by using `FSET`.

The *symbol* may be a forward reference to a symbol defined later in the program, subject to the rules explained in Section 4.2.5 *Forward References to Numeric and Textual Symbols*, page 32.

Example:

```
foo     FSET    3.14159265359
        fmove.d #foo,fp0
foo     FSET    2.71828182845
        fmove.x #foo,fp1

will be assembled to:

fmove.d #3.14159265359,fp0
fmove.x #2.71828182845,fp1
```

symbol **EQUR** *text* — Define textual symbol
symbol **EQUR** <*text*>
symbol **EQUSTR** *text*
symbol **EQUSTR** <*text*>
symbol **FEQUR** *text*
symbol **FEQUR** <*text*>

Attaches *text* to *symbol*, without actually evaluating or interpreting the text in any way. When *symbol* is used in an operand field somewhere else in the program, it is substituted with *text* before the operands are otherwise evaluated. The second form (‘<*text*>’) allows you to include commas, semicolons, or whitespace in the *text*.

The `EQUR` directive is historically meant specifically as an `EQU`-like directive which applies to M68000 registers, or register lists for `movem` instructions, instead of numeric values. Hence the name: “EQUate Register.” (`FEQU`, as you may guess, was the same for floating-point registers).

For example, this code will push all the data registers onto the stack:

```
dregs   EQUR    d0-d7
        movem.l dregs,-(sp)
```

ProAsm extends the historical definition of `EQUR` to allow you to define a symbol to be equal to *any* piece of text.[1] For example, this code fragment will work under ProAsm:

```
msg     EQUR    "Hello world"
        DC.B    msg
```

[1] C programmers will notice that this directive is similar to the `#define` directive of the C preprocessor.

```
will be assembled to:

        DC.B    "Hello world"
```

If you want to include commas, semicolons, or whitespace in the `EQUR` replacement text, you must surround the entire text string with angle brackets, like this:

```
foo     EQUR    <d0,d1>
        move.l  foo                ; ⇒ move d0 to d1
```

See Section 4.2.4 *Textual Symbols*, page 31, for more information on how textual symbols defined by `EQUR` are expanded by ProAsm.

symbol **SETR** *text* — Define textual symbol
symbol **SETR** <*text*>
symbol **SETSTR** *text*
symbol **SETSTR** <*text*>
symbol **FSETR** *text*
symbol **FSETR** <*text*>

Attaches *text* to *symbol*, without actually evaluating or interpreting the text in any way. When *symbol* is used in an operand field somewhere else in the program, it is substituted with *text* before the operands are otherwise evaluated. The second form ('<*text*>') allows you to include commas, semicolons, or whitespace in the *text*.

These directives are identical to the `EQUR` directive (see `EQUR`, page 73), with the exception that the assignment is temporary and the *symbol* may be redefined. You can always change the *text* of a textual *symbol* later in the program by using one of these directives.

The `EQUR` and `SETR` directives allow you to define a symbol to be equal to *any* piece of text. For example, this code fragment will work under ProAsm:

```
msg     EQUR    "Hello world"
        DC.B    msg
msg     SETR    "Hello again"
        DC.B    msg

will be assembled to:

        DC.B    "Hello world"
        DC.B    "Hello again"
```

If you want to include commas, semicolons, or whitespace in the SETR replacement text, you must surround the entire text string with angle brackets, like this:

```
foo     SETR    <d0,d1>
        move.l  foo             ; ⇒ move d0 to d1
```

See Section 4.2.4 *Textual Symbols*, page 31, for more information on how textual symbols defined by EQUR or SETR are expanded by ProAsm.

symbol **REG** *register list* — Equate register list mask to a symbol
symbol **EQURL** *register list*

These directives assign a register list to a symbol that can be used in place of the register list for a MOVEM instruction. The format of the *register list* is the same as for the MOVEM instruction. The advantage of using it is that if you decide to change the register list, you only have to change the register list on the REG directive instead of changing every MOVEM instruction that uses it.

Example:

```
foo     REG     d0
bar     REG     d0-d3/d5-d6/a0-a6

movem.l bar,-(a7)
...
movem.l (a7)+,bar
```

This directive performs the historical function of the EQUR directive: it will *only* work with register lists, not with arbitrary text strings as EQUR does.

symbol **SETREG** *register list* — Equate register list mask to a symbol
symbol **SETRL** *register list*

These directives assign a register list to a symbol that can be used in place of the register list for a MOVEM instruction. These directives are identical to the REG directive, with the exception that the assignment is temporary and the *symbol* may be redefined. You can always change the *register list* of a register list mask *symbol* later in the program by using one of these directives.

The format of the *register list* is the same as for the MOVEM instruction.

For example:

```
foo     SETR     d0-d2/d5-d6/a0-a6

movem.l foo,-(a7)
...
movem.l (a7)+,foo

foo     SETR    d0-a6
movem.l foo,-(a7)
...
movem.l (a7)+,foo

will be assembled to:

movem.l d0-d2/d5-d6/a0-a6,-(a7)
...
movem.l (a7)+,d0-d2/d5-d6/a0-a6

movem.l d0-a6,-(a7)
...
movem.l (a7)+,d0-a6
```

symbol **FREG** *register list* Equate floating-point register list mask to a symbol

This directive assigns a floating-point register list to a symbol that can be used in place of the register list for a `FMOVEM` instruction. The format of the *register list* is the same as for the `FMOVEM` instruction. The advantage of using it is that if you decide to change the register list, you only have to change the register list on the `FREG` directive instead of changing every `FMOVEM` instruction in the source code that uses it.

The `FREG` directive can be used for both, the floating-point data and the floating-point control registers.

Example:

```
foo     FREG     fp0
bar     FREG     fp0-fp3/fp5-fp6    ; floating-point data registers
abcd FREG   fpcr/fpsr/fpiar    ; floating-point control register

fmovem.x bar,-(a7)
fmovem.l abcd,-(a7)
...
fmovem.l (a7)+,abcd
fmovem.x (a7)+,bar
```

This directive performs the historical function of the `FEQUR` directive: it will *only* work with register lists, not with arbitrary text strings as `FEQUR` does.

symbol **FSETRL** *register list* Equate floating-point register list mask to a symbol

This directive assigns a floating-point register list to a symbol that can be used in place of the register list for a `FMOVEM` instruction. The format of the *register list* is the same as for the `FMOVEM` instruction. This directive is identical to the `FREG` directive, with the exception that the assignment is temporary and the *symbol* may be redefined. You can always change the *register list* of a register list mask *symbol* later in the program by using one of these directives.

The `FSETRL` directive can be used for both, the floating-point data and the floating-point control registers.

Example:

```
foo     FSETRL  fp0-fp3/fp5-fp6  ; floating-point data registers

fmovem  foo,-(a7)
...
fmovem  (a7)+,foo

foo     FSETRL  fp0-fp6          ; floating-point data registers

fmovem  foo,-(a7)
...
fmovem  (a7)+,foo

will be assembled to:

fmovem  fp0-fp3/fp5-fp6,-(a7)
...
fmovem  (a7)+,fp0-fp3/fp5-fp6

fmovem  fp0-fp6,-(a7)
...
fmovem  (a7)+,fp0-fp6
```

5.5.2 Structure Offsets

Highlevel languages usually have language elements to declare a structure:

C/C++ 'struct'

Pascal/Modula/Oberon
'RECORD'

...

Structures in highlevel languages are declarations of a collection of elements as a unit, even if the elements are of different types (heterogeneous structures). The origin of this data structures lies in commercial data processing.[2]

Accessing and defining structures in assembler can demand great toil and effort. A structure as used in the assembly language is a collection of symbols which represent an offset in that structure. To access an element of a structure in assembly language, you typically use the "Address Register Indirect with Displacement" addressing mode or one if its variations (see Section 4.4 *Addressing Modes*, page 36), with the address of the beginning of the structure in the address register and the offset of the element you want to access as the displacement. For example, to load the element named `LN_TYPE` from a structure pointed to by address register `A2`, you could use the instruction '`move.b (LN_TYPE,a2),d0`'.

Accessing structures from assembly language is not difficult; what can be a pain is figuring out the offset of each element and declaring a symbol for it. That's what the assembler directives described in this section are useful for.

You can declare structures in several ways. The most common methods are shown below as examples. The '`List Node Structure`' from the '`exec/nodes.i`' include file from Commodore is taken as a base for the examples.

The simplest, most straightforward way to declare a structure is by using the `EQU` directive.

```
LN_SUCC EQU     0
LN_PRED EQU     4
LN_TYPE EQU     8
LN_PRI  EQU     9
LN_NAME EQU     10
LN_SIZE EQU     14
```

However, this method requires careful computing of the offset of each element based on the size and offset of the preceding element. Also, it provides no easy way to insert or change the size of

[2] Programming language COBOL.

an element: for example, if a new element is to be inserted at the beginning of a long structure, all of the elements following the new one have to be corrected by hand.

Another technique of declaring structures is by using macros as (for example) defined in the 'exec/types.i' include file of Commodore.

```
        ...
BYTE    MACRO
\1      EQU     SOFFSET
SOFFSET SET SOFFSET+1
        ENDM

WORD    MACRO
\1      EQU SOFFSET
SOFFSET SET SOFFSET+2
        ENDM
        ...
```

More data storage macros can be found in the 'exec/types.i' include file from Commodore.

The advantages of using these macros is that the defined structures can be ported very easily to other languages such as C/C++, and that the type of an element can be seen clearly from its declaration in the source code.

```
        STRUCTURE  LN,0
          APTR     LN_SUCC
          APTR     LN_PRED
          UBYTE    LN_TYPE
          BYTE     LN_PRI
          APTR     LN_NAME
          LABEL    LN_SIZE
```

A disadvantage of using macros to define structures is that macros are textual replacements and therefore it assembles more slowly than the first and the following method.

The easiest method of declaring structures is using the structure offset directives that are described later:

```
        RSRESET
LN_SUCC RS.L    1
LN_PRED RS.L    1
LN_TYPE RS.B    1
LN_PRI  RS.B    1
LN_NAME RS.L    1
```

```
LN_SIZE RSVAL
```

Using these directives, elements can be inserted, removed, or changed with hardly any effort at all.

To make it easier to declare data structures, ProAsm features two different kinds of structure offset directives. These directives do not directly affect your code or data space at all; they only define symbols for use in other parts of the program.

Each of the structure offset counters (`__RS`, `__SO`, and `__FO`) is a special symbol and can only be affected by its directives (see `__RS`, page 171).

[*symbol*] **RS.***size expression*
[*symbol*] **SO.***size expression*

These directives will assign the current value of the structure offset counter symbols (`__RS` and `__SO`, respectively) to the specified *symbol*, and then increment the counter according to *size* and *expression*. The *expression* is the number of data items of the size *size* the assembler reserves space for; in this way the structure offset directives work much like the `DS` directive. The *symbol* does not have to be specified; if it is omitted, then the directive only increments the structure offset counter.

The *size* specifier must be one of the following:

`B` byte (8 bit),	`W` word (16 bit),
`L` long word (32 bit),	`S` single precision (32 bit),
`D` double precision (64 bit),	`X` extended precision (96 bit),
`P` packed decimal (96 bit),	`Q` quad word (64 bit)

Example:

```
                RSRESET
pa_next         RS.L 1
pa_registers    RS.L 16
pa_fpuregisters RS.X 16
pa_SIZEOF       RSVAL
```

Note that the `RS` and `SO` directives work exactly the same way, but they use different and independent structure offset counters. Therefore, you can use either directive to define a structure and get the same results, but in the definition of one particular structure you have to be consistent in which set of directives you use (either just `RS` or just `SO`).

[*symbol*] **FO.***size expression*

This directive will decrement the frame offset counter according to *size* and *expression* and then assign its value to the optionally given *symbol*. It can be used to define a list of offset for a stack frame data structure (e.g. for the `link` instruction). In other respects it works just like the `RS` and `SO` directives.

For example, suppose you define a stack frame data structure this way:

```
            CLRFO            ; ⇒ 0
fx_Pred     FO.L     1       ; ⇒ -4
fx_Succ     FO.L     1       ; ⇒ -8
fx_Flags    FO.B     1       ; ⇒ -9
fx_pad      ALIGNFO.W        ; ⇒ -10
fx_SIZEOF   FOVAL            ; ⇒ -10
```

Within the source code you could use this stack frame definition as shown in the following code fragment:

```
link     a5,#fx_SIZEOF      ; allocate 10 bytes on the stack
movem.l  d0/d1,fx_Pred(a5)  ; store fx_Pred and fx_Succ
move.b   #$80,fx_Flags(a5)
...
move.l   fx_Pred(a5),a0
...
unlk     a5                 ; unlink
```

RSRESET Clear offset counter `__RS`
CLRSO Clear offset counter `__SO`
CLRFO Clear offset counter `__FO`

These directives clear their associated structure offset counters to zero. They are typically used at the beginning of a new structure definition.

RSRESET
is equal to `RSSET 0`

CLRSO equals to `SETSO 0`

CLRFO is equal to `SETFO 0`

[*symbol*] **RSSET** *expression* Set offset counter `__RS`
[*symbol*] **SETSO** *expression* Set offset counter `__SO`
[*symbol*] **SETFO** *expression* Set offset counter `__FO`

These directives can be used to set the corresponding offset counters to a specific desired value (*expression*).

An optionally given *symbol* will be set to zero.

Consider the following example:

```
MH            RSSET   LN_SIZE   ; sets initial counter value to LN_SIZE
MH_ATTRIBUTES RS.W    1
MH_FIRST      RS.L    1
MH_LOWER      RS.L    1
MH_UPPER      RS.L    1
MH_FREE       RS.L    1
MH_SIZE       RSVAL
```

This defines the `MH` structure as an *extension* of the `LN` structure, by starting its structure offset counter at `LN_SIZE` instead of zero.

The preceding structure is actually the '`Memory Region Header`', defined in the '`exec/memory.i`' Commodore include file:

```
        STRUCTURE    MH,LN_SIZE
              UWORD  MH_ATTRIBUTES
              APTR   MH_FIRST
              APTR   MH_LOWER
              APTR   MH_UPPER
              ULONG  MH_FREE
              LABEL  MH_SIZE
```

symbol **RSVAL** Assign `__RS` offset value to symbol
symbol **SOVAL** Assign `__SO` offset value to symbol
symbol **FOVAL** Assign `__FO` offset value to symbol

These directives can be used to assign the current offset counter value to the given *symbol*.

RSVAL	is equal to *symbol* EQU __RS
SOVAL	equals to *symbol* EQU __SO
FOVAL	is equal to *symbol* EQU __FO

5.5.3 Case Sensitivity

By default, all symbols in ProAsm are case-sensitive: '`foo`', '`Foo`', '`FOO`', and '`FoO`' are all different symbols. However, code written for other assemblers may depend on symbols being case-insensitive, for example by making a reference '`foo`' to a symbol defined as '`Foo`'. ProAsm provides the following directives to control case sensitivity.

CASEON Make symbols case-sensitive (default)
OPT C+
OPT CASE
CASEOFF Make symbols case-insensitive
OPT C-
OPT NOCASE
OPT C*n*+ Make the first part of symbols case-sensitive
OPT C*n*- Make the last part of symbols case-sensitive

The first four forms turn case sensitivity on or off as specified. `OPT C`*n*`+` makes the first *n* characters of every symbol case sensitive, and the rest case-insensitive. `OPT C`*n*`-` does just the opposite: it makes the first *n* characters of every symbol case-insensitive, and the rest case-sensitive. *n* must be in the range of 1 to 256.

These options should only be used before any symbols are defined or an '`option must be at beginning`' error will be reported.

OPT LOCALU Use underscore character ('`_`') to indicate local labels
OPT U+
OPT LOCALDOT Use period ('`.`') to indicate local labels (default)
OPT U-

The first two forms should be used if the underscore ('`_`') rather than the dot ('`.`') should introduce a local label. This option is useful if you assemble source codes developed with other assemblers which use the underline sign to introduce a local label. The character used to introduce a local label defaults to the dot.

These options should only be used before any symbols are defined or an '`option must be at beginning`' error will be issued.

OPT U1+ Enable period (`.`) as local label introducer (default)
OPT U1- Disable period as local label introducer
OPT U2+ Enable underscore (`_`) as local label introducer
OPT U2- Disable underscore as local label introducer (default)

These options similar to the preceding options, except that they can be used to individually enable or disable each type of local label introducer, so all four combinations are possible.

5.6 Assembly Control

5.6.1 Syntax Options

RELAX Accept both new and old syntax
NEWSYNTAX Accept new syntax only
OLDSYNTAX Accept old syntax only

Normally, ProAsm accepts new M68000 syntax (e.g., '`move.l (16,a0),d0`'), and old syntax (e.g., '`move.l 16(a0),d0`'). However, you can use the `NEWSYNTAX` or `OLDSYNTAX` directives to make ProAsm accept *only* new or old syntax, respectively, and generate an '`Addressing mode not recognized`' error if it encounters the "forbidden" syntax. The `RELAX` directive returns ProAsm to its normal state where it allows both new and old syntax. See Section 4.4 *Addressing Modes*, page 36, for the exact differences between new and old syntax.

OPT CHKIMM Check absolute addresses for missing '`#`'
OPT I+
OPT NOCHKIMM Do not check absolute addresses (default)
OPT I-

When this option is turned on the assembler will report a '`probably immediate addressing mode`' error on all instructions using the absolute addressing mode as source operand, unless it is the AbsExecBase ('`4`').

This option may be very useful for detecting typing errors, since a missing pound sign ('`#`') can cause subtle, hard-to-find bugs in which an instruction reads an operand from some arbitrary location in memory when an immediate value was intended.

You may force the assembler to use absolute addresses by appending one of the absolute address size specifiers '.L' or '.W'.

Example:

```
OPT      I+
move.l   4,a6           ; no error will be reported.
move.l   123456,d0      ; immediate addressing mode
                        ; was probably meant.
move.l   $f80000.L,d0 ; no error will be reported.
```

OPT CHKPC Ensure that code is position-independent
OPT P+
OPT NOCHKPC Disable check
OPT P-

If this option is enabled the assembler reports a 'relocation not allowed' error on any instructions that require relocation. Using this option you can make sure that the produced code will be position-independent.

Note that addresses defined by the ORG directive do not produce an error since they do not require relocation.

OPT TYPE Enable type checking
OPT T+
OPT NOTYPE Disable type checking
OPT T-

These options forces the assembler to do or to omit checks for the correct use of symbols and expressions in certain addressing modes.

If type checking is enabled (OPT T+) relocatable symbols are not allowed in absolute word and address register indirect (indexed or not) addressing modes. These addressing modes require absolute values. However, sometimes type checking can be more of an obstacle than a help, so the checking can be disabled (OPT T-).

Examples:

```
; default
move.l  (foo).w,d0      ; ⇒ error
move.l  foo(a4),d7      ; ⇒ ok
```

```
            OPT     T+
            move.l  (foo).w,d0      ; ⇒ error
            move.l  foo(a4),d7      ; ⇒ error

            OPT     T-
            move.l  (foo).w,d0      ; ⇒ ok
            move.l  foo(a4),d7      ; ⇒ ok
foo:
```

By default, the assembler adopts a middle course. The type checking is done only for the absolute word addressing mode. To have the type checking completely enabled or disabled, these options have to be used.

5.6.2 Processor Options

MC68000 Select processor specific instruction set
MC68008
MC68010
MC68020
MC68030
MC68040
MC68060
MC68EC020
MC68EC030
MCRELAX Select complete instruction set of the M68000 family
MC680X0

These directives are used to specify the processor to be programmed for. They tell the assembler the instruction set to be used, valid addressing modes, and the best code optimization possibilities.

You can use `MCRELAX` or `MC680X0` to force the assembler to allow the complete instruction set of the M68000 family.

These directives do not have a negative form. By default, ProAsm is set to `MC68000`.

MC68881 Select allowed coprocessor
MC68882
MC68851

These directives tell the assembler what coprocessor you want to program for to allow their instruction set.

To decline a selected coprocessor you can use the `OPT P=-`*coprocessor* option (see `OPT P=`, page 87).

The following example specifies the MC68020 processor together with the MC68882 FPU and MC68851 MMU coprocessors:

```
MC68020              ; only the 68020 instruction set
MC68882              ; plus the 68882 FPU
MC68851              ; and the 68851 MMU instruction set
...
OPT       p=-68851   ; disables the MC68851 instructions
```

OPT P=[-][*processor*][*coprocessor*] Select processor specific instruction set

This option can be used to specify the processor and coprocessor to be programmed for. It tells the assembler the instruction set to be used, valid addressing modes, and the best code optimization possibilities.

The optional given *processor* argument must be one of the following:

`68000`

`68010`

`68020`

`68030`

`68040`

`68060`

`68EC030`

`68EC020`

Valid *coprocessor* arguments are:

```
68881
68882
68851
```

A list of *coprocessors* can be selected just by separating them using a forward slash ('/'):

```
        OPT     P=68882/68851
```

If more than one *processor* is selected, the last one is taken into account:

```
        OPT     P=68020/68040          ; ⇒ MC68040 processor selected
```

The advantage of this option is that you have the possibility to unselect *coprocessors* by putting a minus sign ('-') in front of the first *(co)processor*. Note that *processor* selections have no negative form, therefore they cannot be unselected. (By default only the MC68000 processor is specified).

Consider the following examples:

```
        OPT     P=68030/68882           ; select MC68030 and MC68882
        ...

        OPT     P=-68040/68882/68851    ; select MC68040, but
        ...                             ; unselect MC68882 and MC68851

        OPT     P=68000                 ; select the MC68000 processor,
        OPT     P=68851                 ; and the MC68851 coprocessor
        ...

        OPT     P=-68882                ; unselect the MC68882 coprocessor
```

OPT FPSP40 Enable MC68040 software-supported instructions (default)
OPT FPSP60 Enable MC68060 software-supported instructions (default)
OPT NOFPSP40 Forbid MC68040 software-supported instructions
OPT NOFPSP60 Forbid MC68060 software-supported instructions

Both the MC68040 and the MC68060 processor have an optimized floating-point unit to directly execute the most commonly used subset of the extensive MC68881/MC68882 instruction set through hardware. The remaining instructions are emulated by Motorola's floating-point software package to ensure complete compatibility to the floating-point coprocessors.

These options can now be used to control the allowance of the software-supported instructions for the specified processor.

By default, all software-supported instructions are enabled.

Example:

```
MC68060              ; select the MC68060 as target processor,
OPT      NOFPSP60    ; but forbid the floating-point emulation.
...
fadd.x   fp1,fp0     ; allowed FPU instruction.
fasin.x  fp0         ; a 'MC68060 software-supported instruction used'
...                  ; error will be reported.
```

OPT SP60 Enable MC68060 integer instruction emulation (default)

OPT NOSP60 Forbid emulated instructions

The MC68060 left some low-use integer instructions unimplemented to streamline internal operations. These unimplemented integer instructions are software emulated to provide user object-code compatibility with the M68000 family.

These options can now be used to control the allowance of the software-supported integer instructions for the MC68060.

By default, the software-supported instructions are enabled.

The unimplemented integer instructions include 64-bit divide and multiply, move peripheral data, `cas2`, `chk2`, and `cmp2`. In addition, CAS used with a misaligned effective address is also unimplemented. The unimplemented integer instructions are:

`divu.l`	<ea>,*Dr:Dq*	$64/32 \Rightarrow$ 32r,32q
`divs.l`	<ea>,*Dr:Dq*	$64/32 \Rightarrow$ 32r,32q
`mulu.l`	<ea>,*Dr:Dq*	$32*32 \Rightarrow 64$
`muls.l`	<ea>,*Dr:Dq*	$32*32 \Rightarrow 64$
`movep`	*Dx,(d16,Ay)*	size = W or L
`movep`	*(d16,Ay),Dx*	size = W or L
`chk2`	<ea>,*Rn*	size = B, W, or L
`cmp2`	<ea>,*Rn*	size = B, W, or L
`cas2`	*Dc1:Dc2,Du1:Du2,(Rn1):(Rn2)*	size = W or L
`cas`	*Dc,Du,*<ea>	size = W or L, misaligned <ea>

Refer to the *M68000 Family Programmer's Reference Manual* for details on these instructions.

SUPER ON Enable warnings on supervisor-only opcodes (default)
OPT SUPER
OPT SW+
SUPER OFF Disable warnings
SUPER
OPT NOSUPER
OPT SW-

This option tells the assembler either to enable or disable the warnings reported if a privileged instruction is assembled. `SUPER OFF` should be used if you are writing code that will run in supervisor mode, but it is a good idea to leave `SUPER ON` for normal use to help avoid accidentally using instructions that are unavailable.

READMODWRITE Disable warnings for read/modify/write instructions
READMODWRITE OFF
READMODWRITE ON Enable warnings (default)

This directive can be used to control the warnings produced by the `CAS`, `CAS2`, or the `TAS` instructions. These instructions trigger a special bus cycle, intended for multiprocessor support, which many models of the Amiga do not handle correctly. Using these instructions can conflict with system DMA, and are documented by Commodore as being unsuitable for use on the Amiga. The `BSET` instruction can be used as a substitute for `TAS` on the Amiga. By default the assembler will report a warning message.

SETKFACTOR *expression* Set default static k-factor for FPU Packed Decimal

This directive sets the default k-factor used for the `FMOVE` floating-point instruction if the destination format is Packed Decimal, to specify the format of the decimal string.

The default k-factor is only used if no k-factor (static or dynamic) is given to the `FMOVE.P` instruction. Format of the instruction with a given and suppressed k-factor:

```
fmove.p fpn,<ea>{dx}     ; dynamic k-factor given in a
                         ; data register dx
fmove.p fpn,<ea>{#k}     ; static k-factor given as value k

fmove.p fpn,<ea>         ; no k-factor given,
                         ; the assembler uses
                         ; the default k-factor instead.
```

The given *expression* must be in the range of -64 to +63, where the value defines the format as follows:

-64 to 0 — Indicates the number of significant digit to the right of the decimal point (Fortran "F" format).

+1 to +17 — Indicates the number of significant digits n the mantissa (Fortran "E" format).

+18 to +63 — Sets the OPERR bit in the FPSR exception byte, treated as +17.

The following table gives several examples of how the k-factor value affects the format of the decimal string that is produced by the FPU.

k-Factor	Source Operand Value	Destination String
-5	+12345.678765	+1.234567877 E+4
-3	+12345.678765	+1.2345679 E+4
-1	+12345.678765	+1.23457 E+4
0	+12345.678765	+1.2346 E+4
+1	+12345.678765	+1 E+4
+3	+12345.678765	+1.23 E+4
+5	+12345.678765	+1.2346 E+4

The k-factor value defaults to zero if not specified. Refer to the *MC68881/MC68882 Floating-Point Coprocessor User's Manual* or any other manual that describes the MC68881/MC68882 coprocessors for detailed information about the k-factor.

5.6.3 Assembly Options

DEFAULT *type,mode* — Define default behaviour

This directive can be used to set the default behaviour of ProAsm. In almost all cases this defines the size the assembler should use for either instructions or addressing modes if forward referenced addresses are found.

The most *types* are only useful when code utilizing the new addressing modes of the MC68020 or later processors is written.

As default *type* the following keywords are accepted:

`_ADRBASEDISP`
: As *mode* either `_WORD` or `_LONG` can be given. This sets the default size for the forward referenced address register base displacements to 16 or 32 bit respectively. By default, the assembler uses 16 bit displacements (`_WORD`).

`_BASEDISP`
: This *type* works exactly like `_ADRBASEDISP`, with the exception that it sets the default size for address base displacements (`_ADRBASEDISP`) and program counter relative base displacements (`_PCBASEDIP`). By default, the assembler uses 16 bit displacements (`_WORD`).

`_BRANCH`
: Using this *type* the default size for branch instructions (`Bcc` and `BSR`) can be set to a 32, 16, or 8 bit jump offset respectively by selecting `_LONG`, `_WORD`, or `_BYTE` as *mode*. The `_SHORT` keyword is also supported as a synonym for the `_BYTE` *mode*. By default, the assembler uses 16 bit jump offset (`_WORD`).

`_LINKREF`
: This *type* can be used to select between two different linkable object file formats. Using `_BASERELATIVE` as *mode*, the assembler generates a standard object module compatible with the Amiga standard linker (‘`ALINK`’) and ‘`BLINK`’ (the replacement linker from ‘The Software Distillery’). Is `_RELATIVE` given as *mode*, object modules compatible with some older (non-standard) linkers will be generated. By default, `_BASERELATIVE` is used.

`_OUTERDISP`
: This *type* works in the same manner as `_ADRBASEDISP`, with the exception that it sets the default size for outer displacements. Refer to Section 4.4 *Addressing Modes*, page 36, for detailed information about the outer displacement. By default, the assembler uses 16 bit displacements (`_WORD`).

`_PCBASEDIP`
: This *type* works precisely in the same manner as `_ADRBASEDISP`, except that it sets the default size for program counter relative base displacements. See Section 4.4 *Addressing Modes*, page 36, for detailed information about the program counter relative base displacement. By default, the assembler uses 16 bit displacements (`_WORD`).

All the keywords are case-insensitive, and the leading underscore (‘`_`’) of *type* and *mode* is optional.

OPT ABL Set default behaviour
OPT ABW
OPT BDL
OPT BDW
OPT BRL
OPT BRW
OPT BRB
OPT BRS
OPT ODL
OPT ODW
OPT PCBL
OPT PCBW

These options are abridged versions of the `DEFAULT` directive and can be used to set the default behaviour of ProAsm.

Here you find a list of these options and their matching `DEFAULT` directive:

```
ABL     DEFAULT _ADRBASEDISP,_LONG

ABW     DEFAULT _ADRBASEDISP,_WORD

BDL     DEFAULT _BASEDISP,_LONG

BDW     DEFAULT _BASEDISP,_WORD

BRL     DEFAULT _BRANCH,_LONG

BRW     DEFAULT _BRANCH,_WORD

BRB     DEFAULT _BRANCH,_BYTE

BRS     DEFAULT _BRANCH,_SHORT

ODL     DEFAULT _OUTERDISP,_LONG

ODW     DEFAULT _OUTERDISP,_WORD

PCBL    DEFAULT _PCBASEDISP,_LONG

PCBW    DEFAULT _PCBASEDISP,_WORD
```

See `DEFAULT`, page 91, for more information about the meaning of each `DEFAULT` argument.

5.6.4 Optimization

OPT AUTOPC Automatic PC-relative addressing
OPT A+
OPT NOAUTOPC Disable automatic PC-relative addressing
OPT A-

If `OPT AUTOPC` is specified the assembler uses the PC-relative addressing mode where possible, instead of the absolute long addressing. The use of this option may result in considerable reduction of the object code size and runtime.

This transformation is made before the instruction is actually assembled so if the address is out of range an error will be reported. To override this transformation you can force the assembler to use the absolute long addressing mode by appending the '`.L`' size specifier, as with the absolute word addressing mode.

`OPT NOAUTOPC` is the default. See Section 4.4 *Addressing Modes*, page 36, for more information about the PC-relative addressing mode.

```
OPT     A+
move.l  foo,d0
; will be assembled to:
move.l  foo(PC),d0

move.l  (foo).L,d0
; will be left unaffected
```

OPTIMIZE Enable all optimizations
OPT O+
NOOPTIM Disable all optimizations (default)
OPT O-
OPTIMON *n*[,*m*...] Enable optimizations *n*, *m*, ...
OPT O*n***+** Enable optimization *n*
OPTIMOFF *n*[,*m*...] Disable optimizations *n*, *m*, ...
OPT O*n***-** Disable optimization *n*

ProAsm is capable of performing various optimizations causing instructions to be smaller and faster. No optimizations are performed by default.

All optimizations performed will be reported by a warning. You can control these warnings using the `OW+` or `OW-` options. If any optimization has been done the assembler will report the number of optimizations made and bytes saved at the end of the assembly.

You may specify single optimizations by inserting a number between the '`O`' letter and the plus ('`+`') or minus ('`-`') sign. '`O`*n*`+`' will enable the optimization and '`O`*n*`-`' is used to disable it.

Example:

```
OPT   o+           ; turns all optimizations on
OPT   o+,o1-,o6-   ; turn all optimizations on, except 1 and 6
OPT   o-,o3+,o2+   ; only optimizations 2 and 3 are turned on
OPT   o5+          ; allow the optimization of add and sub
```

The following specific optimizations are available:

`O1+`

`O1-` Optimizes backwards branches to their short form if in range of -128–0 bytes.

Example:

```
foo:    ...
        bra     foo
        ; will be optimized to
        bra.s   foo
        ; (2 bytes saved)
```

`O2+`

`O2-` Optimizes the address register indirect with displacement addressing mode to the address register indirect, if the displacement is zero.

Example:

```
bar     EQU     0
        move.l  0(a2),d0
        move.l  bar(a1),d2
        ; will both be optimized to
        move.l  (a2),d0
        move.l  (a1),d2
        ; each optimization saved 2 bytes
```

`O3+`

`O3-` Absolute long addressing mode within the range of -32768–32767 will be optimized to absolute word.

Example:

```
        move.l  4,a6
        ; will be optimized to
        move.l  4.W,a6
        ; and 2 bytes saved
```

Note that if the address size is given specifically as absolute long ('.L') no optimization will be made.

04+

04- `move.l #x,dn` statements with an immediate value within the range of -128–127 will be optimized to `moveq #x,dn`. This optimization saves four bytes.

05+

05- The `add` and `sub` instructions with an immediate number between 1 and 8 as source operand will be optimized to their quick forms.

Example:

```
        add.w   #2,counter(a5)
        add.l   #4,d0
        ; can be optimized to
        addq.w  #2,counter(a5)
        addq.l  #4,d0
        ; and 2 respectively 4 bytes saved
```

06+

06- This is not really an optimization. The assembler just reports a warning on all forward branches that can be shortened.

You can optimize it by hand; saves two bytes.

Example:

```
        ...
        beq.s   foo         ; shortened forward branch to 'foo'
        ...
foo:
```

07+

07- Backward referencing absolute long addressing modes will be optimized to PC-relative addressing modes if within the range of -32768–0 bytes.

Note that if the absolute long address size is given specifically no optimization will be made.

Example:

```
foo:    ...
        lea     foo,a0
        ; will be optimized to
        lea     foo(PC),a0
        ; and 2 bytes saved, but
        lea     (foo).L,a0
        ; won't be optimized
```

`o8+`

`o8-` `movea.l`, `adda.l`, and `suba.l` instructions with an immediate value within the range of -32768–32767 will be shortened to word operation size (e.g. `movea.w`).

Example:

```
adda.l #$100,a0
; will be shortened to
adda.w #$100,a0
; and 2 bytes saved
```

`o9+`

`o9-` `cmp`, `cmpi`, and `cmpa` instructions with an immediate source operand will be optimized to a `tst` instruction if the immediate value is zero. This optimization saves either two or four bytes, depending on the used operation size.

Note that a `cmpa` instruction will only be optimized if code generation for a MC68020 or higher processor is enabled. Refer to Section 5.6.2 *MC68020*, page 86 for more information on the processor selection.

`o13+`

`o13-` A base displacement within the range of -32768–32767 will be optimized to word size.

Note that if the address size is given specifically to the base displacement (‘`.L`’) no optimization will be made. See Section 4.4 *Addressing Modes*, page 36, for detailed information about the base displacement.

`o14+`

`o14-` An outer displacement within the range of -32768–32767 will be optimized to word size.

Note that if the address size is given specifically to the outer displacement (‘`.L`’) no optimization will be made. See Section 4.4 *Addressing Modes*, page 36, for detailed information about the outer displacement.

`o16+`

`o16-` This is not really an optimization. The assembler reports a warning on all forward referencing absolute long addressing modes that can be made PC-relative.

You can optimize it by hand; two bytes can be saved.

`o17+`

`o17-` This is not really an optimization. A warning will be displayed if an address register indirect with displacement addressing mode can be optimized to an address register indirect, if the forward referenced displacement is zero.

You can optimize it by hand; two bytes can be saved.

`O18+`

`O18-` This is not really an optimization. The assembler reports a warning on all forward referenced absolute long addressing modes that can be shortened to absolute word.

Note that no warning is displayed for all absolute long addressings with an absolute address size specifier (‘`.L`’).

You can optimize it by hand; two bytes can be saved.

OPT Q+ Enable all additional optimizations
OPT Q- Disable all additional optimizations (default)
OPT Q*n*+ Enable additional optimization *n*
OPT Q*n*- Disable additional optimization *n*

Next to the set of the standard optimizations, ProAsm supports various additional optimizations. In the most cases these optimizations convert instructions into other instructions or set of instructions with the same result to gain a smaller and faster code. No optimizations are performed by default.

All optimizations performed will be issued by a warning. You can control these warnings using the `QW+` or `QW-` options. If any optimization has been done the assembler will report the number of optimizations made and bytes saved at the end of the assembly.

You may specify single optimizations by inserting a number between the ‘`Q`’ letter and the plus (‘`+`’) or minus (‘`-`’) sign. ‘`o`*n*`+`’ will enable the optimization and ‘`o`*n*`-`’ is used to disable it.

Example:

```
OPT   q+           ; turns all additional optimizations on
OPT   q+,q1-,q7-   ; turn all optimizations on, except 1 and 7
OPT   q-,q3+,q2+   ; only optimizations 2 and 3 are turned on
OPT   q5+          ; allow the optimization of add and sub
```

The following specific optimizations are available:

Q1+

Q1- Optimizes `clr.l` with a data register operand to a `moveq #0,d`*n* instruction. This optimization saves no bytes, but it is faster than the clear instruction.

Q2+

Q2- An `asl` instruction will be optimized to an `add` instruction if a data register is arithmetically shifted by one bit. It optimizes also the `roxl` instruction to `addx` if a data register is rotated by one bit. The result of this optimization is a gain in time.

Example:

```
asl.w   #1,d3          ; ⇒ add.w d3,d3
roxl.l  #1,d4          ; ⇒ addx.l d4,d4
```

Q3+

Q3- Optimizes a `movea` instruction with an immediate source operand of zero to `suba`. This optimization saves either two or four bytes, depending on the used operation size.

Example

```
movea.l  #0,a4         ; ⇒ suba.l a4,a4
```

Q4+

Q4- If this optimization is turned on any `adda` and `suba` instruction will be skipped by the assembler if the immediate source operand is zero:

```
suba.l  #0,a4     ; ⇒ instruction skipped
adda.w  #0,a2     ; ⇒ instruction skipped
```

An addition or subtraction of zero has no effect to the address register in the destination operand. This optimization saves either four or six bytes, depending on the used operation size.

Q5+

Q5- A `move.l` instruction with an immediate source operand and a data register as destination will be optimized to a combination of a `moveq` and a `not.b` or `not.w` instruction.

The immediate value must be within the range of 128–255, 65408–65535, or -65409–-65536. This optimization saves two bytes.

Example:

```
move.l  #65409,d1
```

```
will be optimized to:
```

```
moveq   #126,d1
not.w   d1
```

`Q7+`

`Q7-` A `move.l` instruction with an immediate source operand and a data register as destination will be optimized to a combination of a `moveq` and a `subq.l` instruction.

The immediate value must be within the range of -136–-129. This optimization saves two bytes.

For example:

```
        move.l  #-132,d0

    will be optimized to:

        moveq   #128,d0
        subq.l  #4,d0
```

`Q8+`

`Q8-` A `move.l` instruction with an immediate source operand and a data register as destination will be optimized to a combination of a `moveq` and a `swap` instruction.

The immediate value must have the lower 16 bits set to zero and be within the range of 65536–8323072 or -8323073–-65537. This optimization saves two bytes.

Example:

```
        move.l  #$10000,d6

    will be optimized to:

        moveq   #1,d6
        swap    d6,d6
```

`Q9+`

`Q9-` A `move.l` instruction with an immediate source operand and a data register as destination will be optimized to a combination of a `moveq` and a `add.b` instruction.

The immediate value must be even and within the range of 128–254 or -256–-130. This optimization saves two bytes.

Example:

```
        move.l  #200,d2

    will be optimized to:

        moveq   #100,d2
        add.b   d2,d2
```

`Q11+`

`Q11-` Optimizes a `move.b` instruction with an immediate source operand to a `st.b` instruction if the immediate value is -1. This optimization saves two bytes.

Example:

```
            move.b  #-1,(a0)

    will be optimized to:

            st.b    (a0)
```

Caution, the `move.b #-1,`<*ea*> instruction affects the condition code flags, while the `ST.B` <*ea*> instruction does not. Refer to the *M68000 Family Programmer's Reference Manual* for more details about these instructions.

`Q12+`

`Q12-` `eor` and `eori` instruction with an immediate source operand will be optimized to a `not` instruction if the immediate value is zero. This optimization saves either two or four bytes, depending on the used operation size.

For example:

```
            eori.w  #-1,foo_flag(a3)

    will be optimized to:

            not.w   foo_flag(a3)
```

MULTIPASS

Enable multipass optimization

The `MULTIPASS` directive causes the assembler to use more than two passes for an assembly task if needed. This allows to gain an even more optimized code.

Due to the nature of a two pass assembler forward references cannot be optimized. Forward references are only known in the second pass and the assembler is thereby unable to generate an optimized code.

With the possibility to use more than two passes, unknown forward references vanish and multiple forward references "hopes" can be resolved. All these previously unknown references can now be taken into account by optimizations.

The assembler terminates a task, if no more passes have to be done or any circular references were found.

The termination criteria for a multipass assembly are fulfilled when no more optimization can be made and when no label had to be changed due an optimization in the last pass.

Circular references are symbol definitions that assign themselves to themselves:

```
a       EQU     a       ; a circular reference

a       EQU     b       ; another circular reference
b       EQU     c       ; spread over three symbols
c       EQU     a       ;
```

For all of the above written examples ProAsm reports an '`unresolved symbol found`' error if multi-passing is enabled.

The `MULTIPASS` directive will have no effect if never any optimizations were enabled (using the `OPT O` or `OPT Q` options or any synonym).

This directive has no negative form. By default, the assembler performs only two passes.

OPT OPTIMLIB enable the use of the optimizer library
OPT NOOPTIMLIB disable the use of the optimizer library

These options control the use of the optimization support library. This library can be used by ProAsm to recognize more and complex optimization possibilities.

The possible optimizations will be displayed. A short description informs the user about the saved space and whether the optimization could be made or not. If it could not be made by the library, the way how the optimization can be achieved is described.

If the library could not be opened by `OPT OPTIMLIB`, a warning will be reported.

See Section 7.3 *The proasmoptim.library*, page 179, for more information about the use of this library and its function.

5.6.5 Assembler Message Control

5.6.5.1 Generating Warnings and Errors

Sometimes you may want to make your source code do some automatic "sanity checking" on macro parameters or other conditional assembly options. The following directives make this possible.

FAIL *message* Generate an assembler error

This directive generates an error, causing the assembler to display this source line and refuse to produce an output file. For example, this macro generates an error if it is invoked with more or less than four arguments:

```
ListEntry   MACRO
            IFNE    NARG-4
            FAIL    ** wrong number of arguments passed!
            ELSE
            dc.w    \1,\2
            dc.l    \3,\4
            ENDC
            ENDM
```

WARN *message* Generate a warning message

This is like `FAIL`, except it is not fatal and does not prevent the assembler from producing an output file; it only displays the source line containing the `WARN` directive. For example, this macro produces a warning if invoked without any parameters:

```
DataEntry   MACRO
            IFC     '\1',''
            WARN    ** no argument, using default value.
            dc.w    0
            ELSE
            dc.w    \1
            ENDC
            ENDM
```

You can use special backslash symbols such as `\`*n* within `FAIL` and `WARN` messages; they will be expanded before the message is printed. This example demonstrates how it can be useful:

```
Entry       MACRO
            IFLT    \1,4
            FAIL    ** argument must be at least 4, was \1
            ELSE
            dc.w    \1
            ENDC
            ENDM
```

If this macro is called with the parameter 5, ProAsm will fail with this message:

```
            FAIL    ** argument must be at least 4, was 5
```

5.6.5.2 Controlling the Message Output

FAILAT *expression* Specify maximum number of errors

The *expression* specifies the maximum number of errors to be reported before aborting assembly. An *expression* of zero sets the limit to unlimited number of errors. This can be used to prevent screenfuls of error message "spewage" from being dumped onto the display because of one minor error in the source code which cascades through and causes many other errors.

OPT E+ Show errors messages (default)
OPT E- Suppress error messages

This option enables or disables the report of error messages to the standard output and the error file. It may be useful when the assembler is used within a script file or something similar and the report of error messages would be disturbing.

By default, all errors are displayed.

OPT WARN Show warning messages (default)
OPT W+
OPT NOWARN Suppress warning messages
OPT W-

Use this option if you wish to display or to suppress the warnings produced by the assembler. See Appendix B *Warnings*, page 275, for detailed information on the warnings generated by ProAsm.

OPT OW+ Show all warnings caused by optimizations (default)
OPT OW- Suppress all warnings caused by optimizations
OPT OW*n*+ show warnings caused by optimization *n*
OPT OW*n*- suppress warnings caused by optimization *n*

The first two forms are used to control the warnings produced by all optimizations.

You can also control the warnings produced by one particular type of optimization by using either `OWn+` or `OWn-`. The number *n* is the number denoting the type of optimization; see `OPT O`, page 94, for more details.

OPT QW+ Show all warnings caused by additional optimizations (default)
OPT QW- Suppress all warnings caused by additional optimizations
OPT QW*n*+ show warnings caused by additional optimization *n*
OPT QW*n*- suppress warnings caused by additional optimization *n*

The first two forms are used to control the warnings produced by all advanced optimizations.

You can also control the warnings produced by one particular type of advanced optimization by using either `QWn+` or `QWn-`. The number *n* is the number denoting the type of optimization; see `OPT Q`, page 98, for more details.

ODDOK Disable misalignment and odd access checks
ODDERROR Enable checks

These directives can be used to control the check for misalignment and odd accesses.

Designing code for the MC68020 or higher microprocessors it is not always necessary to check for word alignement for data, since these processors can access data at any alignement. However, should the code be downwards compatible the right data alignement has to be ensured.

The `ODDERROR` directive tells the assembler to report any not word aligned code and data, and any non-byte accesses to odd addresses.

By default, the checks are enabled.

Example:

```
        ...
        ODDOK
        move.l  d0,DosBase       ; ⇒ ok
        add.w   counter(pc),d1   ; ⇒ ok

        ODDERROR
        move.l  d0,DosBase       ; ⇒ error
        add.w   counter(pc),d1   ; ⇒ error
        ...

flag:     dc.b    0
counter:  dc.w    2      ; counter is odd aligned ⇒ error
DosBase:  dc.l    0
```

ODD2OK Disable misalignment and odd access checks
ODD2ERROR Enable checks

These directives are extentensions to the above described `ODDOK` and `ODDERROR`.

They enable or disable the same misalignment and odd access checks as the `ODDOK` and `ODDERROR` do. In addition the `ODD2ERROR` directive forces the assembler to report any odd displacement for the address register indirect with displacement and the address register indirect with index addressing modes (see Section 4.4 *Addressing Modes*, page 36).

Consider the following example:

```
ODD2ERROR

progstart:  lea progstart(pc),a4 ; set program base in A4
clr.l counter(a4) ; ⇒ ok
clr.b flag(a4) ; ⇒ ok
clr.w foo(a4) ; ⇒ error
...

counter:  DC.L 0
flag:  DC.B 0
foo:  DC.W 0
```

The main goal of the additional checks are that possible odd accesses through the use of the address register indirect with displacement and address register indirect with index addressing modes can be spotted. But these checks are only useful if the address register is set to a 2-byte boundary. The assembler assumes that the address register holds an even address, since its contents is not known during assembly.

By default, these checks are disabled.

OPT F+ Display filenames of all loaded files
OPT F- Do not display filenames (default)

This option allows you to enable or disable the report of all names of the files loaded by the either `INCLUDE`, `INCBIN`, or one of their synonyms.

This messages will only be issued during the first pass.

OPT Z+ Show the preprocessed source line with messages
OPT Z- Show the original source line (default)

Whenever an error or a warning message is displayed, the assembler also displays the corresponding source code line. Using this option you can tell the assembler to display either the original written line or the preprocessed line, with `EQUR` and similar symbols expanded. It can be very useful to determine the actual cause of an error in the presence of elaborate textual symbols. The original source code line is shown as default.

The following example reports in both cases an '`undefined symbol`' error, but different source lines will be displayed.

```
foo     EQUR    D8

        OPT     z-      ; display the original written source code line
        move.l  foo,d0  ; 'move.l foo,d0' is shown next to the error message

        OPT     z+      ; show the assembled source code line
        move.l  foo,d0  ; 'move.l D8,d0' is written to the standard output
```

OPT CHKBIT Report error if bit number not in bounds
OPT WARNBIT Report warning if bit number not in bounds
OPT NOCHKBIT Do not check bit number (default)

These options tell the assembler to report either an error message, a warning message, or nothing at all, if the bit number specified in the immediate source operand of a bit manipulation instruction is not in bounds. The bit number must be either from 0 to 7 for byte operations or from 0 to 31 for long word operations.

Bit manipulating instructions are the `bchg`, `bclr`, `bset`, and `btst` instructions. When the destination is a data register, the M68000 processors automatically uses the bit number specified by the modulo 32 bit number. When the destination is a memory location, the operation is a byte operation, and any bit number is modulo 8.

Example:

```
OPT     warnbit
btst    #8,(a0)
; you get a warning from the assembler
OPT     chkbit
bset    #32,d0
; an error message will be displayed
OPT     nochkbit
bclr    #13,14(a4)
; nothing reported, bit 5 will be cleared
```

5.6.6 Baserelative Assembly

BASE *expression* Set base location

This directive forces the assembler to use a base for the address register indirect with displacement (indexed or not) addressing modes.

ProAsm allows the use of relocatable symbols as displacement for the above mentioned addressing modes. If no base is defined (as it is by default), the offset of the relocatable symbols are taken into account for the displacements. (What is exact the same as a base defined to the start of the current section, or a base of zero respectively.)

```
        move.l  foo(a4),d0
        ...
foo:
```

To assure now a correct effective address calculation, the assembler must know the base that is used. The example above works only if the address register `a4` is assigned to the beginning of the current section. But what if the address register is set to another location within the program code (but still within the same section)? Moving the base that is hold in the base register (`a4` in the example) to another location, allows us to access data in a wider range (from 0–32767 up to -32768–32767).

To tell the assembler the location of the new base you can apply the `BASE` directive, with the *expression* set to this new location. The effective address is corrected by subtracting the offset of the base location (*expression*) from the displacement of the mentioned addressing modes.

The *expression* describes the new location relative to the start of the current section. An *expression* of zero forbids the effective address correction. It must be a relocatable expression, absolute expressions are not allowed and an error is reported. (With the exception that zero (‘0’) can be used to disable the use of bases.)

Examples:

```
        BASE    progstart+4096
        ; Set base 4kbytes from program start,
        ; effective access range is -4096–32767.

        BASE    progbase
        ; Using a special symbol for the base,
        ; you have the possibility to set it manually.
```

The advantage of using the `BASE` directive is that if you decide to change the base location, you only have to change the *expression* on the `BASE` directive instead of changing every displacement of a base relative access:

```
start:  ...
        ; traditional base relative access
        lea     start(pc),a4      ; load a4 with the base address
        move.l  foo-start(a4),d0  ; base relative access

        ; new method
        BASE    start             ; set the base location to start
        BASEREG a4                ; use only a4 as base register
        lea     start(pc),a4      ; load a4 with the base address
        move.l  foo(a4),d0        ; base relative access
        ...
foo:
```

The following example shows you two different methods to assign the base to the base register:

```
        BASE    progbase

        lea     progbase(pc),a4
        ; common way to set the register
```

```
        lea     __base(pc),a4
        ; setting the register using the __BASE symbol
        ...
progbase:
```

This example works only if the base is in the same section as the register assignment.

To handle section overlapping bases correctly, consider the following example:

```
        BASE    Data+32766
        SECTION "code",CODE
        ...
        lea     __base,a4
        ; set base register to the data section.
        ; the same as lea Data+32766,a4
        ...
        move.l  d0,DosBase(a4)

        SECTION "data",DATA
Data:                              ; mark start of data section
DosBase:        dc.l    1
ImageData:
```

Note that a base movement done by the `BASE` directive affects the effective address calculation of all address register indirect with displacement addressing modes for **all address registers (except a7)**. To restrict this correction to one or to a list of address registers, use the `BASEREG` directive (see its description below).

The `__BASE` symbol contains the current base address, if any defined. See Chapter 6 *Special Symbols*, page 171, for the description of the `__BASE` symbol. Be aware that when no base is defined this symbol contains the absolute value of zero. Assigning `__BASE` to a address register in such a situation will load the address register with the value of zero (identical to `lea 0,a4`).

You can use the `BASE` directive more than once within a program code. For a temporary change of the base location the following mechanism can be used:

```
oldBase EQU     __base          ; store current base
        BASE    newbase         ; set new base
        ...
        BASE    oldbase         ; restore previously used base
```

Consider also the following example that uses the `OPT T` in combination with the `BASE` and `BASEREG` directives for a stronger typechecking:

```
         BASE    progbase
         BASEREG a4
         OPT     T+               ; enable typechecking
progbase:
         ...
         lea     progbase(pc),a4
         move.l  d0,foo(a4)
         move.l  d1,bar(a5)       ; ⇒ ERROR
         ...
foo:     dc.l    0
bar:     dc.w    0
```

If in the example above the typechecking would be disabled, no error would be reported by the assembler.

By default, no base is defined.

NOBASE
BASE 0

Forbid base correction

These directives forbid the effective address correction for all address register indirect with displacement (indexed or not) addressing modes.

By setting the base to zero (as `NOBASE` does) the base offset is resetted to its default, and effective address correction is turned off.

These directives can be used in combination with the `BASE` directive more than once in the program code if desired.

BASEREG *address register list*

Declare base register list mask

Using the `BASEREG` directive, a list of address registers (or a single address register) can be defined, that are accepted as base registers.

The *address register list* is a standard register list, as known from the `MOVEM` instruction, but only address registers are allowed.

If a `BASE` directive is used to define a new location for the program base, the displacements of all address register indirect with displacement addressing modes are corrected.

Using the `BASEREG` directive you can select the base registers for which the correction is made.

For example:

```
BASEREG a4          ; select only a4 as base register
BASEREG a2/a4-a5    ; select a2, a4, and a5 as base registers
BASEREG a0-a7       ; select all registers
BASEREG a0-a6       ; select all registers form a0 to a6 (default)
```

By default, the address registers a0–a6 are accepted for displacement correction.

5.6.7 Absolute Assembly

ORG *expression* — Set absolute origin

The `ORG` directive forces the assembler to enter absolute assembly mode. The location counter is set to the *expression* in the operand field.

This directive is normally used to set the starting address of ROM based code when the `BINARY` directive is used (see `BINARY`, page 130).

Note that ProAsm generates a warning when this directive is used if the location counter is unequal to zero. Using the `ORG` directive while generating executable or linkable object code is not recommended. The Amiga is a multitasking platform and therefore assumption about absolute memory addresses should not be made.

For example:

```
ORG     $F80000           ; set location counter to $F80000
...
ORG     $F80000-$10000    ; set location counter to $F70000
...
```

The location counter defaults to zero at the start of the assembly.

ENDORG Terminate absolute assembly mode

This directive can be used to terminate absolute assembly mode introduced by the `ORG` directive (even if more than one `ORG` directive was used).

Example:

```
        bsr     foobar
        moveq   #0,d0
        rts
        ...

        ORG     $f70000         ; start absolute code with the
foo:    ...                     ; location counter set to $F70000.
        ENDORG                  ; end absolute code

foobar: ...
```

RORG *expression* Re-define program origin

The `RORG` directive defines a new offset for the subsequent code. *Expression* is the new offset relative to the start of the current section, and it must not contain any forward references.

For example:

```
        ...
        movem.l (a7)+,d1-a6
        rts

        RORG    1024
        ...
```

Should the result of the given *expression* be smaller than the current program counter, the assembler would have to overwrite already generated code. In such a case an error is reported.

5.7 Data Output Directives

5.7.1 Initialized Data (`DC`)

[*label*] **DC.B** *value*[,*value*[,...]] Define Bytes
[*label*] **DB** *value*[,*value*[,...]]

Reserves memory for one or more bytes in the output file, and initializes them to the specified values. Numeric values are stored directly in single bytes. They can be either signed or unsigned, and must be in the range from -128 to 255. (The values -128 to -1 are equivalent to the values 128 to 255.) String operands can be included as well, enclosed in single or double quotes. They can be of arbitrary length, and are stored in order as sequences of bytes.

[*label*] **DC.W** *value*[,*value*[,...]] Define Words
[*label*] **DW** *value*[,*value*[,...]]

Reserves 16-bit words. Numeric operands must be in the range from -32768 to 65536. You can use quoted strings, but they must be only one or two characters long. Single quoted characters are zero-extended to 16 bits. (The high-order byte of the word is set to zero, and the low-order byte is set to the character specified.) Strings of two characters are placed in a single 16-bit word with the first character in the upper byte and the second character in the lower byte.

[*label*] **DC.L** *value*[,*value*[,...]] Define Longwords
[*label*] **DL** *value*[,*value*[,...]]

Reserves 32-bit long words. Numeric operands can be anywhere in the range -2147483648 to 4294966295. Quoted strings must be from one to four characters in length. They are packed into single longwords, with the last character occupying the least-significant byte in the longword. The longword is zero-extended to 32 bits if the string is less than four bytes in length.

In addition to constants, you can use relocatable values such as labels in `DC.L` directives, as long as the output file is in a relocatable or linkable format. Such values generate 32-bit relocations or 32-bit external references in the output file.

Here are some examples demonstrating the use of these directives:

```
DC.B        1,2,3,$23,-1,"hello",'world'
; ⇒ $01020323 ff68656C 6C6F776F 726C64

DC.W        1,2,3,$1234,-1,"a","b","cd"
; ⇒ $00010002 00031234 FFFF0061 00626364

DC.L        1,$1234,-1,"a","bcd",my_label
; ⇒ $00000001 00001234 fffffff 00000061 00626364 (reloc32)
```

Note that if you want a string to be null-terminated (as most operating system functions and C programs expect), you must add the null byte at the end yourself, like this:

```
msg     DC.B        "This is a message.",0
        ; ⇒ $54686973 20697320 61206D65 73736167 652E00
```

5.7.2 Initialized Data with Restricted Range

[*label*] **UB** *value*[,*value*[,...]] Define Unsigned Bytes
[*label*] **UW** *value*[,*value*[,...]] Define Unsigned Words
[*label*] **UL** *value*[,*value*[,...]] Define Unsigned Longwords

These directives work like `DB`, `DW`, and `DL`, respectively, except that their operands are restricted to unsigned numbers only: using a negative number as a *value* generates an error. For example, `UB` accepts only numbers between 0 and 255, while `DB` accepts anything between -128 and 255. Note that these directives do not actually restrict the output data you can generate, because large unsigned numbers can always be used instead of negative numbers.

[*label*] **SB** *value*[,*value*[,...]] Define Positive Bytes
[*label*] **SW** *value*[,*value*[,...]] Define Positive Words
[*label*] **SL** *value*[,*value*[,...]] Define Positive Longwords

These directives are the converse of `UB`, `UW`, and `UL`; their operands are restricted to signed numbers only. For example, `SB` only accepts numbers between -128 and 127.

[*label*] **PB** *value*[,*value*[,...]] Define Positive Bytes
[*label*] **PW** *value*[,*value*[,...]] Define Positive Words
[*label*] **PL** *value*[,*value*[,...]] Define Positive Longwords

These directives work like `UB`, `UW`, and `UL`, except that their range is *further* restricted to only numbers whose binary representations have their high bit clear: *signed positive* numbers. For example, `PB` only accepts numbers between 0 and 127 instead of 0 and 255.

[*label*] **NB** *value*[,*value*[,...]] Define Negative Bytes
[*label*] **NW** *value*[,*value*[,...]] Define Negative Words
[*label*] **NL** *value*[,*value*[,...]] Define Negative Longwords

These directives are the converse of `PB`, `PW`, and `PL`: they accept negative numbers only. For example, `NB` only accepts numbers between -128 and -1.

Examples:

```
DB      -50     ; ⇒ $CE
UB      -50     ; ⇒ Error!
SB      -50     ; ⇒ $CE
PB      -50     ; ⇒ Error!
NB      -50     ; ⇒ $CE

DB      50      ; ⇒ $32
UB      50      ; ⇒ $32
SB      50      ; ⇒ $32
PB      50      ; ⇒ $32
NB      50      ; ⇒ Error!

DB      150     ; ⇒ $96
UB      150     ; ⇒ $96
SB      150     ; ⇒ Error!
PB      150     ; ⇒ Error!
NB      150     ; ⇒ Error!
```

5.7.3 Declaring Data Block

[*label*] **DS.***size* *length*[,*expression*] define storage
[*label*] **DCB.***size* *length*[,*expression*] define constant block
[*label*] **BLK.***size* *length*[,*expression*]

These directives can be used to reserve memory space within the object code. The given *expression* is stored in memory *length* times with the size of *size*. The *length* must be an absolute integer expression. The *expression* can be an expression of any type, unless the given *size* contradicts with *expression* (as in `DS.B 4,-1.34E14`). If no *expression* is given a value of zero is used.

The *size* specifier must be one of the following:

`B` byte (8 bit), `W` word (16 bit),
`L` long word (32 bit), `S` single precision (32 bit),
`D` double precision (64 bit), `X` extended precision (96 bit),
`P` packed decimal (96 bit), `Q` quad word (64 bit)

For example:

```
                ALIGN.L
fileinfo:       DS.B    fib_SIZEOF,0  ; dos/dos.i
```

is the same as:

```
                ALIGN.L
fileinfo:       DS.B   fib_SIZEOF    ; dos/dos.i
```

These directives are used within BSS sections to declare storage. If such a directive is found within a BSS section with an *expression* unequal to zero, a warning is reported.

Defining storage in a BSS section can look like this:

```
        SECTION "bss",BSS
DosBase DS.L    1
GfxBase DS.L    1,0
IntBase BLK.L   1
Flag    DC.B    0
        ALIGN.W
Image   DS.B    1024,0
```

A special form of these directives will align the program counter to an even boundary by using `DS.W 0`, likewise, `DS.L 0` will align the program counter to a longword boundary, and so on for all remaining sizes. See Section 5.7.5 *Alignment Padding*, page 120, for more information.

[*label*] **DX.***size* *length*[,0] Define uninitialized extra storage

This directive can be used to reserve memory space within the object code. The assembler reserves space in the program code depending on the given size specifier *size* and *length* (*length* is the number of data items of the size *size*).

The *length* must be an absolute integer expression, and the *size* specifier must be one of the following:

`B` byte (8 bit),	`W` word (16 bit),
`L` long word (32 bit),	`S` single precision (32 bit),
`D` double precision (64 bit),	`X` extended precision (96 bit),
`P` packed decimal (96 bit),	`Q` quad word (64 bit)

Memory blocks defined by the `DX` directive must be at the end of a section (unless within a BSS section) and no other code or data generating directive is allowed after a `DX` directive.

Unlike the data block declaring directives (see Section 5.7.3 *Declaring Data Blocks*, page 116), the DX directive does no memory initialization. If your program requires the memory to be cleared then you must write a small routine to clear that memory block (as a part of the initialization of your program). For example:

```
           ...
           lea     DXStart(pc),a1
           move.w  #DXEnd-DXStart-1,d7
.clrdx:    clr.b   (a1)+
           dbra    d7,.clrdx
           ...

DXStart:
DosBase:   DX.L    1              ; allocate 4 bytes
GfxBase:   DX.L    1
ArgStr:    DX.L    1
ArgLen:    DX.B    4              ; allocate 4 bytes

foo:       DX.X    1              ; allocate 12 bytes
bar:       DX.D    3              ; allocate 24 bytes
DXEnd:
           END
```

The advantage of the DX directive is that the program code can be made smaller and, as a consequence, will be loaded faster by the AmigaDOS loader.

5.7.4 Defining Strings

[*label*] **CSTRING** *string* — Define a null-terminated string
[*label*] **CSTR** *string*

This directive is an extension to the DC.B directive. It works similar to the DC.B directive except that an additional null byte is appended after the *string*. The result is a null-terminated (C-style) string as used for strings in the programming language C.

Consider the following example:

```
CSTRING "Hello World"
; ⇒ DC.B "Hello World",0

CSTRING $9b,"1mHello World",$9b,"0m"
; ⇒ DC.B $9b,"1mHello World",$9b,"0m",0
```

[*label*] **ISTRING** *string* Define an OS-9 string
[*label*] **ISTR** *string*

This directive is an extension to the `DC.B` directive. It works similar to the `DC.B` directive except that bit 7 of the last byte in the given *string* is inverted.

For example:

```
ISTRING "error occurred"      ; ⇒ DC.B "error occure","d"|$80
```

Since the bit 7 is inverted, characters with an ASCII value higher than 127 can also be handled.

This directive has the advantage that a string intensive program can save a lot of space by using it instead the `CSTRING` directive (for example).

It is easy to write string handling routines that can detect the end of such a string. For example a simple string copy routine that just copies the string:

```
;
; A0: pointer to the source i-string
; A1: place the string is copied to
;
copy_string:
        move.b  (a0)+,(a1)+    ; copy character
        bpl.s   copy_string    ; until a negative byte detected (bit 7 set),
        bchg    #7,-1(a1)      ; invert bit 7 of the last copied byte.
        rts
```

Note that the small routine above does not handle ASCII values greater than 127 (they would be seen as the end of the string).

Within your program it can look like that:

```
        ...
        lea     title(pc),a0
        lea     buffer,a1
        bsr     copy_string

        ...
title:  ISTRING "Example Copy_String v1.0"
```

[*label*] **PSTRING** *string* Define a BCPL string
[*label*] **PSTR** *string*

This directive is an extension to the `DC.B` directive. It works similar to the `DC.B` directive except that an additional byte is added in front of the *string* that contains the length of the given *string*.

Due to the fact that the length is stored as byte, the string may not be longer than 255 characters.

For example:

```
PSTRING "BCPL Strings"   ; ⇒ DC.B 12,"BCPL Strings"
```

So defined strings (BCPL strings) were used by the AmigaDOS (up to OS1.3).

5.7.5 Alignment Padding

It is often necessary or desirable for certain data structures or other constructs to have certain alignment properties, such as being aligned on a 2-byte or 4-byte boundary. For one thing, all code for the M68000 family has to obey certain alignment conventions:

- All machine instructions must start on even-byte boundaries. That should not be a problem unless byte sized data and code get mixed. For instance:

```
        bra.s   foo
        DC.B    "Hello world!",0  ; 13 bytes
foo:    moveq   #0,d0             ; this instructions lies on an uneven boundary
```

  The assembler reports a '`odd address`' error if an instruction is located at an odd address. To ensure that the program counter is forced to an even address use the `EVEN` directive or one of its alternate forms:

```
        bra.s   foo
        DC.B    "Hello world!",0   ; 13 bytes.
        EVEN                       ; ensure word boundary!
foo:    moveq   #0,d0
```

- When working with word or long word sized data you must ensure that they are on an even address. (This is not necessarily for the MC68020 or higher microprocessors, since they can access data at any alignement, but it is recommended for downwards compatibility and for better performance). The assembler gives an '`odd address`' error message if an instruction that would access a misaligned word- or longword-sized data item is detected:

```
          move.l  myData,d0
          ...
          dc.b 0
myData:   dc.l  5                 ; myData is misaligned
```

Data structures in the Amiga Operating System must be word aligned, except for a few structures that need to lie on a long word boundary. (For detailed information on the data structures of the AmigaOS refer to *AMIGA ROM Kernel Reference Manual: Includes and Autodocs*).

The start of a new section is always automatically long word aligned.

CNOP *expression*[,*expression*] Align program counter
ALIGN *expression*[,*expression*]

These directives allow you to align code or data to any specified boundary.

If only one argument is supplied with these directives then it is the desired boundary. When both arguments are supplied the first *expression* is the offset beyond this alignement and the second *expression* is the desired alignement.

The program counter is padded to the desired boundary by inserting the required number of null-bytes if necessary. The offset (given by the first *expression*) will then be added to the program counter and filled with null-bytes.

Example:

```
CNOP    2       ; aligns program counter to word boundary
CNOP    0,4     ; aligns program counter to long word boundary
CNOP    2,4     ; aligns PC to long word boundary and adds 2 bytes
CNOP    13,24   ; aligns PC to the next 24-byte boundary
                ; and adds 13 bytes

CNOP    6,2
; is similar to
EVEN
DS.B    6
```

ALIGN.*size* Align program counter

The `ALIGN` directive supplied with an operation size is an alternate form for the `CNOP` directive described above.

The program counter is padded to the desired boundary as specified by *size*. Null-bytes will be inserted as filler if necessary.

The following operation sizes are allowed for *size*:

`.W`	word, align the program counter to word boundary. (equal to `CNOP 0,2`.)
`.L`	long word, align program counter to long word boundary. (equal to `CNOP 0,4`.)
`.S`	single precision, align program counter to long word boundary. (equal to `CNOP 0,4`.)
`.D`	double precision, align the program counter to 64-bit boundary. (equal to `CNOP 0,8`.)
`.X`	extended precision, align the program counter to 96-bit boundary. (equal to `CNOP 0,12`.)
`.P`	packed, align the program counter to 96-bit boundary. (equal to `CNOP 0,12`.)
`.Q`	quad word, align program counter to 64-bit boundary. (equal to `CNOP 0,8`.)

EVEN Align output to word boundary
DS.W *0*[,*pad-value*]

This directive pads the output data to the next word boundary (even address), by inserting a pad byte if necessary. If `EVEN` or `DS.W` is used with only one parameter, the pad byte will be zero. If `DS.W` is used with two parameters, the second parameter will be used as the pad byte. If the output data is already on the desired boundary, the directive will have no effect.

Example:

```
ORG $100
a:   ; at $100
dc.b "A"
b:   ; at $101
EVEN ; generates a pad byte
c:   ; at $102
dc.b "B"
```

QUAD Align program counter to long word boundary

This directive pads the output to the next long word boundary, by inserting the required number of null pad bytes. If the program counter is already on the desired boundary, the directive will have no effect.

ODD Align output to odd byte boundary

The `ODD` directive forces the assembler to align the output to the next odd byte address (the next address with bit 0 equal to 1). This directive will have no effect if the output is already on the desired boundary.

CCNOP *expression*[,*expression*] Align program counter

This directive allows you to align code or data to any specified boundary. It is functionally identical to the `CNOP` directive above. The only difference is that the program counter is padded to the desired boundary by inserting `NOP's` ($4e71) instead of null-bytes. This directive is specially intended to align program code to the desired boundary.

If only one argument is supplied with these directives then it is the desired boundary. When both arguments are supplied the first *expression* is the offset beyond this alignement and the second *expression* is the desired alignement.

Example:

```
        moveq   #14,d7
        CCNOP   0,4
loop:   ...
        dbra    d7,loop
```

A null-byte will still be inserted if the pad length needed to obtain the desired alignement is odd. Consider the following example:

```
        DC.B    0
        CCNOP   0,4
        rts
```

The code lines above is identical to:

```
DC.B    0
DC.B    0
; insert a null-byte filler
; to obtain an even alignement
; for the NOP instruction
NOP
NOP
rts
```

A '`odd address or offset detected`' warning will be reported if the offset (given by the first *expression*) or the current program counter is odd.

ALIGNRS *expression*[,*expression*] Align __RS offset counter
ALIGNSO *expression*[,*expression*] Align __SO offset counter
ALIGNFO *expression*[,*expression*] Align __FO offset counter
ALIGNDX *expression*[,*expression*] Align DX area

These directives are in their function identical to the `CNOP` directive described above except that they are intended for the use with structure, frame offset or `DX` directives. (See Section 5.5.2 *Structure Offsets*, page 77, or Section 5.7.3 *Uninitialized Data Blocks*, page 117, for more information.)

No null-bytes are inserted.

Example:

```
        RSRESET
foo     RS.B    1
        ALIGNRS 0,2     ; align __RS counter to word boundary
bar     RS.L    1
```

Note that any of these directives will only work with its counter. Using `ALIGNRS` instead of `ALIGNSO` won't work.

ALIGNRS.*size* Align __RS offset counter
ALIGNSO.*size* Align __SO offset counter
ALIGNFO.*size* Align __FO offset counter
ALIGNDX.*size* Align DX area

These directives work in the same manner as the `ALIGN.`*size* directive described above except that they are intended for the use with the structure offset, the frame offset or the `DX` directives. (See Section 5.5.2 *Structure Offsets*, page 77, or Section 5.7.3 *Uninitialized Data Blocks*, page 117, for more information.)

No null-bytes are inserted.

Example:

```
foo     DX.B    3
        ALIGNDX.W          ; align DX counter to word boundary
bar     DX.L    1
```

Note that any of these directives will only work with its counter.

5.8 Convenience Pseudo-Opcodes

Pseudo-Opcodes are special assembler statements that generate object code but do not correspond to actual M68000 family instructions. These Pseudo-Opcodes are merely implemented for a programmer's sake. The way they are named or the functions they fulfill, are all done to make the life of a programmer easier.

It is not guaranteed that all assemblers support Pseudo-Opcodes or that they are compatible to others. ProAsm understands the most commonly used Pseudo-Opcodes, and in addition it comes with some new ones.

You find the descriptions of all Pseudo-Opcodes known by ProAsm in the following sections.

5.8.1 Stack Manipulation

PUSH.*size ea* Move *ea* on stack
POP.*size ea* Move *ea* from stack

These pseudo-opcodes are abbreviations for `MOVE.`*size* instructions when dealing with the stack.

`PUSH` moves an *ea* on the stack similar to the `MOVE` *ea*`,-(SP)`.

`POP` is the opposite form of `PUSH`. It can be used if an *ea* is moved from the stack (`MOVE (a7)+,`*ea*).

Example:

```
POP.W   (a0)
; ⇒ move.w (a0),-(sp)

PUSH.L  (foo,a3,d0.w)
; ⇒ move.l (a7)-,(foo,a3,d0.w)
```

Valid *sizes* are byte, word, and longword. But note, when you use byte as operation size, the stack pointer will automatically align the stack to the next word boundary downwards before the byte is written on the stack.

PUSHM *register list* — Move *register list* on stack
POPM *register list* — Move *register list* from stack

These pseudo-opcodes are alternatives for the `MOVEM.L` instructions when dealing with the stack.

The `PUSHM` pseudo-opcode moves the given *register list* on the stack, and `POPM` removes the registers from the stack.

The *register list* is identical to the one used by the `MOVEM` instruction. The used operation size is longword.

The `_MOVEMREGS`, `_MOVEMBYTES`, and `_MOVEMLIST` symbols are updated if one of these pseudo-opcodes is used. See Chapter 6 *Special Symbols*, page 171, for more detailed information about these three symbols.

For example:

```
PUSHM   d0-d4/d7/a2-a6
; ⇒ movem.l d0-d4/d7/a2-a6,-(a7)

POPM    d0-a6
; ⇒ movem.l (a7)+,d0-a6
```

APUSHM Push automatically generated register list on stack
APOPM [*register list*] Pop automatically generated register list from stack

These pseudo-opcodes are special variations of the above described `PUSHM` and `POPM`.

They generate automatically a register list of all used registers between an `APUSHM` and a matching `APOPM`. The `APUSHM` will then be replaced by a `MOVEM.L` instruction that moves these registers on the stack. `APOPM` will be replaced by a `MOVEM.L` that moves these registers from the stack.

The optionally given *register list* (as argument of `APOPM`) describes the registers that are excluded from the generated register list. This *register list* is identical to the one used by the `MOVEM` instruction. The used operation size is longword. Consider the following example:

```
        APUSHM
        move.l  d0,a0
        move.w  (a0),d1
        neg.w   d1
        move.l  (a0,d1.w),d0
        APOPM   d0              ; exclude d0 from the generated register list.

will be assembled to:

        movem.l  d1/a0,-(a7)
        move.l  d0,a0
        move.w  (a0),d1
        neg.w   d1
        move.l  (a0,d1.w),d0
        movem.l  (a7)+,d1/a0
```

The `_MOVEMREGS`, `_MOVEMBYTES`, and `_MOVEMLIST` symbols are updated if one of these pseudo-opcodes is used. See Chapter 6 *Special Symbols*, page 171, for more detailed information about these three symbols.

5.8.2 Move Effective Address

MEA *ea1,ea2* Move effective address

This is a special pseudo-opcode that is implemented to make program counter relative assembly easier.

It moves the effective address of the first operand (*ea1*) to *ea2* using the stack. `MEA` is splitted into a `PEA` *ea1* and a `MOVE.L (a7)+,`*ea2* instruction.

For example:

```
        MEA     foo(pc),d0

will be assembled to:

        pea     foo(pc)
        move.l  (a7)+,d0
```

If the destination (*ea2*) is an address register or an address register indirect with predecrement with the stack pointer as register (‘`-(A7)`’), the assembler automatically optimizes the `MEA` pseudo-opcode to a `LEA` *ea1*`,varea2` instruction or a `PEA` *ea1* instruction respectively:

```
        MEA     foo(pc),a2      ; ⇒ LEA foo(pc),a2
        MEA     foo(pc),-(a7)   ; ⇒ PEA foo(pc)
```

The advantage of using the `MEA` pseudo-opcode lies in the possibility to avoid relocatable references. This is useful for writing program counter relative code. A `move.l #foo,d0` instruction can simply be replaced by `MEA foo(pc),d0` (as far as `foo` is a relocatable symbol).

5.8.3 The `PFLUSHA` instruction

Both the MC68030 and MC68040 processors have an instruction called `PFLUSHA`. Unfortunately, these instructions have different encodings on the two processors. Therefore, when ProAsm sees a `PFLUSHA` instruction, it must somehow be told what *kind* of `PFLUSHA` instruction to write.

PFLUSHA *operands* `PFLUSHA` instruction

If either the `MC68030` or `MC68040` directive is in effect, ProAsm uses its setting to control the encoding of `PFLUSHA`. If `MCRELAX` is in use, ProAsm always generates the MC68030 form.

This is an instruction of the M68000 family, refer to the *M68000 Family Programmer's Reference Manual* for more information about the `PFLUSHA` instruction.

PFLUSHA30 *operands* Pseudo-Opcode for the MC68030 `PFLUSHA`
PFLUSHA40 *operands* Pseudo-Opcode for the MC68040 `PFLUSHA`

To allow both forms of `PFLUSHA` to be produced while using `MCRELAX` mode, ProAsm also provides these two alternate instruction forms, which always produce the MC68030 or MC68040 forms, respectively.

5.9 Controlling the Output File

5.9.1 Output File Name

OUTPUT *filename* Set assembly output file
OBJFILE *filename*

This directive is used to specify the filename for the output file. This filename can be overridden by the '-O'/OBJNAME command line option. For example, this line tells ProAsm to place the assembled output into the file '`ram:test`':

```
OUTPUT  'ram:test'
```

If more than one OUTPUT directive is present, the first one will define the output name; any others that specify a different filename will generate a warning.

OBJ *filename* Set name of linkable object file

This directive is equivalent to the following:

```
OUTPUT  filename
LINKABLE
```

In other words, it sets the output filename and instructs ProAsm to make it a linkable AmigaDOS object file (see Section 5.9.2 *Output File Format*, page 129).

5.9.2 Output File Format

By default, ProAsm creates an AmigaDOS executable.

EXECUTABLE Generate an AmigaDOS executable
EXE
EXEOBJ
OPT L-

Any of these directives instruct ProAsm that the output file should be an AmigaDOS executable, ready to load and run from the command line or Workbench. The program may not reference any external symbols, since it will not be linked with anything, and it may not use `ORG`, because AmigaDOS may load the program at any place in memory. See Section 5.9.3 *Executables*, page 132, for more information about AmigaDOS executables.

LINKABLE Generate a linkable object module
LINKOBJ
OPT L+

These directives instruct ProAsm to create an object file which can be linked with other object files by a linker such as BLink, eventually resulting in an AmigaDOS executable. This is one way to write big programs spread over several source files, although this can also be done using include files (see Section 5.1.2 *Include Files*, page 47). More importantly, this allows you to link assembly language programs assembled by ProAsm with object files generated by a high-level language compiler, such as a C compiler. See Section 5.9.4 *Object Modules*, page 141, for more information about linkable object modules.

BINARY Generate a binary image
BINARYONLY
BINRYONLY
ASEG

These directives instruct ProAsm to output a "raw" binary file, containing only the data explicitly defined in the source code. No linking or debug information can be generated, so `XREF` may not be used. Labels may not be referenced in 32-bit absolute modes unless `ORG` is used to specify the precise address at which the image is going to be run (see `ORG`, page 112).

PREASM Generate a preassembled file
OPT GENSYM

The `PREASM` directive tells the assembler to generate a preassembled file. Use the `OUTPUT` or the `OBJFILE` directive to name the resulting file.

A preassembled file contains specially formatted symbol and macro lists that can immediately be added to the symbol and macro tables without further parsing of directives and expressions, as must be done with non-preassembled include file. The use of files produced using the `PREASM` directive will result in faster assembly times and less memory usage.

Next to these tables a list of all included files is likewise stored in a preassembled file. The assembler checks all new include files for matches in this list before including them. Only files that do not match will be loaded since all the others are already included in the *preasm file*.

The following symbol types are stored in the *preasm file* along with the macro definitions and include file names:

`Absolute symbols`
: (declared with either `EQU` or `SET`)

`External references`
: (declared with `XREF`)

`Relocatable symbols`
`Symbols assigned register lists`
`Symbols that are defined as synonyms for other symbols`
`Symbols equated to FPU constants`
`Symbols assigned to FPU register lists`
`Temporary symbols`
`Textual symbols`

The following directives and their synonyms will be ignored if used with the `PREASM` directive: `ADDSYM`, `CSYMFMT`, `DEBUG`, `OPT DEBUG`, `OPT HCLN`, `OPT X+`, `SECSYM`.

You will get a warning if any code or data producing statements, the `XDEF` directive, or section statements are used together with the `PREASM` directive, since they are meaningless in this context.

A preasm file can later be loaded using one of the following directives: `INCLUDE`, `INCEQU`, `MACLIB`, `HEADER`.

NOOBJ Suppress output

This directive forces the assembler not to create any output file at all. It is useful if you want to run a test assembly to check for syntax errors in the source code.

It is the same as the `NOOBJ` and `-N` command line arguments.

SREC *format,record length,address*[*,name*] Generate Motorola S-record output

This directive instructs ProAsm to generate a Motorola S-record output file. The S-record format is for encoding programs or data files in a portable format for transportation between computer systems. It is often used for writing embedded M68000 applications. For more information on the S-record format, refer to the *M68000 Family Programmer's Reference Manual* (see Appendix F *Bibliography*, page 299).

format is the Motorola Record format type and must be a value from 1 to 3.

record length is the count of character pairs in the record, excluding the type and record length; the value must be from 16 to 255.

address is the load address. ProAsm sets the location counter offset to this address (see `ORG`, page 112).

name can be used to specify the module name. A module name that contains a whitespace must be enclosed in double or single quotes. If no *name* is given, '`ProAsm`' will be used.

Example:

```
SREC    2,64,$f20000,"foobar"
```

If several directives, controlling the output file format, appear in the source code, only the last one is used.

5.9.3 Creating AmigaDOS Executables

5.9.3.1 Sections

When building AmigaDOS executables, it is often desirable to divide a program up into a few separate *sections* or *hunks*. Each section is a contiguous block of memory which has certain attributes. All of the code or data within a particular section is guaranteed to remain in the order in which you defined it, but different sections can be loaded anywhere in memory by AmigaDOS. This is known as *scatter-loading*. The following directives are used to define sections in ProAsm:

SECTION *name*[*,type*[*,memtype*[*,typecode*]]][*,reloctype*] Begin section

This directive ends any previous section and starts adding code and data to a new section. The *name* is a string up to 256 characters long. It must be quoted if it contains special characters such as whitespace or commas. It can be anything you want, but code sections are usually called '`code`' or '`text`', while data and bss sections are usually called '`data`' or '`__MERGED`'. Section *names* are case-sensitive.

The *type* may be '`CODE`', '`DATA`', or '`BSS`'. (They do not need to be written in uppercase, however.) Any data defined in a '`BSS`' section, such as data produced by '`DC`' statements, is lost: only its size is remembered, and AmigaDOS initializes the entire section to zero when the program is loaded. The default section type is '`CODE`'.

If the *memtype* is present, it specifies that the section must be loaded in a certain type of memory. It can be either '`CHIP`', '`FAST`', '`PUBLIC`', '`MEMF`', or '`ADVISORY`'. If *memtype* is '`MEMF`', then the additional *typecode* argument must be supplied, which is a numeric value to be passed to the operating system's memory allocator (`AllocMem()`) when loading this section. This is usually some combination of the `MEMF_` values defined in the include file '`exec/memory.i`'.

Programs assembled with the '`MEMF`' option can only be loaded on Kickstart 2.0 or later, and object files which use this feature may not be compatible with some linkers. Therefore, we recommend that you do *not* use the '`MEMF`' option if you are only specifying chip or fast memory; use '`CHIP`' or '`FAST`' instead.

The *memtype* '`ADVISORY`' is only supported by AmigaDOS 3.0 (V39) or later. A hunk marked with '`ADVISORY`' will be ignored by the loader if its type is not understood. When ignored, the marked hunk is threated like a debug hunks. Under AmigaDOS versions prior to 3.0 executables marked with '`ADVISORY`' will fail to load with a bad hunk type error.

You can combine the *type* and the *memtype* by appending an underscore ('_') and the first letter of the *memtype* to the *type*. For example, 'CODE_C' is the same as 'CODE,CHIP'.

The *reloctype*, if specified, can be RELOC32 or RELOC32SHORT. RELOC32 is the default setting, and generates a standard relocation hunks (hunk_reloc) in the output. RELOC32SHORT generates a hunk_reloc32short chunk if possible to save some space in the output file and make loading slightly faster. The hunk_reloc32short chunk is functionally identical to hunk_reloc. It is only more compact and applicable only to smaller programs. Also, this chunk type is only supported under AmigaDOS 2.0 or later, so it should not be used in programs that must be able to run under earlier versions of AmigaDOS.

If a previous section was defined earlier with the same name as this section, ProAsm continues adding code and data to that section instead of creating a new section. The *type* and *memtype* may not conflict with the previous definition. If they are not specified at all, they are assumed to be the same. Case is always significant when comparing section names.

If any code or data is defined before the first SECTION directive (or one of its equivalents below), this data will be placed in a default code section, as if CODE had been included at the very beginning of the file.

Some examples:

```
SECTION "foo",code,public,reloc32short
; same as SECTION "foo",code,,reloc32short
...
SECTION "bar",data,chip
...
SECTION "foofoo",data,memf,(MEMF_REVERSE|MEMF_PUBLIC)
...
SECTION "foobar",bss
...
```

CODE [*memtype*[*,typecode*]][*,reloctype*] Begin 'CODE' section
CODE *name*[*,memtype*][*,reloctype*]
DATA [*memtype*[*,typecode*]][*,reloctype*] Begin 'DATA' section
DATA *name*[*,memtype*[*,typecode*]][*,reloctype*]
BSS [*memtype*[*,typecode*]][*,reloctype*] Begin 'BSS' section
BSS *name*[*,memtype*[*,typecode*]][*,reloctype*]
CSEG [*memtype*[*,typecode*]][*,reloctype*] Begin 'CODE' section
CSEG *name*[*,memtype*[*,typecode*]][*,reloctype*]
DSEG [*memtype*[*,typecode*]][*,reloctype*] Begin 'DATA' section
DSEG *name*[*,memtype*[*,typecode*]][*,reloctype*]

These are short forms of the `SECTION` directive, which begin new, facultatively unnamed, sections of type '`CODE`', '`DATA`', and '`BSS`', respectively, optionally with a specified *memtype*. Since the name is optional, names that are similar to *memtype* keywords are invalid (`CHIP`, `FAST`, `PUBLIC`, `MEMF`, and `ADVISORY`).

If `MEMF` is given as *memtype* an additional argument must be supplied with the directive which is a numeric value to be passed to the operating system's memory allocator (`AllocMem()`) when loading this section. This is usually some combination of the `MEMF_` values defined in the include file '`exec/memory.i`'.

The *reloctype*, if specified, can be `RELOC32` or `RELOC32SHORT`. `RELOC32` is the default setting, and generates a standard relocation hunks (hunk_reloc) in the output. `RELOC32SHORT` generates a hunk_reloc32short chunk if possible to save some space in the output file and make loading slightly faster. The hunk_reloc32short chunk is functionally identical to hunk_reloc. It is only more compact and applicable only to smaller programs. Also, this chunk type is only supported under AmigaDOS 2.0 or later, so it should not be used in programs that must be able to run under earlier versions of AmigaDOS.

If a previous section was defined earlier with the same name (or no name) as this section, ProAsm continues adding code and data to that section instead of creating a new section. The *type* and *memtype* may not conflict with the previous definition. If they are not specified at all, then they are assumed to be the same. Case is always significant when comparing section names.

Refer to `SECTION`, page 133, for detailed information about defining sections.

Some Examples:

```
CODE    "Function",,reloc32short
; same as CODE "Function",,reloc32short
; and SECTION "Function",code,,reloc32short
...
DATA    "Images",chip
...
CODE
...
BSS
...
BSS     memf,MEMF_CLEAR
...
```

SECTION __OLDSECTION — Revert to the previous section

This directive reverts to the section that was in effect *before* the most recent `SECTION` (or equivalent) directive. This can be used in include files, for example, to temporarily switch to a different section and then later switch back to the section that was in use by the "parent" source file. This feature does not stack, however; additional `SECTION __OLDSECTION` directives merely toggle between the two most recent sections.

The keyword `__OLDSECTION` is case-insensitive.

Example:

```
moveq   #0,d0
SECTION 'lolo',code         ; Section: 'lolo'
nop
SECTION  __OldSection       ; Section: default (CODE),
rts                         ; where 'moveq' is
SECTION  __OldSection       ; Section: 'lolo'
rts
END
```

```
I implemented it for an easy code/data handling for something
like 'runtime generated' structures:
```

```
MyImage MACRO
        section "GUI_Structures_Images",data,chip
\1:
        dc.l    \2,\3
        dc.b    \4,0
        even
        incbin  "dh1:asm/images/\5"
        ...
        section __OldSection
        ENDM
```

Now within the code you may have a more structured ''layout'':

```
*
* Handle Image #1
*
HandleMyImage1:
        jsr     xxx(a6)
        ...
        rts

        MyImage image1,$14,0,"Add Font",FontImage.iff
```

At the absolute minimum, a program really only needs one section containing all the program's code and data. However, it is often considered good practice to divide a program into at least two separate sections: a 'CODE' section containing instructions and a 'DATA' section containing the program's data. While AmigaDOS does not currently require this, some other operating systems, such as Unix, do and AmigaDOS may will in the future. In addition to the code and data sections, a "bss" section is often used to hold variables that do not need to be initialized to explicit values on startup, conserving space in the executable file.

If your program contains graphics, sampled sounds, copper lists, or other data that must be accessed directly by the Amiga's custom chips, remember to place this data into a 'CHIP' section. Otherwise, the program will not work on any machine with fast memory. It is permissible to put *all* your code and data into one 'CHIP' section. However, this may make your program run more slowly, since machine code runs faster from 'FAST' memory.

SMALLOBJ Merge all hunks into one
NORMOBJ Disable merging

The `SMALLOBJ` directive tells the assembler to merge all hunks into one single `CODE` hunk. The default is to keep individual chunks separate in the output. `NORMOBJ` can be used to counteract `SMALLOBJ`.

SMALLCODE Merge all code hunks into one
SMALLDATA Merge all data hunks into one
SMALLBSS Merge all bss hunks into one

These directives force the assembler to merge all hunks of the specified type (code, data or bss) into one single hunk. The default is to keep individual chunks separate in the output. There is no negative form to empower merging.

5.9.3.2 Debugging Information

AmigaDOS executables and object modules have the capability to store *debug information* of various types, which are not necessary for actually running the program, but can be used by debuggers to make debugging the program easier. You can instruct ProAsm to attach debug information to its output files with the `DEBUG` directive.

DEBUG [*keyword*[,*keyword*...]] Output debugging information

This directive instructs ProAsm to output debugging information, and specifies exactly what kind of debugging information to generate.

The *keywords* are used to specify the kind of information to be produced.

The following modes specify the debugging output format. If none of them is used, it defaults to `LINE` or the last specified:

`LINE` produces line number information (SAS/C compatible debug hunk format).

`HCLN` produces compressed line number information (SAS/C compatible debug hunk format).

`FULL` is an alias for '`LINE,ALL`'.

`OFF` turns of the debugging information generation.

The types below are used to specify the type of debugging information that is to be produced. If none is used, it defaults to `CODE,DATA` or the last specification:

`CODE` generates debugging information for the M68000 instruction set.

`NOCODE` is the complement of the `CODE` keyword.

`DATA` generates debugging information for the data producing directives.

`NODATA` is the complement of the `DATA` keyword.

`ALL` generates debugging information for all included files.

`ADDSYM` adds symbol information to all hunks of an executable or a linkable output file, see `ADDSYM`, page 139.

`NOSYM` is the complement of the `ADDSYM` keyword, see `NOSYM`, page 139.

If you just specify `DEBUG` with no operand, it defaults to '`DEBUG LINE,CODE,DATA`' or the last set specification.

The `DEBUG` directive will generate a warning if used for neither an executable nor a linkable output file.

```
DEBUG   HCLN
DEBUG   LINE,CODE,NODATA,ALL
DEBUG
```

OPT DEBUG Enable debugging information
OPT NODEBUG Disable debugging information

These directives enable or disable debugging information without changing the options specified with `DEBUG`. You can use these directives to output debugging information selectively for only certain parts of your program.

OPT HCLN Enable compressed debugging information
OPT NOHCLN Disable compressed debugging information

These directives enable or disable compressed debugging information. The options specified with the `DEBUG` directive may be changed. This is a more efficient way of encoding debugging information in a file since it reduces the size of the output file.

You can use these options to output debugging information selectively for only certain parts of your program.

ADDSYM Generate symbol information
OPT D+
NOSYM Disable symbol information
OPT D-

The `ADDSYM` directive tells the assembler to add symbol information to all hunks of an executable or a linkable output file. Only global labels representing a relocatable location within the hunk will be added to the symbol information.

The `ADDSYM` directive will be ignored if neither an executable nor a linkable output file is generated.

The produced symbol information can be used by any symbolic debugger which supports the AmigaDOS symbol hunk format. Note that this option mutually excludes the `x+` option.

OPT XDEBUG Generate symbol information for exported symbols only
OPT X+
OPT NOXDEBUG Suppress symbol information (default)
OPT X-

These options are equivalent to the above, except that they only control symbol information generation for exported (`XDEF`) symbols (see `XDEF`, page 142). It is only useful if linkable code is produced. For executables, symbol information for all symbols will be generated, as if `ADDSYM` was used.

SECSYM Generate symbol information for current section

This directive is a special form of the above mentioned `ADDSYM` directive. The `SECSYM` forces the assembler to add symbol information to the executable or linkable output file only for the current section (while `ADDSYM` adds symbol information to all hunks). Only global labels representing a relocatable location within the hunk will be added to the symbol information.

Using this directive you can choose the sections from whom symbol information should occur in the output file. The `SECSYM` is normally used in the following way:

```
SECTION "code",CODE     ; add symbol information only
SECSYM                  ; for the code section
...
SECTION "foo",DATA
...
```

The `SECSYM` directive will be ignored if neither an executable nor a linkable output file is generated.

SELSYM *symbol*[,*symbol*[,. . .]] Generate symbol information for single symbols

The `SELSYM` directive is another special variant of the `ADDSYM` directive. Using this directive you can force the assembler to add the symbol information of the *symbol* given as arguments to an executable or a linkable output file. Only global labels representing a relocatable location within the hunk can be added to the symbol information.

Example:

```
        SELSYM  foo,bar    ; generate symbol information
        ...                 ; only for the foo and bar symbols
foo:
foobar:
bar:
foofoo:
```

The `SELSYM` directive will be ignored if neither an executable nor a linkable output file is generated.

5.9.4 Creating Linkable Object Modules

Object modules are usually divided into sections just like executables are. However, in this case, the names assigned to sections assume more importance, because the linker always merges sections with the same name into a single section in the final executable.

IDNT *string* Specify program unit name
IDENTIFY *string*

This directive will set the module name (hunk_unit) to the given *string*. The name can be up to 128 characters long and should be enclosed in double or single quotes if it contains any whitespaces. The directive is only useful if a linkable output is produced; else it is ignored. Only the last of these directives appearing in the source will be used.

5.9.5 Defining and Referencing External Symbols

XREF *symbol*[,*symbol*[,...]] Reference an external symbol

The `XREF` directive is used to specify a list of symbols that is referenced within this object module but is defined in another object module (via `XDEF`). If this directive is used while no linkable or preassembled output is being generated, a warning will be reported and the directive will be ignored.

Example:

```
        XREF GetThis,GetThat,DoThis,DoThat
        XREF start
        ...
        jsr     GetThis
        jsr     DoThat
```

XDEF *symbol*[,*symbol*[,...]] Declare a symbol as externally visible

For each symbol defined in the symbol list following the `XDEF` directive, the assembler generates an external symbol definition, making it possible for other object modules to reference these symbols. A warning will be issued if this directive is use while no linkable or preassembled output is generated.

Example:

```
        XDEF GetThis,GetThat,DoThis,DoThat
        XDEF start

start:
        ...
GetThis:
        ...
GetThat:
        ...
DoThis:
        ...
DoThat:
        ...
```

PUBLIC *symbol*[,*symbol*[,...]] Defining and referencing external symbols

The `PUBLIC` directive is treated as either `XREF` or `XDEF` directive, depending on whether the symbol in question has been defined in the current object module or not.

Symbols defined in the object module will be exported by the assembler, making it possible for other object modules to reference these symbols. The other symbols that are not defined in the object module will be referenced by the assembler as external symbols.

If this directive is used while no linkable or preassembled output is being generated, a warning will be reported and the directive will be ignored.

Example:

```
        PUBLIC GetThis,DoThat,Start
        ...
Start:  jsr     GetThis
        jsr     DoThat
```

AUTOXREF Reference all unknown symbols as external symbols

The `AUTOXREF` directive forces the assembler to treat all undefined symbols as external symbols.

If this directive is used while no linkable or preassembled output is being generated, a warning will be issued and the directive will be ignored.

For example:

```
AUTOXREF
        ...
Start:  jsr     GetThis
        jsr     DoThat
```

`GetThis` and `DoThat` are not defined within the object module and therefore they will be referenced by the assembler as external symbols. The same result can be achieved in the example above when the `AUTOXREF` is replaced by `XREF GetThis,DoThat`.

If case insensitivity is in effect, symbol names that are written to the AmigaDOS object file are written in all-uppercase.

5.9.6 Output File Attributes

See *The AmigaDOS Manual*, 3rd Edition, Bantam Computer Books, for more information about AmigaDOS file attributes.

5.9.6.1 Protection Flags

PURE Set pure bit on the output file

If this directive appears in the assembly source file, the assembler's output file will be marked pure (the file's 'p' protection bit is set). This will allow the file to be made resident with the AmigaDOS `Resident` command.

Note that ProAsm does not check to see if your code really is pure. It is your responsibility to make sure the program does not use any statically allocated data.

`PURE` is just a special form of the `FILEPROTECT` directive.

FILEPROTECT `+`*flags* Set output file protection bits
FILEPROTECT `-`*flags*
FILEPROTECT `=`*flags*

The `FILEPROTECT` directive sets the AmigaDOS file protection flags for the output file. Which bits are set, cleared, or left alone depends on the first character in the operand:

'`+`' Set the specified flag bits, leaving all others unchanged.

'`-`' Clear the specified flag bits, leaving all others unchanged.

'`=`' Set the specified flag bits and clear all others

Here is a list of the supported flags and their meanings under AmigaDOS.

'`r`' Read permission

'`w`' Write permission

'`e`' Execute permission

'`d`' Delete permission

'`a`' Archived

'`p`' Pure (can also be set with the `PURE` directive)

'`s`' Script

'h' Hidden

For example, this line causes the pure and archive bits to be set on the output file:

```
FILEPROTECT +pa
```

5.9.6.2 Comment

FILENOTE *comment* Set the output file comment

This directive allows you to set the AmigaDOS comment attached to the output file, which can be up to 79 characters long. (This string is displayed when the file is listed with the AmigaDOS `List` command, for example.) If the *comment* includes spaces, tabs, or semicolons, it must be enclosed in single or double quotes. If no *comment* argument is given, any existing filenote will be deleted from the output file.

Example:

```
FILENOTE "my first program"
```

If no `FILENOTE` directive appears in the source file, the comment on the output file is left unchanged (or the comment is set to an empty string, if the output file did not exist before ProAsm was run).

5.10 Auxiliary Output Files

Besides its normal output of assembled code, ProAsm can also generate two types of auxiliary output files which reflect the results of the assembly process: error files, equate files, source listings, and cross-reference listings.

An *error file* is a file listing all errors ProAsm encountered during assembly. Many text editors have the capability of automatically invoking an assembler on source code being edited and reading the resulting error file. The user can then step through each error in turn, and the editor automatically positions the cursor at the place in the source code where the error was found, allowing the user to correct it easily. See your editor's reference manual for information about using features like this.

An *equate file* contains all symbols and labels defined in the source code.

A *listing* file can be generated, which will contain a copy of the original source code re-formatted in a way that clearly indicates how ProAsm interpreted the source code. For example, macros and include files are usually expanded in the listing, making it easier to determine their behavior and debug them.

A *cross-reference listing* file shows the usage of symbols, of labels with the number of references made to them and to the label's offset, and of absolute symbols with their values. The file gives also additional information on the hunk structure of the produced executable or linkable object file.

5.10.1 The Error File

ERRFILE *filename* Set the name of the error file

This directive sets the name of the file to which ProAsm writes error and warning messages. If the assembler encounters more than one `ERRFILE` directive, only the first one is used and a warning message will be issued for all other occurrences. The filename specified by this directive can be overridden with the '`-e`' option on the command line (see Section 3.1 *Invoking*, page 9).

The *filename* must be in normal AmigaDOS format and must be enclosed in double or single quotes if it contains any whitespaces.

Note that no error file is generated unless at least one error or one warning message is reported.

The messages written to the error file are of a shorter form than the ones displayed in the shell (CLI), to allow easier processing by other software (e.g. by a text editor's ARexx interface).

The following example shows different errors and their depiction in the error file:

```
foo:
foo:                        ; the same symbol 'foo' is defined twice
        mova.l  d2,a0       ; movea.l would be the correct instruction
```

The two errors in the code lines above are displayed in the error file like this:

```
Pass 1
2       : symbol defined twice
3       : unrecognized instruction 'mova'
```

5.10.2 The Equate File

EQUFILE *filename* Set the name of the equate file

This directive sets the name of the file to which the assembler writes the equate listing.

If the assembler encounters more than one `EQUFILE` directive, only the last one is used. The filename specified by this directive can be overridden with the '`-q`' option on the command line (see Section 3.1 *Invoking*, page 9).

The *filename* must be in normal AmigaDOS format and must be enclosed in double or single quotes if it contains any whitespaces.

All symbols and labels defined in the source code (this includes also external source files loaded into the program source) will be written to the equate file.

The following example shows the equate file (shortened) of the '`perfmon.s`' example source code:

```
**
** ProAsm Equate Listing
**
** created on: 07.10.92
** for:        dh1:sources/perfmon.s
**

...
progbase                        equ $00000000
clistartup                      equ $00000028
wbstartup                       equ $0000003A
main                            equ $000001A4
DoQuit                          equ $00000352
DoAbout                         equ $00000358
mulu32                          equ $00000370
divu32                          equ $0000038E
PrintTitle                      equ $000003B8
smc_PrintText                   equ $000003C0
smc_afterPrintText1643          equ $000003E8
DoRawFmt                        equ $000003E8
```

```
InstallDaemon                   equ $00000402
DaemonCode                      equ $00000464
waitloop                        equ $000004EA
de_closedevice                  equ $00000512
de_remport                      equ $0000051E
de_freesignal                   equ $0000051E
de_exit                         equ $0000052C
de_signal                       equ $0000052E
DaemonName                      equ $0000053E
DaemonNameReal                  equ $00000552
Switch                          equ $0000056A
Launch                          equ $000005A4
...
end
```

5.10.3 The Listing File

LISTFILE *filename* — Set the name of the list file

This directive sets the name of the file to which ProAsm writes the listing. If ProAsm encounters more than one `LISTFILE` directives, only the last one is used. Note that no listing file is generated unless listing is actually turned on with the `LIST` directive at some point in the program The filename specified by this directive can be overridden with the '`-p`' option on the command line (see Section 3.1 *Invoking*, page 9). If no listing file is specified, the listing will be sent to '`PRT:`' by default.

LIST — Enable listing
OPT LIST
NOLIST — Disable listing
OPT NOLIST

The `LIST` directive enables listing generation, while `NOLIST` disables it. By default listings are not generated.

Pairs of `NOLIST` followed by `LIST` directives can be nested. For example, if listing is enabled and three `NOLIST` directives are encountered, then listing will be disabled until after three `LIST` directives.

5.10.3.1 Content of Listings

OPT MD List macro definitions
OPT NOMD Suppress macro definitions in listing

This option includes or suppresses the macro definition text in the listing. By default, macro definitions are included in the listing.

OPT MEX List expanded macros
OPT M+
MLIST
OPT NOMEX Leave macros collapsed in listing
OPT M-
NOMLIST

This option includes or suppresses the complete macro text for all macro expansions in the listing. All lines in the expanded macros are preceded by a plus sign ('`+`') in the listing. By default, the macros are not expanded in the listing.

LISTSYMS *expression* Generate symbol listing in listing file
OPT SYMTAB
OPT S+
OPT NOSYMTAB Suppress symbol listing (default)
OPT S-

This option creates or suppresses the printing of a symbol listing at the end of the list file. Only the last option of this type is taken into account.

The `LISTSYMS` directive supports an *expression* as additional argument. This *expression* will be used to confine the listing to only those symbols that have been referenced at least that many times in the program code.

OPT CL List conditional assembly directives (default)
CLIST
OPT NOCL Suppress listing of conditional assembly directives
NOCLIST

This option enables or disables the printing of conditional assembly directives in the listing file. Refer to Section 5.3 *Conditional Assembly*, page 61 for more information on conditional assembly.

LFCOND List false branches of conditionals
SFCOND Suppress false branches of conditional in listing

These directives are used to control the inclusion in the listing file of conditional expressions that evaluated false. By default, only the conditional expressions that evaluated true (i.e. the ones that actually got assembled) are included in the listing.

Example:

```
LFCOND
foo     EQU     1
IFNE    foo
...
ELSE
...
; this block will be written to the listing
ENDC
```

LISTCHAR *expression*[,*expression*...] Send special strings to the listing file

The given stream of *expressions* will be broken down into an ASCII string as with `DC.B`, and sent to the listing file instead of the output file. This can be used, for example, to send control codes to a printer or console window to which the listing is being sent.

Example:

```
LIST     ; Enables the listing
LISTFILE "CON:0/0/640/200/Listing File"
         ; Sends the listing to a console window
LISTCHAR $9b,"1","m"
         ; Sets the typeface to bold
...
```

5.10.3.2 Formatting the Listing

LLEN *line-length* Set line length

The `LLEN` directive sets the line length in characters of the assembly listing to *line-length*, which may be from 38 to 255. By default, the line length is set to 132 characters per line. For example, this statement sets the line length to 80 characters:

```
LLEN 80
```

PLEN *page-length* Define page length

The `PLEN` directive sets the page length for the assembly listing to *page-length*, which may be from 12 to 255. A value of zero turns paging off. By default, the page length is set to 60 lines. For example, this line instructs the assembler to assume pages of 88 lines:

```
PLEN 88
```

SPC *lines* Insert blank lines in listing

This directive is used to waste paper. The integer expression in the operand field specifies the number of blank lines that are to be put in the listing. It won't space past the top of a new page.

Example:

```
SPC 15    ; output 15 blank lines in the listing
```

FORMAT *option*[,*option*[,...]] Control listing format

This directive may be used to alter the default listing format by controlling various options. All options are specified by one digit followed by a plus ('`+`') or minus ('`-`') sign. '*n*`+`' will enable the format option and '*n*`-`' disables it. Multiple options can be set by separating them with a comma ('`,`').

0+
0-
: This option can be used to control the inclusion of line numbers in the listing. By default, the line numbers are written to the listing ('`0+`').

1+
1-
: This option tells the assembler to include ('`1+`') or suppress the section number and program counter offset in the listing.

2+
2-
: This option enables ('`2+`') or disables the writing of the produced code as hexdump to the listing.

2:*expression*
: Specify the allowed number of bytes in the hexdump field. The range of a valid *expression* is from 0–22. An odd *expression* will be aligned to the next word boundary. An *expression* of zero disables the hexdump. The assembler defaults to a field size of 2 bytes.

Example:

```
FORMAT  2:8        ; specifies a hexdump field of 8 bytes
```

4+

4- This option includes (`4+`) or suppresses the complete macro text for all macro expansions in the listing. By default, the macros are not expanded in the listing. It is identical to the `OPT M` option.

5+

5- This option includes (`5+`) or suppresses the contents of an included file (via `INCLUDE`) in the listing.

7+

7- This option forces the assembler to include (`7+`) or suppress all titles and subtitles (defined using `TTL` and `SUBTTL`) in the listing.

PAGE Next page
PAGEUP

Unless paging has been inhibited (page size is zero) or listing is disabled, this directive causes the listing to move to the top of the next page.

NOPAGE Disable paging

This directive turns off the output of page headers and form-feed characters. This is equivalent to '`PLEN 0`'.

TTL *title* Set page title
TITLE *title*

The `TTL` directive sets the page title to *title*. The string will be printed in the third line of the page header at the top of each page in the listing until a new title is set or paging is disabled. The title string may be up to 256 characters long. If it contains spaces, tabs or semicolons, it must be enclosed in single or double quotes. If no title string is defined, the line is either left blank or the name of the current include file is written.

Example:

```
TTL 'listing of my first program'
```

SUBTTL *subtitle* Set page subtitle

The `SUBTTL` directive sets the page subtitle to *subtitle*. The supplied subtitle will be printed below the listing title (in the fourth line respectively the third line in the listing header if no title is given). until a new subtitle is specified or paging is disabled. The string may be up to 256 characters long. If it contains any whitespaces or semicolons, it must be enclosed within single or double quotes. To turn off the printing of the subtitle in the listing a null string can be used as *subtitle* argument. By default, no subtitle string is defined.

Consider for example:

```
TTL     "Example for TTL and SUBTTL"

SUBTTL  "subtitle for page 1"      ; pre-define subtitle for first page
SUBTTL  "subtitle for page 2"      ; pre-define subtitle for 2nd page
SUBTTL  "subtitle for all the other pages"

LIST                               ; start listing...
...
```

5.10.4 The Cross-Reference Listing File

CREFFILE *filename*[,*expression*] Set the name of the cross-reference file

This directive sets the name of the file to which the assembler writes the cross reference listing.

If the assembler encounters more than one `CREFFILE` directive, only the last one is used. The filename specified by this directive can be overridden with the '`-r`' option on the command line (see Section 3.1 *Invoking*, page 9).

The *filename* must be in normal AmigaDOS format and must be enclosed in double or single quotes if it contains any whitespaces.

An *expression* can optionally follow the *filename* (separated by a comma), that specifies the lowest number of references for the symbols which you want to have in the cross reference listing.

The following example shows the cross reference listing (shortened) for the '`perfmon.s`' example source code:

```
**
** ProAsm Cross Reference List
**
** created on: 07.10.92
** for:        dh1:sources/perfmon.s
**


SECTION

   Size    (= Size + DX Size)  Hunk  Mem   Reloc32 Reloc16 Reloc8  Xdef's Xref's
--------------------------------------------------------------------------------
Section #0:
 $00000546 $0000044E $000000F8 CODE PUBLIC      17       0      0       0      0



SYMBOLS

 Symbolname                        Type  Offset/Value  References  Section#
----------------------------------------------------------------------------
...
progbase                             R      $00000000           7         0
clistartup                           R      $00000028           1         0
wbstartup                            R      $0000003A           1         0
main                                 R      $000001A4           1         0
DoQuit                               R      $00000352           1         0
DoAbout                              R      $00000358           1         0
mulu32                               R      $00000370           3         0
divu32                               R      $0000038E           1         0
PrintTitle                           R      $000003B8           1         0
smc_PrintText                        R      $000003C0           0         0
smc_afterPrintText1643               R      $000003E8           0         0
DoRawFmt                             R      $000003E8           2         0
InstallDaemon                        R      $00000402           1         0
...

NARG                                 A      $00000000           0         0
RARG                                 A      $00000000           0         0
__FO                                 A      $00000000           0         0
__PR                                 A      $00000004           0         0
__CP                                 A      $00000000           0         0
__TIME                               s              -           0         0
...
_MOVEMLIST                           r      $00007FFF           0         0
...
```

```
__NAN                                F            -          0        0
__SNAN                               F            -          0        0
__INFINITY                           F            -          0        0
_LINENUM                             A     $00000389         0        0


----
A: absolute, F: floating point, f: floating point register, R: relocatable,
r: register (REG), S: setable (SET), s: string (EQUR/EQUSTR), x: external (XREF)
```

5.11 Miscellaneous Directives

OPT *option*[,*option*[,...]] control assembler options
OPTION *option*[,*option*[,...]]

These directives may be used to alter the assemblers default behavior by controlling various options.

Most options are specified by one or two letters followed by a plus ('`+`') or minus ('`-`') sign. However, some options have two forms: the base form which enables the option, and the option name preceded by '`NO`' which will disable the option. As an example, the following lines will enable and disable, respectively, the printing of macro definitions in the listing file:

```
OPT     MD
OPT     NOMD
```

Multiple options can be set by separating them with a comma ('`,`'). Unless otherwise noted, all options may be used as many times as you wish. All options are case-insensitive.

The options themselves are described in the appropriate places in other parts of this manual. For quick reference, here is a list of the supported options, each with a reference to the place in the manual where it is described:

`A` Automatic PC-relative assembly. See `OPT AUTOPC`, page 93.

`ABL` Set default address register base displacement size to longword. See Section 5.6.3 *Set default behaviour*, page 92.

`ABW` Set default address register base displacement size to word. See Section 5.6.3 *Set default behaviour*, page 92.

`AUTOPC` Enable automatic PC-relative assembly. See `OPT AUTOPC`, page 93.

`BDL` Set default base displacement size to longword. See Section 5.6.3 *Set default behaviour*, page 92.

`BDW` Set default base displacement size to word. See Section 5.6.3 *Set default behaviour*, page 92.

`BRL` Set default size for branch instructions to longword. See Section 5.6.3 *Set default behaviour*, page 92.

BRW Set default size for branch instructions to word. See Section 5.6.3 *Set default behaviour*, page 92.

BRB Set default size for branch instructions to byte. See Section 5.6.3 *Set default behaviour*, page 92.

BRS Set default size for branch instructions to byte. See Section 5.6.3 *Set default behaviour*, page 92.

C Case sensitivity control. See Section 5.5.3 *Case Sensitivity*, page 83.

CASE Case sensitivity. See Section 5.5.3 *Case Sensitivity*, page 83.

CHKBIT Report error if bit number not in bounds. See `OPT CHKBIT`, page 107.

CHKPC Enable position-independent code check. See Section 5.6.1 *Position-independent code*, page 85.

CL List conditional assembly directives in the listing file. See `OPT CL`, page 149.

D Control output of a symbol table for debugging. See `ADDSYM`, page 139.

DEBUG Enable debugging information. See `OPT DEBUG`, page 139.

E Control display of error messages. See `OPT E`, page 104.

F Control filename display during assembly. See `OPT F`, page 107.

FPSP40 Enable MC68040 software-supported instructions. See `OPT FPSP40`, page 88.

FPSP60 Enable MC68060 software-supported instructions. See `OPT FPSP60`, page 88.

GENSYM Generate a preassembled file. See `PREASM`, page 130.

HCLN Enable compressed debugging information. See `OPT HCLN`, page 139.

I Check for immediate operands accidentally written in absolute addressing mode. See `OPT CHKIMM`, page 84.

L Specify creation of linkable or executable output. See `LINKABLE`, page 130, and see `EXECUTABLE`, page 129.

LIST Enable listing. See `LIST`, page 148.

LOCALDOT Use the period (‘.’) character to introduce local labels. See Section 5.5.3 *Local Label Introducer*, page 83.

LOCALU Use the underscore (‘_’) character to introduce local labels. See Section 5.5.3 *Local Label Introducer*, page 83.

M Include or suppress macro expansions in the listing file. See `OPT M`, page 149.

MD List macro definitions. See `OPT MD`, page 148.

`MEX` Include macro expansions in the listing file. See `OPT MEX`, page 149.

`NOAUTOPC` Disable automatic PC-relative assembly. See `OPT NOAUTOPC`, page 93.

`NOCASE` No case sensitivity. See Section 5.5.3 *Case Sensitivity*, page 83.

`NOCHKBIT` Do not check bit number. See `OPT NOCHKBIT`, page 107.

`NOCHKPC` Disable position-independent code check. See `OPT NOCHKPC`, page 85.

`NOCL` Do not list conditional assembly directives in the listing file. See `OPT NOCL`, page 149.

`NODEBUG` Disable debugging information. See `OPT NODEBUG`, page 139.

`NOFPSP40` Disable MC68040 software-supported instructions. See `OPT NOFPSP40`, page 88.

`NOFPSP60` Disable MC68060 software-supported instructions. See `OPT NOFPSP60`, page 88.

`NOHCLN` Disable compressed debugging information. See `OPT NOHCLN`, page 139.

`NOLIST` Disable listing. See `OPT NOLIST`, page 148.

`NOMD` Suppress macro definitions in listing. See `OPT NOMD`, page 148.

`NOMEX` Suppress macro expansions in the listing file. See `OPT NOMEX`, page 149.

`NOOPTIMLIB`
Disable the use of the optimizer library See `OPT NOOPTIMLIB`, page 102.

`NOSP60` Forbid MC68060 integer instruction emulation. See `OPT NOSP60`, page 89.

`NOSUPER` Enable warnings on supervisor-mode-only instructions. See `OPT NOSUPER`, page 90.

`NOSYMTAB` Suppress symbol listings in the list file. See `OPT NOSYMTAB`, page 149.

`NOTYPE` Disable type checking. See `OPT NOTYPE`, page 85

`NOWARN` Disable assembler warning messages. See `OPT NOWARN`, page 104.

`NOXDEBUG` Suppress debug symbol table in the output file for exported symbols only. See `OPT NOXDEBUG`, page 140.

`NOXPK` Disable XPK support. See `OPT NOXPK`, page 160.

`O` Optimization options. See Section 5.6.4 *Optimization*, page 93.

`ODL` Set default size for outer displacement to longword. See Section 5.6.3 *Set default behaviour*, page 92.

`ODW` Set default size for outer displacement to word. See Section 5.6.3 *Set default behaviour*, page 92.

`OPTIMLIB` Enable the use of the optimizer library See `OPT OPTIMLIB`, page 102.

`OW` Optimization warnings. See `OPT OW`, page 104.

`P` Check position-independent code. See Section 5.6.1 *Position-independent code*, page 85.

`P=`*processor*
Specify processor type. See `OPT P=`, page 87.

`PCBL` Set default size for program counter relative base displacement to longword. See Section 5.6.3 *Set default behaviour*, page 92.

`PCBW` Set default size for program counter relative base displacement to word. See Section 5.6.3 *Set default behaviour*, page 92.

`Q` Advanced optimization options. See `OPT Q`, page 98.

`QW` Advanced optimization warnings. See `OPT QW`, page 105

`S` Generate or suppress symbol listings in the list file. See Section 5.10.3.1 *Symbol listing*, page 149.

`SP60` Enable MC68060 integer instruction emulation. See `OPT SP60`, page 89.

`SUPER` Disable warnings on supervisor-mode-only instructions. See `OPT SUPER`, page 90.

`SW` Enable or disable warnings on supervisor-mode-only instructions. See `OPT SW`, page 90.

`SYMTAB` Generate symbol listings in the list file. See Section 5.10.3.1 *Symbol listing*, page 149.

`T` Enable or disable type checking. See Section 5.6.1 *Type Checking*, page 85.

`TYPE` Enable type checking. See `OPT TYPE`, page 85.

`U` Specify whether the underscore ('`_`') or period ('`.`') character is used to introduce local labels. See Section 5.5.3 *Local Label Introducer*, page 83.

`W` Enable or disable assembler warning messages. See `OPT W`, page 104.

`WARN` Enable assembler warning messages. See `OPT WARN`, page 104.

`WARNBIT` Report warning if bit number not in bounds. See `OPT WARNBIT`, page 107.

`X` Create or suppress debug symbol table in the output file for exported symbols only. See `OPT X`, page 140.

`XDEBUG` Create debug symbol table in the output file for exported symbols only. See `OPT XDEBUG`, page 140.

`XPK` Enable XPK support. See `OPT XPK`, page 160.

`Y` Ignore or allow duplicate includes of the same file. See `OPT Y`, page 48.

`Z` Show original or preprocessed source lines with error and warning messages. See `OPT Z`, page 107.

OPT XPK Enable XPK support (default)
OPT NOXPK Disable support

If the XPK support is enabled, any packed file (with XPK) will be automatically unpacked by the assembler. Note that encryption sublibraries are not supported.

The XKP package is not required by ProAsm to run. It enlarges only capacity of ProAsm if installed.

But should you force the XPK support to be enabled (by using the `OPT XPK` option) and ProAsm cannot open the required '`xpkmaster.library`' library, an error will be reported.

By default, the assembler enables the XPK support if the '`xpkmaster.library`' can be opened successfully. No message will be displayed if it failed.

For more information about the `XPK Data Compression Package`, refer to the package itself that is freely distributed and can be found on Aminet and many public domain libraries. There is also a developer package for all programmers that can also be found on Aminet.

OPT STO Temporarily store states
OPT RCL Recall stored states
OPT RESET Reset states

`OPT STO` and `OPT RCL` can be used to force the assembler to temporarily store and recall the states of almost all options, modes, and settings of ProAsm.

The possibility to store and recall these states can be used to make routines, that are included into the source code, more modular. The states can be stored at the beginning of a routine, then changed to the routines needs, and finally restored at the end of the routine to their previous settings.

Consider the following example:
A routine that is included into the source code if used, but it should not get in conflict with the current settings and states.

```
        IFND    RESET_FPU_R     ; This IFND mechanism forbids
RESET_FPU_R     EQU     1       ; this include file to be loaded twice

        OPT     STO             ; store current states,
        OPT     O+,OW-,Q+,QW-   ; enable optimization
        MC68882                 ; and select MC68882

ResetFPU:
        ...
        rts

        OPT     RCL             ; restore temporarily saved states
                                ; => previous used states
        ENDC
```

The use of `OPT STO` and `OPT RCL` cannot be nested. Only the last stored states can be recalled. If `OPT RCL` is used when no settings were stored previously, the option is ignored.

`OPT RESET` causes the assembler to initialize most of the options, modes, and states to their default.

The states of the following directives and options are stored, recalled, and resetted by using the described options (Note that only the names of the directives and options are used below, without any further declarations and without their negative respectively positive form):

CSYMFMT,	DEFAULT,	ESCAPESTR,
FORMAT,	LFCOND,	MC68000...MC68060,
MC68851,	MC68881,	MC68882,
MCRELAX,	NEWSYNTAX,	ODD2OK,
ODDOK,	OLDSYNTAX,	OPT A,
OPT C,	OPT Cn,	OPT CHKBIT,
OPT CL,	OPT E,	OPT F,
OPT FPSP40,	OPT FPSP60,	OPT I,
OPT M,	OPT MD,	OPT NOCHKBIT,
OPT On,	OPT OPTIMLIB,	OPT OWn,
OPT P,	OPT Qn,	OPT QWn,
OPT SP60,	OPT T,	OPT W,
OPT WARNBIT,	OPT XPK,	OPT Y,
OPT Z,	READMODWRITE,	RELAX,
SETKFACTOR,	SFCOND,	SUPER

OPT ESS1+ Select symbol search algorithm
OPT ESS2+
OPT ESS3+
OPT ESS1- Unselect symbol search algorithm
OPT ESS2-
OPT ESS3-

Next to ProAsm's default symbol search algorithm, three additional, enhanced algorithms can be selected.

They do not only differ in the resulting search time, but also in the memory usage. `OPT ESS1+` uses 131072 bytes, `OPT ESS2+` 32768 bytes, and `OPT ESS3+` 524288 bytes! (The last one is probably not usable on machines with less than 2MB of memory).

The memory usage an algorithm uses does still not guarantee a faster search. For example, source code produced by any reassembler contains tons of symbols that look quite similar (i.e. '`Lxx00002`' etc.). In such cases the `OPT ESS1+` option is usually better than the other two algorithms.

If you often use a reassembler, you probably have to experiment which one of these algorithms brings you the most advantage in assembling the produced source codes.

If not enough memory is available for the selected algorithm, ProAsm drops back to its default algorithm.

These options should only be used before any symbols are defined or an '`option must be at beginning`' error will be reported. By default, none of these additional algorithm is selected.

ESCAPESTR Enable escape sequences
ESCAPESTR *ON*
ESCAPESTR *OFF* Disable escape sequences

The `ESCAPESTR` directive can be used to control the allowance of escape characters inside quoted strings of data generating directives (such as `DC`, `CSTRING` and many more).

Escape character in strings are represented by a backslash character ('`\`') and a second character.

The legal escape sequences and their meaning are listed below:

`\0`	Zero byte (DB 0)
`\b`	Backspace (DB 8) [ANSI C]
`\c`	Control sequence introducer (DB $9b)
`\e`	Escape (DB 27)
`\f`	Form feed (DB 12) [ANSI C]
`\n`	Newline (DB 10) [ANSI C]
`\r`	Carriage return (DB 13) [ANSI C]
`\t`	Horizontal tab (DB 9) [ANSI C]
`\v`	Vertical tab (DB 11) [ANSI C]
`\x`*nn*	Insert a two digit hex value (DB $*nn*)
`\\`	Backslash (DB "\") [ANSI C]

The escape sequences marked with '`[ANSI C]`' are defined by the ANSI C standard.

Even through you need two keystrokes to write these sequences into your source code, they occupy exactly one byte in the produced object code.

For example:

```
        ESCAPESTR
        DC.B    "Hello\nworld!\0"
;       ⇒ DC.B "Hello",$a,"world!",0

        CSTRING "\c1mA\c0m\\B\n"        ; make 'A' bold
;       ⇒ CSTRING $9b"1mA",$9b,"0m“B",$a
```

CSYMFMT Achieve C symbol format

This directive forces the assembler to prefix all symbols with an underscore ('`_`') that are written either as external references or as external definitions to the object file. No underscore character is added to a symbol if it starts with an atSign character ('`@`').

The advantage of using this directive is that the generated object code can be made linking compatible with common C compilers without the need of manually add an underscore as prefix to each symbol.

The `CSYMFMT` directive is ignored if no linkable output is generated.

VERBOSE Report object and timing information
TIMES Report timing information
QUIET Suppress all additional information (default)

These directives can be used to control the information output that the assembler reports when it finishes the last pass.

Using the `TIMES` directive ProAsm displays the needed time for the current task and the resulting "lines per minute" (LPM) ratio. Also the number of defined and used macros are displayed.

In addition `VERBOSE` displays also hunk information and a list of unused registers.

By default, `QUIET`, no additional information is reported.

ASMPRI *value* Set assembler task priority

Since the Amiga is a multitasking machine, it uses priority numbers assigned to each task to determine the relative importance they should be serviced. This directive can be used to set ProAsm's task priority during assembly.

The range of the priority are the integers from -128 to 127. The CLI and the most tasks have a priority of 0, and it is suggested that you do not set the priority higher than 10. A priority higher than zero means that the assembler will not be slowed down as much by other tasks. Setting the priority lower than 0 will prevent ProAsm from slowing down other programs with normal priority.

Example:

```
        ASMPRI 3        ; Raise assembler priority level to 3
```

COMMENT *delimiter comment delimiter* Define comment block

This directive can be used to define easily a comment that spawns one or more lines.

The first character found is taken as *delimiter* except if it is a whitespace character. The text following this *delimiter* becomes the *comment* block until the next occurrence of the *delimiter*. Should the *delimiter* character be used inside the *comment* block, then double the *delimiter* character to tell the assembler that this is not the end-*delimiter*.

During assembly the *comment* blocks are ignored completely.

The advantage of using the `COMMENT` directive is that you do not need to comment each line using the semicolon (‘;’) or the asterisk (‘*’).

For example:

```
     COMMENT |
This is a comment block
spawned over as many lines as required.
A delimiter character used inside the comment block
must be doubled (||) to tell the assembler that
this is not the end-delimiter.
     |
```

PRINTX *remaining line...* Print remaining line

This directive can be used to output the remainder of the line to the standard output.

For example:

```
IFD     __DEMO__
PRINTX  ** demo version generated.
ELSE
PRINTX  ** full version generated.
ENDC
```

RCRESET Reset return code

This directive sets the `__RCODE` symbol to zero. The `__RCODE` symbol contains the return code ProAsm returns to AmigaDOS if the source file ended (see `__RCODE`, page 175).

RCSET *expression* Set return code

The `RCSET` directive sets the `__RCODE` symbol to the desired *expression*. This symbol contains the return code ProAsm returns to AmigaDOS if the source file ended (see `__RCODE`, page 175).

Setting the return code can be useful if ProAsm is used inside batch files.

ERRFLAG Enable additional error information

This directive instructs ProAsm to display additional information to the error messages and warning reports.

These information can be used to determine the state the assembler was in when the error or warning occurred. This information may be irrelevant for the user, but can be important to us if internal error messages (e.g. '`INTERNAL: ...`') have occurred. This directive was especially implemented for beta testing reasons.

The flags will be printed after the error descriptions, enclosed in square brackets ('`[`*flags*`]`').

The *flags* have following meaning:

	error occurred...
`C`	during conditional assembly.
`I`	inside an included source code.
`M`	inside a macro body.
`R`	inside `REPT/ENDR` loop.
`r`	inside `REPEAT/UNTILcc` loop.
	with the following flag set:
`e0`	Standard symbol search algorithm used.
`e1`	`OPT ESS1+` option selected.
`e2`	`OPT ESS2+` option selected.
`e3`	`OPT ESS3+` option selected.
`N`	Both syntax modes accepted (`RELAX`).
`o0`	Executable output format selected.
`o1`	Linkable output format selected.
`o2`	Binary output format selected.
`o3`	Motorola S-record as output format selected.
`o4`	Preasm as output format selected.

LOCKSYM *symbol*[,*symbol*[. . .]] Lock symbols

UNLOCKSYM *symbol*[,*symbol*[. . .]] Unlock symbols

The `LOCKSYM` directive is used to specify a list of symbols as "locked", meaning that these symbols cannot be referenced anymore. Any references are reported by an error message.

The `UNLOCKSYM` directive on the other hand removes the "lock" mark from the symbols of the given symbol list.

This mechanism of locking symbols allows you to check symbol references. If, for example, symbols were just defined for clearness and should not be referenced in the program code, they can be locked using the `LOCKSYM` directive:

```
        LOCKSYM write_to_StdOut

PrintText:
        ...
write_to_StdOut:                    ; this symbol might be inserted
        move.l  DosBase(pc),a6      ; for commenting a code fragment
        jsr     _LVOOutput(a6)
        move.l  d0,d1
        jmp     _LVOWrite(a6)
```

LABSEG *name* Begin new labseg scope

When ProAsm sees a `LABSEG` directive, it takes the current symbol and macro tables, stores them away somewhere for safe keeping, then creating new empty ones. Only the special internal symbols (`__RS`, etc.) remain.

The *name* is a string up to 256 characters long. It must be quoted if it contains special characters such as whitespaces or semicolons (‘`;`’). `LABSEG` *names* are case-unsensitive and are used to identify the new created tables.

Symbols within a `LABSEG` scope (from the `LABSEG` directive to the next one or to the end of the source code) can have the same names as symbols outside this scope, since they are stored in different symbol tables. The same is also valid for any macros. You have to use the `EQUX` directive to import symbols from other `LABSEG` scopes. See below for the `EQUX` description for more details.

The immediate usefulness of this directive is that you can encapsulate a piece of code that performs some specific function, and ensure that it does not make any (forbidden) references to anything outside that `LABSEG` scope.

With the LABSEG directive you have also the possibility to include source codes of other programs without renaming all the duplicate symbols these sources may have.

If a LABSEG scope was defined earlier with the same *name* as the new scope, ProAsm continues adding the symbols and macros to the first scope instead of creating new tables. Any symbols and macros defined before the first LABSEG directive will be placed in the default tables. The default tables are unnamed, as if a LABSEG directive had been included at the very beginning of the source file with an empty string as *name* ('""').

For example:

```
        eval    EQUX    "calculator",eval    ; import a symbol
        ...
        bsr     eval

        LABSEG  "calculator"            ; create new tables
        INCLUDE "sources:otherprojects/calculator.s"
        LABSEG  __OldLabseg             ; drop back to previous used tables
```

Another example:

```
        ...
        rts

        LABSEG  "foo"           ; create new tables named 'foo'
foo:    ...
        LABSEG  "bar"           ; create new tables named 'bar'
bar:    ...
        LABSEG  "foo"           ; use tables labeled 'foo'
foofoo: ...
        LABSEG  ""              ; drop back to initial symbol
                                ; macro tables
```

LABSEG *__OLDLABSEG* Revert to the previous LABSEG scope

This directive reverts to the LABSEG scope that was in effect before the most recent LABSEG directive.

This can be used in include files, for example, to temporarily switch to a different section and than later switch back to the LABSEG scope that was in use by the "parent" source file. This feature does not stack, however; additional LABSEG __OLDLABSEG directives merely toggle between the two most recent scopes.

The keyword `__OLDLABSEG` is case-insensitive.

Example:

```
foo     EQUX    "foo",bar     ; import symbol 'bar' from LABSEG foo
        dots
        LABSEG  "foo"         ; create new tables named 'foo'
bar:    dots
        LABSEG  __OldLabseg   ; toggle back to previous scope

bar:    dots
        bra     foo           ; jump to symbol 'bar' within LABSEG foo
```

symbol **EQUX** *scope*,*xsymbol* — Import a symbol from another `LABSEG` scope

This directive allows you to import a symbol from another `LABSEG` scope.

The symbol in question is the symbol `xsymbol` from the `LABSEG` scope *scope*, and it will be added to the current symbol table as *symbol*.

Consider the following example:

```
      LABSEG  "mainscope"
foo:  ...

      LABSEG  "subscope_1"
foo2  EQUX    "mainscope",foo ; import symbol 'foo' named as 'foo2'
foo:  ...
      bsr     foo2           ; go to 'foo' from the 'mainscope' LABSEG scope
      bra     foo            ; jump to 'foo' of this scope
```

It works similar to the `EQU` directive, except that you have to name the `LABSEG` scope, the symbol in question (*xsymbol*) is taken from. Note that symbols can only be imported and never exported.

6 Special Symbols

ProAsm defines a variety of built-in symbols which are automatically substituted with certain values when you use them. Some of these are useful at any point in the program, while others are useful only in certain places like inside macro bodies. You may use these symbols in any combination of uppercase and lowercase: for example, `__DATE`, `__date`, and `__Date` are equivalent. These symbols cannot be redefined with `EQU`, `SET`, etc. If you try to, ProAsm reports a '`reserved symbol`' error.

Besides the special symbols listed here, there are a few others which are only useful inside macro bodies; they are listed in Section 5.2.1 *Symbols and Keywords for Macros*, page 54.

__PRO ProAsm version number

This symbol is replaced by the version number of ProAsm, in binary coded decimal. Bits 8–15 contain the version number and bits 0–7 the revision number.

```
$0082  means version 0, revision 82
$0192  means version 1, revision 92
```

Most of the modern assemblers support a similar type of identification to make it possible for the source code to determine which assembler is currently being used. For example, the following source code ensures that ProAsm 1.02 or later is being used to assemble the source code:

```
IFND    __PRO
FAIL    You need ProAsm to assemble this source code.
ENDC

IFGT    __PRO,$0192
FAIL    ProAsm version 1.92 or higher required.
ENDC
```

__RS `RS` structure offset

__SO `SO` structure offset

__FO `FO` frame offset

These symbols always represent the current values of the structure offset maintained by the `RS`... and `SO`... directives, and the frame offset maintained by the `FO`... directives, respectively. See Section 5.5.2 *Structure Offsets*, page 77, for information on these directives.

Note that `__RS` and `__SO` represent the value that will be assigned to the label in the *next* `RS`... or `SO`... directive, respectively, while `__FO` represents the value that *was* assigned to the label in the *previous* `FO`... directive. This is because the `RS`... and `SO`... directives are post-incrementing, while the `FO`... directives are pre-decrementing.

_MOVEMREGS — Number of registers moved in last `MOVEM`
_MOVEMBYTES — Number of bytes moved in last `MOVEM`
_MOVEMLIST — Register list moved in last `MOVEM`

The symbol `_MOVEMREGS` always contains the number of registers moved in the last `movem` instruction seen by the assembler.

`_MOVEMBYTES` contains the number of bytes moved by that `movem`. `_MOVEMBYTES` is always twice `_MOVEMREGS` if the last `movem` was a word (16-bit) instruction, and four times `_MOVEMREGS` if the last `movem` was a longword (32-bit) instruction.

The symbol `_MOVEMLIST` contains the register list moved in the last `movem` instruction seen by the assembler, as if it had been defined with `REG`.

These symbols are useful to an assembly language routine for accessing parameters stored "C-style" on the stack, when the function uses `movem` to save and restore registers:

```
myroutine:
        movem.l d2-d5/a2,-(sp)          ; Save registers
        move.l  _MOVEMBYTES(sp),d0      ; First parameter

        ...

        movem.l (sp)+,_MOVEMLIST        ; Restore registers
        rts
```

This way, you do not have to change the offset for each instruction that accesses these parameters whenever you change the number of saved registers.

Notice that these three symbols are prefixed with only one underscore ('`_`'), unlike most of the other built-in symbols, which are prefixed with two underscores ('`__`'). This is for compatibility with existing assemblers.

__BASE Current base address

This symbol always contains the current base address, if any is defined. For example, after the statement '`BASE base_addr`', `__BASE` will be the same as the symbol '`base_addr`'. If no base is defined, `__BASE` is zero. See `BASE`, page 108, for information about the `BASE` directive.

__V*n* Command-line variable *n*

These symbols are replaced with the values you specify in the '`-V`*n*`=`*value*' command-line options of ProAsm, where *n* is between 0 and 9, as described in Section 3.1 *Invoking*, page 9. If you do not specify a value for one of these symbols on the command line, *value* is set to zero by default.

__PR Host processor

ProAsm replaces this symbol with a number indicating which M68000 family processor ProAsm is currently executing on. It will contain one of the following values:

0	68000
1	68010
2	68020
3	68030
4	68040
6	68060
13	68EC030 (a 68030 without an MMU)
14	68LC040 (a 68040 without an MMU) or 68EC040 (a 68040 without an MMU or FPU)

Note: This symbol represents the processor ProAsm is *executing on* (the *host* processor), not the processor ProAsm is *writing code for* (the *target* processor). This directive has nothing to do with the `MC`... directives, which select the target processor.

__CP Host coprocessors

This symbol is replaced with a number indicating what coprocessors, if any, are installed in the computer ProAsm is running on. Any of the following bits may be set in the number:

Bit 0	Either a 68881 or a 68882 math coprocessor is installed. (The built-in FPU on the 68040 does not cause this bit to be set.)
Bit 1	A 68882 math coprocessor is installed (not a 68881 or the 68040 FPU).
Bit 2	A 68851 MMU is installed. (The built-in MMU on the 68030 or 68040 does not cause this bit to be set.)

The actual values you may get for the various M68000 series processors are broken down in the following table:

68000	0	
68010	0	
68020		
	0	No coprocessors installed.
	1	68881
	3	68882
	4	68851
	5	68881 and 68851
	7	68882 and 68851
68030		
	0	No external coprocessors installed.
	1	68881
	3	68882
68040	0	

__DATE Current date: '`DD-MMM-YYYY`'
__DATE2 Current date: '`DD.MM.YY`'
__DATE3 Current date: '`MM/DD/YY`'
__TIME Current time: '`HH:MM:SS`'
__DAY Current day of the week

As their names indicate, these symbols are automatically replaced with the current date or time (i.e. when ProAsm is assembling the current program), expressed as an ASCII string which you can use in a `DC.B` directive.

The date can be formatted in three different ways, depending on which symbol you use:

`__DATE` The date is formatted as '`DD-MMM-YYYY`', where '`DD`' is the two-digit day of the month (between 01 and 31), '`MMM`' is the month as an abbreviated name ('`Jan`', '`Feb`', etc.), and '`YYYY`' is the year, expressed as a four-digit number (i.e. '`1992`').

`__DATE2` The date is formatted as '`DD.MM.YY`' (European format), where '`DD`' is the day, '`MM`' is the month (from 01 to 12), and '`YY`' is the last two digits of the year (i.e. '`92`' for 1992).

`__DATE3` The date is formatted as '`MM/DD/YY`' (U.S. format)—exactly like `__DATE2`, except the month and day are swapped, and the periods are replaced with slashes.

`__TIME` is substituted with the current time, in the standard '`HH:MM:SS`' format.

`__DAY` is replaced with the current day of the week (i.e. '`Monday`').

Here is a code fragment that demonstrates the use of these symbols:

```
DC.B    'Assembled on ',__DAY,' ',__DATE,' at ',__TIME,0
; ⇒ e.g. 'Assembled on Monday 16-Aug-1993 at 19:51:08'
```

__LINENUM — Current line number

This symbol always contains the current line number of the program text.

__RCODE — Built-in Symbol

If ProAsm has detected any errors during assembly at this point, `__RCODE` is set to 10; otherwise it is set to zero. In effect, it is the return code ProAsm would return to AmigaDOS if the source file ended at the point of the `__RCODE`. You can change the return code ProAsm returns (and thus the contents of `__RCODE`) with the `RC...` directives (see `RCRESET`, page 165, and `RCSET`, page 165).

__LK — Output object type

This symbol is replaced with a number describing the type of object file to be produced from this assembly. To set the output file format, see Section 5.9.2 *Output File Format*, page 129.

`0`	No object file is being produced
`2`	Raw binary
`3`	AmigaDOS linkable object module
`4`	AmigaDOS executable
`5`	Preasm file
`6`	Motorola S-record

__NAN Not-a-number
__SNAN Signaling not-a-number
__INFINITY Infinity

`__NAN` (not-a-number) represents the result of operations that have no mathematical interpretation, such as infinity divided by infinity. Any computation for which a NAN is provided as input will generate a NAN as output: NANs propagate through floating-point computations like a virus. This symbol allows you now to use NANs, for example, to invalidate floating-point variables so that any computations that accidentally use them will produce clearly invalid results.

`__SNAN` represents a signaling not-a-number (SNAN). When an SNAN is used in a computation, the processor generates a floating-point exception.

The symbol `__INFINITY` represents a positive infinite floating-point number. Infinities represent real values that exceeded the overflow threshold.

These symbols can only be used with floating-point instructions or directives.

Example

```
fmove.x #__INFINITY,fp0  ; load FP0 with positive infinity
fmove.d #-__INFINITY,fp1 ; and FP1 with negative infinity
```

Refer to the *MC68881/MC68882 Floating-Point Coprocessor User's Manual* or any other manual that describes the MC68881/MC68882 coprocessors for detailed information about the data formats.

NARG Number of arguments to macro

This symbol is replaced by the number of arguments the macro was invoked with, as illustrated by this code:

```
foo     MACRO
        dc.l    NARG
        ENDM

        foo                 ; ⇒ 0
        foo     a           ; ⇒ 1
        foo     a,b         ; ⇒ 2
```

This feature is usually used to create macros that can operate on different numbers of arguments, performing slightly different functions as appropriate. Therefore, `NARG` is usually used with `IF` directives.

RARG Number of *real* arguments to macro

RARG is quite similar to the NARG symbol, except that NARG contains the number of arguments passed to the macro and RARG the number of arguments that actually contain anything ("real" arguments).

```
myMacro         1,2,3,4,5       ;NARG=5, RARG=5
myMacro         1,2,,4,5        ;NARG=5, RARG=4
myMacro         1,2,,,,5        ;NARG=6, RARG=3
myMacro.b       1,2,3,4,5       ;NARG=6, RARG=6
myMacro.w       1,2,,4,5        ;NARG=6, RARG=5
```

_MCOUNT Current macro number

This symbol can always be used to determine the number of macros currently used. (How many times macros have been expanded.)

7 Support Libraries

The support libraries are shared Amiga libraries that can be used to increase the power and flexibility of ProAsm. They are not required by ProAsm or any of its associated utilities to run. Install the libraries to enlarge the capacity of ProAsm and de-install them to remove these additional capacities.

7.1 Installation and De-installation

The installation and de-installation process is quite as easy as flipping a power switch.

To use the features of one or more libraries, install them by copying the library to the search path of ProAsm. ProAsm searches its libraries in the '`libs:`' assign, the '`libs:proasm`' directory, and in ProAsm's home directory.

To de-install a library, just remove it from the ProAsm's library search pathes. Instead of removing a library we recommend to rename it (e.g. add an underscore ('`_`')to its name). This way that the libraries vanish from your harddisk or disk.

7.2 The `proasmlang.library`

ProAsm fully supports the AmigaDOS 2.1 localization library mechanism for the error texts. Some locale catalogs are included with this release.

To use localization install this library and the desired catalog file. When installed correctly, all during an assembly process reported errors will be issued in the selected language.

7.3 The `proasmoptim.library`

The `proasmoptim.library` looks at the generated code while assembly is in progress and makes suggestions about possible optimizations.

The current library reports only the recognized optimizations and does not lay its hands on the produced code. A future version may have the possibility to optimize the code, but for the actual version all optimizations have to be made by hand.

See also see `OPT OPTIMLIB`, page 102.

8 ProAsm Associated Utilities

8.1 ASX - The ProAsm User Interface

ASX is a user interface for the ProAsm assembler that is implemented as a commodity. Through the use of the commodities.library it can be installed on any hotkey and controlled fully with the Commodities Exchange program.

ASX loads the ProAsm assembler which than can be accessed using the ARexx interface, the asx.library, or the AppIcon possibility. The asx.library and the AppIcon can optionally be enabled or disabled.

The ARexx commands provide a method of controlling ASX from an external program. These ARexx commands can be used to create an integrated programming/development environment with any application that offers an ARexx interface. For example, a program can be written by a programmer on its favourite ARexx equipped texteditor, then an ARexx command can be sent to ASX to assemble the source code. Any error messages and warnings of the assembly are stored by ASX. Using commands such as NEXTERROR and PREVERROR the texteditor is capable to position the cursor in the line of the first error. After correcting that error a single keystroke can jump to the next error, or another keystroke can jump back to the previous error.

Another method of controlling ASX is the use of the optional asx.library. The various functions that this library offers can be used to design own user interfaces with ease.

The AppIcon possibility is another visual user interface that allows one or more source file icons to be assembled by just dropping them over the ASX AppIcon.

Frequently used include files can be loaded residently and managed by ASX. Such residently loaded include files reduce assembly time since they do not need to be loaded each time the assembler is called.

Preferred include file paths can be added to a database that is managed by ASX. During assembly the assembler uses then this database to know where to look for the include files.

ASX also provides a feature called the source manager, which offers a possibility to manage the current project per hotkey. Through the use of an ARexx script file the user can easily define the action that has to be fulfilled when an entry in the source manager window has been selected.

Almost all shooting matches of the source manager can be set by the user to his wishes and needs to allow a wide range of flexibility.

For an easy use of ASX, it comes along with an on-line help feature. Commodore's AmigaGuide is used to display the help text to the user.

8.1.1 Starting from Workbench

The easiest way to run ASX is from the Workbench. A double-click on its icon loads the program. The '`ENV:asx.prefs`' configuration file will be loaded and processed immediately, if not otherwise desired (see the `LOCALPREFS` tooltype below). The configuration file is an ASCII text that can be edited using a texteditor if needed.

If ASX is already running and you invoke it again, it will open the user interface window of the already running version.

When ASX is started from the WorkBench, the following tooltypes are recognized:

`CX_PRIORITY=`*n*
: Set priority of the commodity to *n*. By default, ASX uses a priority of 0.

`CX_POPKEY=`*hotkey*
: This tooltype allows you to specify the hotkey for ASX to *hotkey*. *Hotkey* must be a valid key sequence for a hotkey. If you enter an incorrect description, a message will be displayed or a requester is opened to inform you. (The hotkey format is described in the *AmigaDOS 2.0 manual*). By default, '`lcommand help`' is used as hotkey.

  If you have defined a hotkey, ASX can be called up at any time by pressing that key sequence.

`CX_POPUP=`*YES*`|`*NO*
: This options allows you to select whether the user interface window of ASX is opened at startup or not. *YES* must be used to open the user interface window. By default, ASX does not open the window.

`APPICON`
: If this tooltype is selected, ASX displays an AppIcon on the workbench screen. See Section 8.1.3.7 *The AppIcon*, page 200.

`ICONX=`*x*

`ICONY=`*y*
: These tooltypes allow you to specify the position of the AppIcon on the WorkBench screen relative to the top left edge. The *x* and *y* coordinates are integer values that describe the top left position.

Normally, the AppIcon will be positioned automatically in an appropriate position on the screen, but you may sometimes want to override this with your own preferred coordinates.

`NOLIBRARY`
: If this tooltype is selected, ASX will not add the `asx.library` to the system. (See Section 8.1.5 *The asx.library*, page 214). By default, the library is installed.

`ASMPATH=`*assembler*
: Using this tooltype you can specify the location and the name of ProAsm. *assembler* describes the path and filename of the ProAsm assembler. By default ASX searches the assembler as '`pro`' in the following locations: '`asm:`' and the current directory.

`SWAP`
: This tooltype tells ASX to load ProAsm each time when used. By default, the assembler is once loaded residently. Loading the assembler residently can be useful on disk based systems. This tooltype is also recommended on systems with little memory.

`ERRFILE=`*filename*
: This tooltype defines the name of the error file to *filename* that is automatically used for all assembly task started by ASX (via ARexx and asx.library).

`HEADERFILE=`*filename*
: This tooltype defines the header *filename* that is automatically used for all assembly task started by ASX (via ARexx and asx.library).

`CONFIGFILE=`*filename*
: This tooltype defines the configuration *filename* that is automatically used for all assembly task started by ASX (via ARexx and asx.library).

`NOREQ`
: If this tooltype is selected, ASX will not open any message requesters. This can be useful if you do not want to be interrupted by these requesters. But note that also all error message reported by ASX will be suppressed silently.

`NORASTER`
: To get a stronger 3D-look, ASX fills the background of all its windows with a pattern. If you do not want to have this pattern as background, you can unselect this tooltype and it will be written automatically to the settings file when you save settings. By default, a rastered background is displayed.

`LOCALPREFS=`*filename*
: This tooltype tells ASX to use the file *filename* as configuration file, instead of the default configuration file named '`ENV:asx.prefs`'.

`NOMASTER`
: This tooltype can be used to forbid the source manager. By default, the source manager is enabled.

`AREXXSCRIPT=`*filename*
: This tooltype allows you to specify the ARexx script that is executed when an entry in the source manager is selected. *Filename* is the complete name and path of the ARexx script. By default, '`rexx:pro/sourcemanager.rexx`' is used.

`SMHOTKEY=`*hotkey*

This tooltype allows you to specify the hotkey for the source manager to *hotkey*. *Hotkey* must be a valid key sequence for a hotkey. If you enter an incorrect description, a message will be displayed or a requester is opened to inform you. (The hotkey format is described in the *AmigaDOS 2.0 manual*). By default, '`lcommand shift help`' is used as hotkey.

If you have defined a hotkey, the source manager can be called up at any time by pressing that key sequence.

`SMPUBSCREEN=`*screenname*

This tooltype can be used to specify the public screen the source manager should be opened on. *Screenname* is the name of the desired public screen. By default, the source manager opens its window on the front public screen.

`NOFALLBACK`

This tooltype forbids the source manager window to open its window on the default public screen if the explicitly specified public screen is not available. By default, the source manager does "fall back".

8.1.2 Starting from the Shell

ASX can be started from the shell by typing its name and the parameters you need. Enter '`ASX ?`' for a shell usage template.

The '`ENV:asx.prefs`' configuration file will be loaded and processed immediately, if not otherwise desired (see the `LOCALPREFS` argument below). The configuration file is an ASCII text that can be edited using a texteditor if needed.

If ASX is already running and you invoke it again, it will open the user interface window of the already running version.

There is no need to use the AmigaDOS `Run` command to start ASX as it will automatically self-detach from the shell or CLI that it was started from.

The command line options override the default settings of ASX. In the following you find a list of all command line parameters supported by ASX. See also see Section 8.1.1 *Starting from Workbench*, page 182.

`CX_PRIORITY` *n*

Set priority of the commodity to *n*. By default, ASX uses a priority of 0.

`CX_POPKEY` *hotkey*

This argument allows you to specify the hotkey for ASX to *hotkey*. *Hotkey* must be a valid key sequence for a hotkey. If you enter an incorrect description, a message will be displayed or a requester is opened to inform you. (The hotkey format is described in the *AmigaDOS 2.0 manual*). By default, '`lcommand help`' is used as hotkey.

If you have defined a hotkey, ASX can be called up at any time by pressing that key sequence.

`CX_POPUP` *YES*|*NO*

This argument allows you to select if whether the user interface window of ASX is opened or not. *YES* must be used to open the user interface window. By default, ASX does not open the window.

`APPICON` If this argument is given, ASX displays an AppIcon on the workbench screen. See Section 8.1.3.7 *The AppIcon*, page 200.

`ICONX` *x*

`ICONY` *y* These arguments allow you to specify the position of the AppIcon on the WorkBench screen relative to the top left edge. The *x* and *y* coordinates are integer values that describe the top left position.

Normally, the AppIcon will be positioned automatically in an appropriate position on the screen, but you may sometimes want to override this with your own preferred coordinates.

`NOLIBRARY`

If this tooltype is selected, ASX will not add the `asx.library` to the system. (See Section 8.1.5 *The asx.library*, page 214). By default, the library is installed.

`ASMPATH` *assembler*

this argument allows you to specify the location and the name of ProAsm. *assembler* describes the path and filename of the ProAsm assembler. By default ASX searches the assembler as '`pro`' in the following locations: '`asm:`' and the current directory.

`SWAP` This argument tells ASX to load ProAsm each time when used. By default, the assembler is once loaded residently. Loading the assembler residently can be useful on disk based systems. This tooltype is also recommended on systems with little memory.

`ERRFILE` *filename*

This argument defines the name of the error file to *filename* that is automatically used for all assembly task started by ASX (via ARexx and asx.library).

`HEADERFILE` *filename*

This argument defines the header *filename* that is automatically used for all assembly task started by ASX (via ARexx and asx.library).

`CONFIGFILE` *filename*
: This argument defines the configuration *filename* that is automatically used for all assembly task started by ASX (via ARexx and asx.library).

`NOREQ`
: If this argument is given, ASX will not open any message requesters. This can be useful if you do not want to be interrupted by these requesters. But note that also all error message reported by ASX will be suppressed silently.

`NORASTER`
: To get a stronger 3D-look, ASX fills the background of all its windows with a pattern. If you do not want to have this pattern as background, you can select this argument and it will be written automatically to the settings file when you save settings. By default, a rastered background is displayed.

`LOCALPREFS` *filename*
: This argument tells ASX to use the file *filename* as configuration file, instead of the default configuration file named '`ENV:asx.prefs`'.

`NOMASTER`
: This argument can be used to forbid the source manager. By default, the source manager is enabled.

`AREXXSCRIPT` *filename*
: This argument allows you to specify the ARexx script that is executed when an entry in the source manager is selected. *Filename* is the complete name and path of the ARexx script. By default, '`rexx:pro/sourcemanager.rexx`' is used.

`SMHOTKEY` *hotkey*
: This command line argument allows you to select the hotkey for the source manager to *hotkey*. *Hotkey* must be a valid key sequence for a hotkey. If you enter an incorrect description, then a message will be displayed or a requester is opened to inform you. (The hotkey format is described in the *AmigaDOS 2.0 manual*). By default, '`lcommand shift help`' is used as hotkey.

  If you have defined a hotkey, the source manager can be called up at any time by pressing that key sequence.

`SMPUBSCREEN` *screenname*
: This argument can be used to specify the public screen the source manager should be opened on. *Screenname* is the name of the desired public screen. By default, the source manager opens its window on the front public screen.

`NOFALLBACK`
: This argument forbids the source manager window to open its window on the default public screen if the explicitly specified public screen is not available. By default, the source manager does "fall back".

8.1.3 The User Interface

This section describes the user interface of ASX. As user interface, ASX presents six different windows and an AppIcon. Everything in these windows should be fairly self-explanatory. If ASX is started from the Workbench or the command line, no window will be opened except the '`CX_POPUP=YES`' tooltype or command line option was selected. The window can also be opened by using the hotkey, the `Exchange` program that comes along with the Workbench 2.0 or higher, or by starting ASX again.

A window opened by ASX can present itself in two different forms. A large window occupying nearly one third of a normal 640x400 Workbench screen, and a 'zoomed' window, where only the close gadget, the zoom gadget, the depth gadget, and the window title are visible. If you click the zoom gadget, ASX's window will toggle between the large and the 'zoomed' window.

When using ASX, you may get in contact with one or more of the following basic types of gadgets:

`action` Action-gadgets appear as raised buttons. Normally the buttons are labeled with a small text that is written inside the gadget. Selecting such a button causes an immediate action. For example, the `Quit` gadget in the main window causes ASX to quit.

`list`

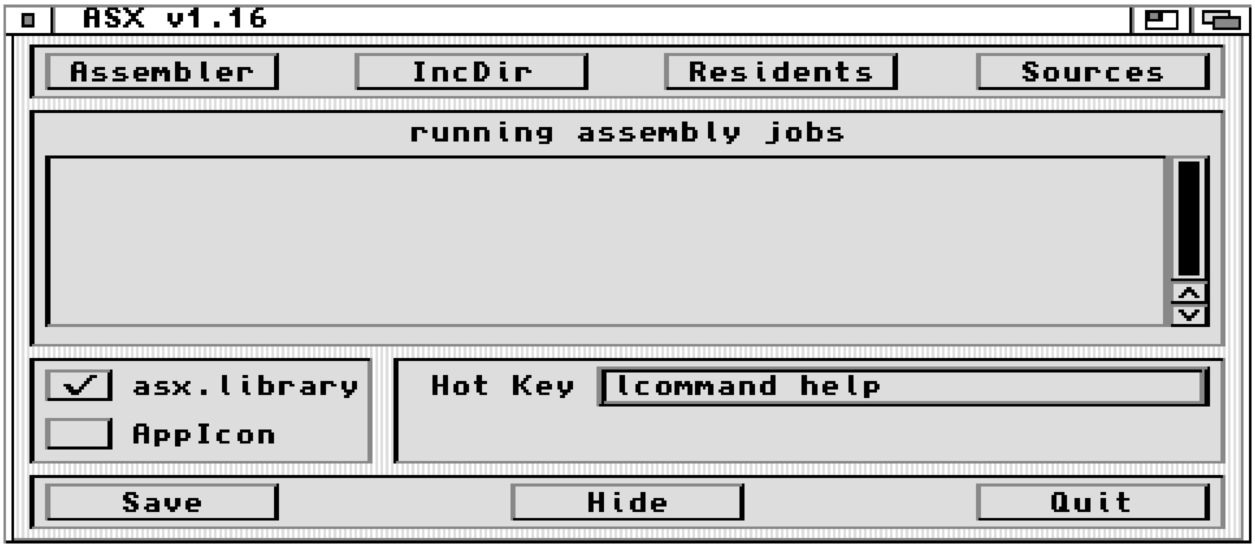
`listview` Generally list-gadgets appear as a set of control gadgets. A small scrollbar, arrow gadgets, and a string area. ASX may have additional control gadgets attached to its list-gadgets. These gadgets are a string-gadget, an add-gadget (in one case), del-gadget, a select-gadget, top-, up-, down-, bottom-, and a sort-gadget. Use the scroll bar and the arrow gadgets to position the scrolling area to a specific entry. To add new entries to the list, select the add- or select-gadget (if available) or type the new entry name into the string-gadget (below the scroll area) and press `RETURN`. Entries can be removed from the list by selecting the entry to be cleared in the scroll area (to copy its name into the string-gadget), and selecting the del-gadget.

The top-, up-, down-, and a bottom-gadget can be used to move the entry to the desired position in the list. Top and bottom move the item directly to either the top end or the bottom end of the list. Up and down move the selected item one position upwards or downwards in the list. The sort-gadget sorts all entries in the list alphabetically. Some gadgets can be disabled if they cannot be used (e.g. on empty lists).

`string` String-gadgets appear as raised ridge around a text area. Any string can be entered by clicking (activating) within the text area and typing your string. When you have finished typing, press the `RETURN` key to confirm or the `TAB` key to confirm and jump to the next string-gadget.

`check` Check-gadgets appear as small rectangular raised buttons, with labeled with a text on the left or the right side of the gadget. When the gadget is selected, a small checkmark appears, or disappears when unselected.

8.1.3.1 The Main Window



This is the main window that shows up when ASX's user interface is opened. From here you can access the additional windows or handle the ASX concerning settings.

The Gadgets

`Assembler`
: By clicking on this gadget, you will switch to the assembler settings window. See Section 8.1.3.2 *The Assembler Window*, page 191.

`IncDir` Go to the IncDir window. There you can specify the directories where the assembler has to search for include files. See Section 8.1.3.3 *The IncDir Window*, page 193.

`Residents`
: By the selection of this gadget you will switch to the residents settings window. See Section 8.1.3.4 *The Residents Window*, page 194.

`Sources`
: Selecting this gadget switches to the source manager preference window. See Section 8.1.3.5 *The Source Manager Preferences Window*, page 196.

`running assembly jobs`
: This listview-gadget shows all running jobs. A job is represented by its ARexx port name and its ID. See Section 8.1.4 *The ARexx Interface*, page 200, for the description of the `DefineID`, the `FindID`, and the `GetPort` commands.

`asx.library`
: This gadget can be used to control the use of the asx.library. If it is checked (selected) the asx.library is installed. See Section 8.1.5 *The asx.library*, page 214.

`AppIcon`
: If this check-gadget is selected an AppIcon is put on the Workbench screen. See Section 8.1.3.7 *The AppIcon*, page 200.

`Hot Key`
: This allows you to select what key sequence is used to open the ASX main window when it is hidden, by entering the key description into the string gadget. Any standard commodities key description can be given. If you enter an incorrect description, a message will be displayed or a requester is opened to inform you. (The hotkey format is described in the *AmigaDOS 2.0 manual*). By default, '`lcommand help`' is used as hotkey.

  If you have defined a hotkey, ASX can be called up at any time by pressing that key sequence.

`Save`
: Stores the current settings to '`ENVARC:asx.prefs`' and '`ENV:asx.prefs`'.

`Hide`
: This function closes the ASX user interface, but leaves ASX installed in the background. This allows you to have ASX constantly available, while using the minimum amount of memory possible.

  You can also hide ASX by clicking on the close gadget of the window.

`Quit`
: This function tells ASX to exit. Usually, ASX can quit immediately. However, sometimes when you try to quit, another program has not ended the ARexx job or closed the asx.library. A requester will inform you by displaying the number of jobs that are still unfinished yet and ASX refuses to quit.

The Menus

Frequently used menu items in ASX have keyboard equivalents so that you can use them without having to move from the keyboard to the mouse if you don't want to. The keyboard equivalents are not case sensitive.

Menu items that have a sequence of dots following the item name open a requester as part of their execution. Items with a question mark ('?') indicate that they use a checkmark to show that their associated mode is active.

`Project`

`Open...` The `Open...` (`AMIGA-O`) command allows you to load an existing configuration file using a file requester.

`Save` The `Save` (`AMIGA-S`) command stores the current settings to '`ENVARC:asx.prefs`' and '`ENV:asx.prefs`'.

`Save as...`
The `Save as...` (`AMIGA-A`) command is very similar to the `Save` command. It allows you to store the current settings to a user specified file. A file requester is opened that allows you to specify the name of the file the configuration is written to. The file requester will always appear with this command, whereas the `Save` command will assume the predefined names.

`About...` The `About` selection will display the copyright and version notice for ASX, and some information about the used assembler.

`Help...` This `Help` (`AMIGA-?`) command pops up a brief description of the main window. ASX uses the AmigaGuide for a context-sensitive on-line manual.

`Hide` The `Hide` (`AMIGA-H`) menu item closes the ASX user interface, but leaves ASX installed in the background. This allows you to have ASX constantly available, while using the minimum amount of memory possible.

`Quit` The `Quit` (`AMIGA-Q`) menu item tells ASX to exit. Usually, ASX can quit immediately. However, sometimes when you try to quit, another program has not ended the ARexx job or closed the asx.library. A requester will inform you by displaying the number of jobs that are still unfinished yet and ASX refuses to quit.

`Window`

`SnapShot Window`
This command tells ASX to remember the current window position. The window will appear in the new position the next time it is opened.

`UnSnapShot Window`
This command is the opposite of `SnapShot Window`. It flushes the previously stored window position.

`Rastered Background?`
To get a stronger 3D-look, ASX fills the background of all windows with a pattern. If you do not want to have this pattern as background, you can

unselect this menu item and it will be written automatically to the settings file when you save settings. By default, this menu item is selected.

`Settings`

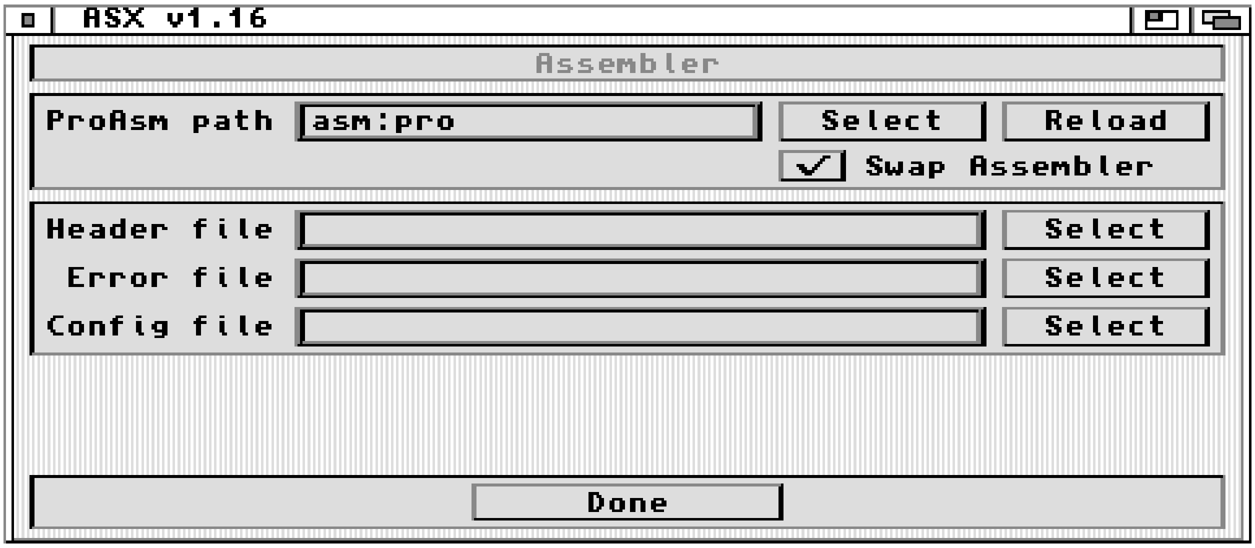
`Assembler`
: The `Assembler` (`AMIGA-E`) menu item lets you switch over to the assembler settings window. See Section 8.1.3.2 *The Assembler Window*, page 191.

`Incdir`
: This `IncDir` (`AMIGA-I`) command changes to the IncDir window. See Section 8.1.3.3 *The IncDir Window*, page 193.

`Residents`
: This `Residents` (`AMIGA-R`) command switches to the residents settings window. See Section 8.1.3.4 *The Residents Window*, page 194.

`Sources`
: This `Sources` (`AMIGA-M`) menu item switches to the source manager preference window. See Section 8.1.3.5 *The Source Manager Preferences Window*, page 196.

8.1.3.2 The Assembler Window



Here you can specify some global assembler settings, that are automatically used when ASX is used to assemble a source code.

All string gadgets in this window are connected to a `Select` gadget. This gadget opens a file requester allowing the desired file to be chosen. The selected file name will instantly be written to the string gadget.

The Gadgets

`ProAsm path`
: Here you can specify the path of the ProAsm assembler. By default ASX searches the assembler as '`pro`' in the following locations: '`asm:`' and the current directory. Note that if you select a new assembler, you have to use `Reload` to force ASX to load it. `Reload` does not have to be used if the `Swap Assembler` gadget is set.

`Reload`
: This gadget forces ASX to reload a new selected assembler. This command must be performed if a new assembler is selected and the `Swap Assembler` is not set.

`Swap Assembler`
: If this check-gadget is selected the assembler is loaded each time when used. By default, the assembler is once loaded residently. Loading the assembler residently can be useful on disk based systems. This tooltype is also recommended on system with little memory.

`Header file`
: Using this string gadget you can define the header file that is automatically used for all assembly tasks started by ASX (via ARexx and asx.library).

`Error file`
: Using this string gadget you can define the error file that is automatically used for all assembly tasks started by ASX (via ARexx and asx.library).

`Config file`
: Using this string gadget you can define the configuration file that is automatically used for all assembly tasks started by ASX (via ARexx and asx.library).

`Done`
: This action gadget toggles back to the main window.

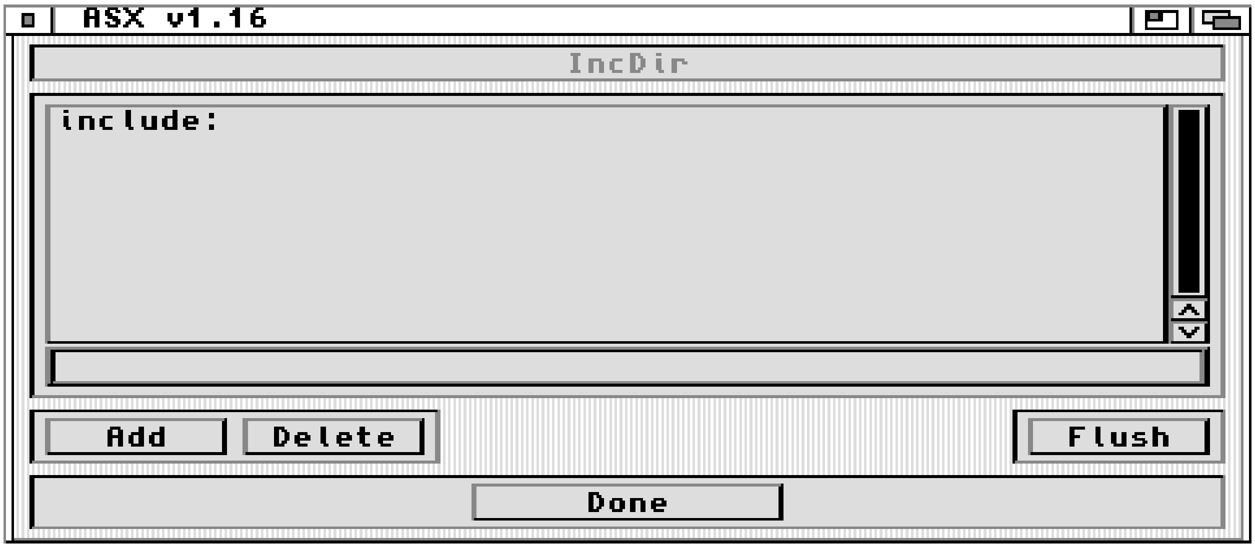
The Menus

The assembler window has only two menu items in the `Assembler` menu:

`Help...`
: The `Help` (`AMIGA-?`) command pops up a brief description of the assembler window. ASX uses the AmigaGuide for a context-sensitive on-line manual.

`Done`
: The `Done` (`AMIGA-X`) command toggles back to the main window.

8.1.3.3 The IncDir Window



Through this interface, you have the possibility to define directories where the assembler (if run by ASX) searches for include files (see Section 5.1.2 *Include Files*, page 47).

The Gadgets

`The listview gadget`
: This gadget shows you the list of all directories that are currently stored by ASX. Use the scroll bar and the arrow gadgets to position the scrolling area to a specific entry. By selecting an entry in the scroll area of the listview gadget its name is copied to the string-gadget.

`The string gadget`
: The string-gadget contains usually the name of the selected entry. A new entry can also be added to the list of directories by entering its name into the string-gadget and pressing `RETURN`.

`Add`
: This command allows you to add a directory to the list of directories using a file requester.

`Delete`
: The `Delete` command deletes the selected directory. A directory can be selected by entering its name into the string gadget, or by selecting the desired directory in the scroll area of the listview gadget.

`Flush` This command deletes all entries in the directory list.

`Done` This command quits the current window and switches back to the main window.

The Menus

The incdir window has five menu items in the `Edit` menu:

`Add` The `Add` (`AMIGA-A`) command allows you to add a directory to the list of directories using a file requester.

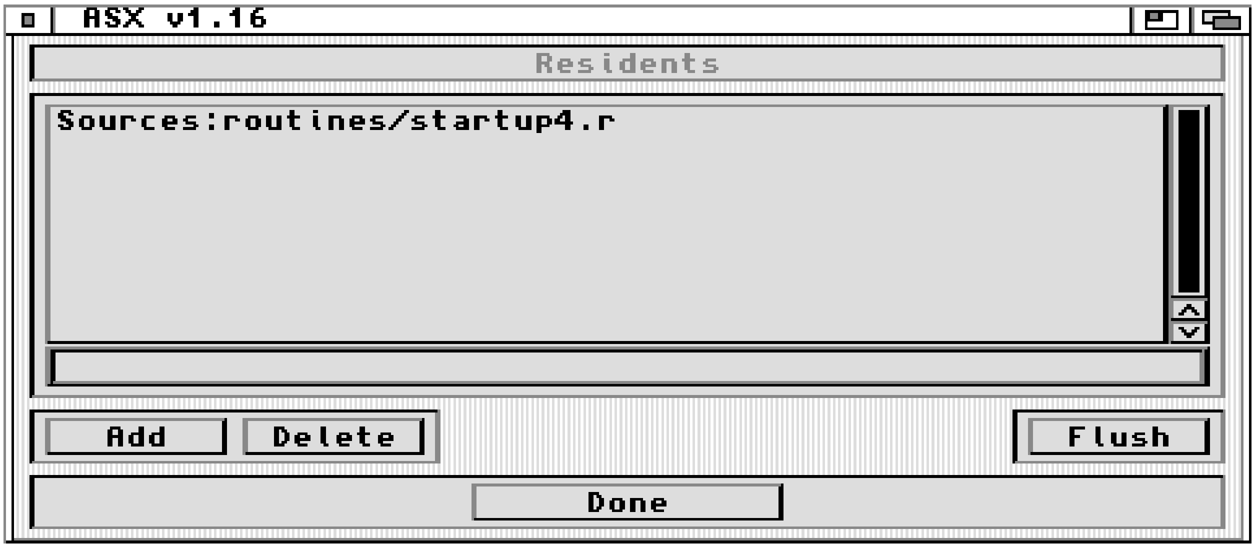
`Delete` The `Delete` (`AMIGA-D`) command deletes the selected directory. A directory can be selected by entering its name into the string gadget, or by selecting the desired directory in the scroll area of the listview gadget.

`Flush` This command deletes all entries in the directory list.

`Help...` The `Help` (`AMIGA-?`) command pops up a brief description of the incdir window. ASX uses the AmigaGuide for a context-sensitive on-line manual.

`Done` The `Done` (`AMIGA-X`) command quits the current window and switches back to the main window.

8.1.3.4 The Residents Window



Through this interface, you have the possibility to load include files residently. The assembler, run by ASX, can later access these files without the need of loading them again. Residently loaded include files speed up your assembly time but reduce the memory.

The Gadgets

`The listview gadget`
: This gadget shows you the list of all files that are currently kept in memory by ASX. Use the scroll bar and the arrow gadgets to position the scrolling area to a specific entry. By selecting an entry in the scroll area of the listview gadget its name is copied to the string-gadget.

`The string gadget`
: The string-gadget contains normally the name of the selected entry. A new entry can also be added to the list of resident files by entering its name into the string-gadget and pressing `RETURN`.

`Add`
: This command allows you to add a file to the list of residently loaded include files using a file requester.

`Delete`
: The `Delete` command deletes the selected file and frees allocated memory. A file can be selected by entering its name into the string gadget, or by selecting the desired file in the scroll area of the listview gadget.

`Flush`
: This command deletes all entries in the file list, and frees all allocated memory.

`Done`
: This command quits the current window and switches back to the main window.

The Menus

The incdir window has five menu items in the `Edit` menu:

`Add`
: The `Add` (`AMIGA-A`) command allows you to add a file to the list of residently loaded include files using a file requester.

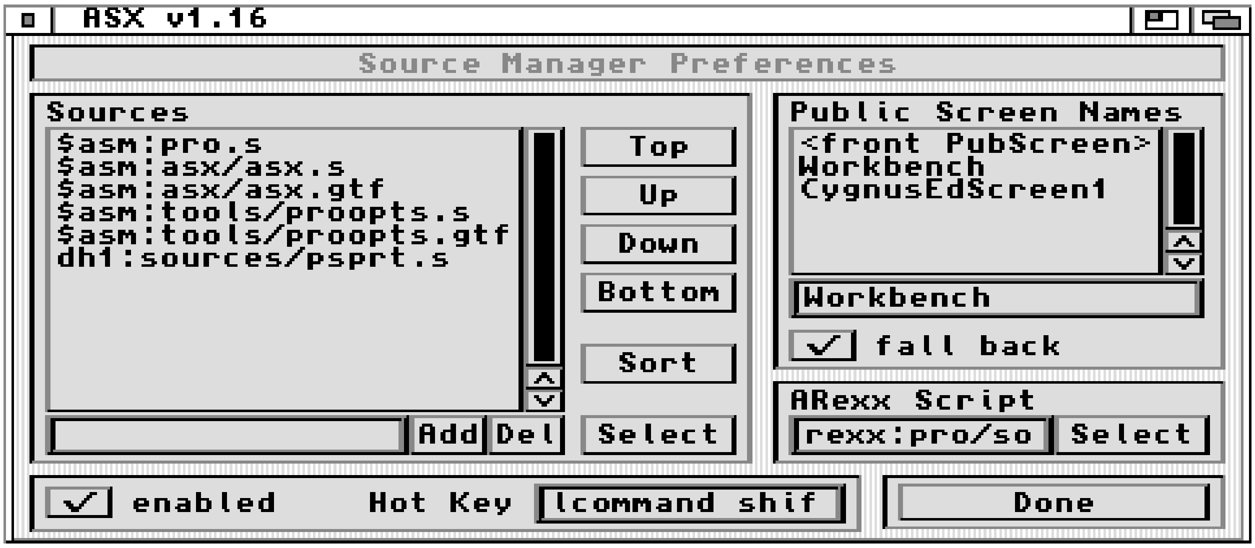
`Delete`
: The `Delete` (`AMIGA-D`) command deletes the selected file and frees allocated memory. A file can be selected by entering its name into the string gadget, or by selecting the desired file in the scroll area of the listview gadget.

`Flush`
: This command deletes all entries in the file list, and frees all allocated memory.

`Help...`
: The `Help` (`AMIGA-?`) command pops up a brief description of the residents window. ASX uses the AmigaGuide for a context-sensitive on-line manual.

`Done` The `Done` (`AMIGA-X`) command quits the current window and switches back to the main window.

8.1.3.5 The Source Manager Preferences Window



The source manager preferences window offers various settings to configure the source manager (see Section 8.1.3.6 *The Source Manager Window*, page 198).

The Gadgets

`The Sources ListView-Gadget`

This listview-gadget shows you a list of all entries that are currently stored by ASX. All these entries will also be shown by the source manager. Use the scroll bar and the arrow gadgets to position the scrolling area to a specific entry. By selecting an entry in the scroll area of the listview gadget its name is copied to the string-gadget directly below.

See Section 8.1.3 *The User Interface*, page 187, for more information about a listview-gadget and how to handle it. New to this listview-gadget is, that it has a `Sort` gadget attached to it. This gadget can be used to sort all entries in alphabetical order.

An entry is a simple string that is later used by the ARexx script (see below).

`The Public Screen Names ListView-Gadget`

This listview-gadgets shows all currently opened public screens plus '`<front PubScreen>`' as first entry. Below the listview-gadget is a string-gadget that contains the name of the selected public screen. Use the scroll bar and the arrow gadgets to position the scrolling area to a specific entry. By selecting an entry in the scroll area of the listview gadget its name is copied to the string-gadget directly below.

The source manager can be limited to be opened on only one public screen by selecting the desired screen. If '`<front PubScreen>`' is selected, the source manager will popup on the front public screen. Which, in the most cases, will be the screen of the program you currently work with.

`fall back` When this check-gadget is selected, the source manager window does "fall back" to open its window on the default public screen if the explicitly specified public screen is not available. Otherwise the source manager does silently abort.

`ARexx Script`

These gadgets allow you to specify the ARexx script that is executed when an entry in the source manager is selected (see Section 8.1.3.6 *The Source Manager Window*, page 198). This can be done by either entering the name and the complete path into the string gadget, or by selecting the `Select` gadget. The `Select` gadget opens a file requester with whom the desired script can be selected more easily.

When an entry is selected using the source manager (see Section 8.1.3.6 *The Source Manager Window*, page 198), its string and the name of the public screen the window is opened on are passed to the ARexx script as arguments. The public screen name can be used to determine the program the source manager is used from. You can use the `PARSE` command of ARexx to put the arguments into ARexx variables. Consider the following example:

```
/* ARexx programs must start with a comment */
    OPTIONS RESULTS
    PARSE ARG source,pubscreen    /* get the arguments */
```

In the above example the `source` variable contains the selected string and `pubscreen` the public screen name. Look at the sample script file '`SourceManager.rexx`' for an example how the source manger can be used.

By default, '`rexx:pro/sourcemanager.rexx`' is used as script.

`enabled` Using this check-gadget you can control the allowance of the source manager. If selected the source manager is enabled and its window will be opened when its hotkey is pressed. By default, the source manager is enabled.

`Hot Key` This allows you to select what key sequence is used to open the source manager window, by entering the key description into the string gadget. Any standard commodities key description can be given. If you enter an incorrect description, a message will be displayed or a requester is opened to inform you. (The hotkey format is described in the *AmigaDOS 2.0 manual*). By default, '`lcommand shift help`' is used as hotkey.

If you have defined a hotkey, the source manager can be called up at any time by pressing that key sequence.

Done This action gadget toggles back to the main window.

The Menus

The source manager preferences window has the following five menu items:

`Add source`
: The `Add source` (`AMIGA-A`) command allows you to add a file name to the list of source codes using a file requester.

`Delete source`
: The `Delete` (`AMIGA-D`)command deletes the selected entry. An entry can be selected by entering its name into the string gadget, or by selecting the desired entry in the scroll area of the 'Sources' listview-gadget.

`Flush source`
: This command deletes all entries in the 'Sources' list.

`Help`
: The `Help` (`AMIGA-?`) command pops up a brief description of the source manager preferences window. ASX uses the AmigaGuide for a context-sensitive on-line manual.

`Done`
: The `Done` (`AMIGA-X`) command toggles back to the main window.

8.1.3.6 The Source Manager Window

The source manager provides a small project manager for a programming/development environment. Using the source manager you can handle your current projects in a very easy way. The interface between the manager and the application program builds an ARexx script. An ARexx script has the advantage that it allows also more than one application to be managed, even applications without an ARexx interface.

The source manager window is probably the simplest window. It pops up on the specified or on the front most public screen when you pressed the source manager hotkey defined in the source manager preferences window (see Section 8.1.3.6 *The Source Manager Window*, page 198). Note that the window of the source manager can only be opened on public screens (see Section 8.1.3.5 *The Source Manager Preferences Window*, page 196). The window presents itself only with a listview-gadget, a window close-gadget, and a menu.

The Gadgets

`The ListView-Gadget`
: The listview-gadget contains the same entries as defined in the source manager preferences (see Section 8.1.3.6 *The Source Manager Window*, page 198). When an entry is selected, by either a doubleclick or the `RETURN` key, the specified ARexx script is executed with the selected entry and the name of the public screen as arguments. For more details about this ARexx script and the argument passing, see Section 8.1.3.6 *The Source Manager Window*, page 198.

`The Window Close-Gadget`
: Select this gadget to cancel. It also closes the source manager window.

The Keyboard

The source manager window is also keyboard controllable:

`up and down arrow keys`
: You may use this keys to select an entry. They have the same function as the small up and down arrow-gadgets attached to the listview-gadget.

`RETURN`

`ENTER`
: One of these keys can be used to execute the ARexx script with the selected entry and the public screen name the window is opened on as arguments. In their function, they are identical to a double-click on the selected entry.

`ESC`
: Press the `ESC` key to cancel. It also closes the source manager window.

`Hotkey`
: Pressing the hotkey while the source manager window is open, the window is forced to the front, and it will be activated.

The Menu

The source manager window has a very short menu. The only menu item is `CANCEL`.

The `CANCEL` (`AMIGA-C`) command closes the source manager window and cancels the operation.

8.1.3.7 The AppIcon

If the `AppIcon` gadget in the main window is selected, an AppIcon is displayed on the Workbench screen. If ASX was started from Workbench, the AppIcon has the same icon as ASX. Otherwise the built in icon is used.

The operations that can be performed with the AppIcon are very easy:

`Show Interface`
: A double-click on the icon forces ASX to open the main window when it is hidden. It has the same effect as pressing the ASX's hotkey.

`Assemble Files`
: Just select one or more file icons (no drawers) on the Workbench, drag them to the ASX AppIcon and drop them. ASX will then assemble one file after the other. Note that no report window is opened to observe the assembly progress. Use the `ERRFILE` directive (see Section 5.10.1 *The Error File*, page 146, for its description) to let the assembler generate error files that can be looked at later.

8.1.4 The ARexx Interface

ARexx is an interpreted intercommunication language for the Amiga with the ability to send commands to and receive commands from other programs. ASX has an ARexx interface built into it that allows external programs to control ASX. The commands offered by ASX can be used to create an integrated programming/development environment with any ARexx equipped application.

If you want to send commands from an ARexx equipped program to ASX, ARexx has to be informed. This is done using the `ADDRESS` command:

```
ADDRESS 'asx_rexx'
```

Be aware that case is important. ARexx will not find the port if the name is not spelled correctly.

8.1.4.1 An ARexx Example

Here is a small example ARexx program that talks to ASX. In the following example all plain ARexx commands are written in upper case, and the ASX ARexx commands in mixed case: For a description of the plain ARexx commands refer to the *AmigaDOS manual*.

```
/* ARexx programs must start with a comment */

OPTIONS RESULTS
PARSE ARG SourceFile,OutputFile      /* get arguments */
ADDRESS 'asx_rexx'                   /* talk to ASX */

BeginAssembly                        /* start an ASX Daemon Task */
DaemonPort = RESULT

IF DaemonPort~='' THEN DO
        ADDRESS (''||DaemonPort)     /* now talk to the daemon task */
        DefineID 'foo'               /* optionally define an ID */
        Assemble SourceFile -o OutputFile -w /* Assemble... */
END

EXIT(0)
```

For more sophisticated examples see the ARexx scripts that come along with ASX.

8.1.4.2 ARexx Commands

This section lists all ARexx commands of ASX in alphabetical order, with their syntax, arguments, and result descriptions.

The ARexx commands of ASX have the following general format. The name of the command comes first, followed by one or more arguments if required. Arguments in square brackets are optional.

All ASX commands when called from ARexx respond by setting two variables: the `RC` (the error status code) variable and the `RESULT` variable. `RC` contains an integer value that indicates the severity of an error:

0	No error occurred.
5	A warning only.
10	Something went wrong.
20	Complete or severe failure occurred.

`RESULT` contains the result of the command if a result is returned. `RESULT` can be a string or an integer value according to the called command. Before using a command that returns a result, it is important to turn on results with the '`option results`' command. After this command has been executed, any results returned by ASX or the daemon task will be in the `RESULT` variable.

Following you find the description of all ARexx commands that have to be send to the ASX ARexx interface (`asx_rexx`).

ARexx Commands Overview

AddIncDir *path*

This command adds the specified *path* to the list of pathes stored in ASX. A *path* name containing one or more whitespaces must be enclosed in double or single quotes.

`RESULT`	True (1) if succeeded, false (0) otherwise.
`RC`	Error status code.

See also `RemIncDir` and `FlushIncDir`.

AddResident *file*

This command loads the specified *file* to ASX's resident list. A *file* name containing one or more whitespace must be enclosed in double or single quotes.

`RESULT`	None.
`RC`	Error status code.

See also `RemResident` and `FlushResident`.

AddSource *string*

This command adds the name of the specified *string* to the source name list of ASX's source manager. A *string* name containing one or more whitespace must be enclosed in double or single quotes.

Note that *string* can be a string of any format.

`RESULT`	None.
`RC`	Error status code.

See also `RemSource`, `FlushSource`.

BegOfAssembly

This command starts a new daemon process that awaits assembly jobs. `BegOfAssembly` must be used before any source code can be assembled.

The following example shows the use of the `BegOfAssembly` command and the addressing of the new created task:

```
        ADDRESS 'asx_rexx'
        BegOfAssembly
        daemon = RESULT
        ...
        ADDRESS (''||daemon)      /* ARexx weirdness */
    ...
    EndOfAssembly
```

Note the strange argument of the second `ADDRESS` command. To address the new created daemon task, the result of the `BegOfAssembly` command must be used as argument of the `ADDRESS` command. Either as `ADDRESS VALUE` *port*, or due to a ARexx weirdness, the argument can have the following format: `(''||`*port*`)`.

`RESULT`	ARexx port name of the new created daemon task.
`RC`	Error status code.

See also `EndOfAssembly`.

DisableFallBack

This command forbids the "fall back" mode for the source manager window. If "fall back" is disabled, the source manager silently aborts if its window cannot be opened on the explicitly specified public screen.

`RESULT` None.

`RC` Error status code.

See also `EnableFallBack`.

DisableManager

This command can be used to disable the source manager via ARexx.

`RESULT` None.

`RC` Error status code.

See also `EnableManager`.

EnableFallBack

This command enables the "fall back" mode for the source manager window. If "fall back" is enabled, the source manager window opens its window on the default public screen if the explicitly specified public screen is not available.

`RESULT` None.

`RC` Error status code.

See also `DisableFallBack`

EnableManager

This is the opposite of the `DisableManager` command and it can be used to enable the source manager via ARexx.

`RESULT` None.

`RC` Error status code.

See also `DisableManager`.

FindID *idstring*

This command searches the daemon process spawned by ASX which carries *idstring* as its ID. An ID can be specified for a daemon process using the `DefineID` command.

`RESULT`	None.
`RC`	Error status code.

See also `DefineID` and `GetID`.

FlushIncDir

This command deletes all entries in the include directory list stored in ASX.

`RESULT`	None.
`RC`	Error status code.

See also `AddIncDir` and `RemIncDir`.

FlushResident

This command deletes all residently loaded include files in the ASX's resident list.

`RESULT`	None.
`RC`	Error status code.

See also `AddResident` and `RemResident`.

FlushSource

This command deletes all entries in the source name list of ASX's source manager.

`RESULT`	None.
`RC`	Error status code.

See also `AddSource` and `RemSource`.

GetPort *num*

This command returns the name of port number *num*. This command seems to be a bit strange, since you do not know the port sequence. The `GetPort` command is merely implemented to have a possibility to walk through the port list and to access all ports, even the unknown ones.

`RESULT`	Name of the port or an empty string, if the port could not be found.
`RC`	Error status code.

Hide

The `Hide` command closes the ASX user interface if opened, but leaves ASX installed in the background. This allows you to have ASX constantly available, while using the minimum amount of memory possible.

`RESULT`	None.
`RC`	Error status code.

IsIncDir *path*

The `IsIncDir` command searches the given *path* in the include directory list stored in ASX.

`RESULT`	A true (1) value is returned if *path* could be found in the list. Otherwise a false (0) is returned.
`RC`	Error status code.

IsResident *file*

This command searches for the given *file* in the list of residently loaded include files.

`RESULT`	True (1) is returned when the search was successful. Otherwise false (0) is returned.
`RC`	Error status code.

IsSource *string*

The `IsSource` command searches for the given *string* in the source name list of ASX's source manager.

`RESULT`	True (1) is returned when the search was successful. Otherwise false (0) is returned.
`RC`	Error status code.

IsThereError

The `IsThereError` returns the port name of the next daemon process with a non-empty error list.

`RESULT`	Daemon's port name or an empty string if no daemon process could be found.
`RC`	Error status code.

IsTherePort

This command returns the port name of the next demon process. This command can be used to traverse through the complete daemon port list.

`RESULT`	Daemon's port name or an empty string if no daemon process could be found.
`RC`	Error status code.

Quit

This command tells ASX to exit. Usually, ASX can quit immediately. However, sometimes when you try to quit, another program has not ended the ARexx job or closed the asx.library yet. In such a case, ASX refuses to quit.

`RESULT`	None.
`RC`	Error status code.

RemIncDir *path*

This command removes the specified *path* from the list of pathes stored in ASX. A *path* name containing one or more whitespace must be enclosed in double or single quotes. If the given *path* is not in the list, the operation will be ignored silently.

`RESULT`	None.
`RC`	Error status code.

See also `AddIncDir` and `FlushIncDir`.

RemResident *file*

This command removes the specified *file* from the resident list. A *file* name containing one or more whitespace must be enclosed in double or single quotes. If the given *file* is not in the list, the operation will be ignored silently.

`RESULT`	None.
`RC`	Error status code.

See also `AddResident` and `FlushResident`.

RemSource *string*

This command removes the specified *string* from the source name list of ASX's source manager. A *string* name containing one or more whitespace must be enclosed in double or single quotes. If the given *string* is not in the list, the operation will be ignored silently.

Note that *string* can be a string of any format.

`RESULT`	None.
`RC`	Error status code.

See also `AddSource` and `FlushSource`.

SetARexxScript *filename*

This command specifies the ARexx script that is executed when an entry in the source manager is selected. *Filename* is the name of the ARexx script file. The *filename* must be enclosed in double or single quotes if it contains any whitespaces.

`RESULT`	None.
`RC`	Error status code.

SetPubScreen *ScreenName*

This command can be used to specify the name of the public screen on which the source manager should open its window.

`RESULT` None.

`RC` Error status code.

See also `EnableFallBack`.

Status *number*

This command allows you to find out the values of the 21 internal variables of ASX.

Some of the variables whose values are returned hold a true (1) or false value (0). Those that return true or false values have a question mark (‘`?`’) after them in the table below. Other variables return numbers or strings.

The given *number* argument specifies the number of the internal variable you want information on. Valid *numbers* currently range from 0 to 21. Following you find a list of all the internal variables and their numbers:

`0` This returns the version string of ASX.

`1` The number of jobs running.

`2` The number of resident files loaded.

`3` The number of include pathes stored.

`4` The number of error lists stored by ASX that are not looked at.

`5` ASX user interface hidden?

`6` This returns the version string of ProAsm.

`7` `asx.library` installed?

`8` This returns the open count value of the `asx.library`.

`9` AppIcon displayed?

`10` The number of source file names in the source list of the source manager.

`11` This returns the name of the specified pubscreen for the source manager.

`12` FallBack enabled?

`13` Source manager enabled?

`14` This returns the name of the ARexx script file that is executed when a source is selected in the source manager.

`15` The string of the current ASX hotkey definition.

`16`	The string of the current source manager hotkey definition.
`17`	This returns the path name of ProAsm.
`18`	This returns the name of the specified header file.
`19`	This returns the name of the specified configuration file.
`20`	This returns the name of the specified error file.
`21`	Swap assembler?

The following two variables reflect the result of the `Status` command:

`RESULT`	Contents of the desired internal variable.
`RC`	Error status code.

ARexx Commands Overview For The Daemon Process

Following you find all ARexx commands that have to be send to the daemon process that is spawned by the `BegOfAssembly` command (see also `BegOfAssembly`). Such a demon process must be started, before any source code can be assembled. Consider the following example that starts such a daemon process:

```
        ADDRESS 'asx_rexx'
        BegOfAssembly
        daemon=port
        ...
        ADDRESS (''||daemon)      /* ARexx weirdness */
...
EndOfAssembly
```

Assemble *arguments*

This command executes the ProAsm assembler. *Arguments* can be any of the command line arguments supported by ProAsm. For the *argument* syntax the same syntax rules are valid as for the command line.

A few texteditors have the possibility to return the start address of the source code in memory. In this case you may use the `-A/ADDRESS` command line argument of ProAsm. For example:

```
Assemble ADDRESS the_start_address
asmresult = RESULT
```

Using another editor, that does not support this feature, you can cause the editor to save a temporary file that is assembled. The temporary file can then be deleted after the assembly is done. For example:

```
Assemble the_temp_file
asmresult = RESULT
ADDRESS COMMAND "c:delete "||the_temp_file
```

`RESULT` The `RESULT` variable contains the message string returned by the assembler. The strings informs you about the number of errors (`E`), warnings (`W`), and optimizations encountered (`O`). It informs you likewise about the number of bytes saved by optimizations (the second value succeeding the (`O`) in the format string), the code size (`C`), and the workspace used (`S`). In general, it is the same message that is displayed in the shell after the assembler has finished its job. The returned string is of the following format:

`E` *num* `W` *num* `C` *num* `O` *num* *num* `S` *num*

You can use the `PARSE` command of ARexx to split the message in various parts and put the different values into ARexx variables:

```
Assemble foo
PARSE VAR RESULT . err . warn . opt obytes . size . spc
/* Where:
    err:    #of errors
    warn:   #of warning messages
    opt:    #of optimizations encountered
    obytes: #of bytes saved by optimizations
    size:   code size in bytes
    spc:    used workspace (in bytes)
*/
```

The values are stored in the different variables in the same order as described above. Refer to the *AmigaDOS manual* for the description of the ARexx commands.

`RC` Error status code.

DefineID

This command allows you to define an ID string to mark your assembly job. Usually this is used to identify a programming/development environment.

For example:

```
ADDRESS 'asx_rexx'
FindID 'TextEditor'
port = result
DO WHILE port~=''
  ADDRESS (''||port)
  EndOfAssembly          /* quit all open jobs */
  ADDRESS 'asx_rexx'
  FindID 'TextEditor'
  port = result
END

BegOfAssembly            /* begin a new job    */
port = result

IF port~='' THEN DO
  ADDRESS (''||port)     /* ARexx weirdness    */
  DefineID 'TextEditor'  /* set ID             */
  ...
END
```

The ARexx fragment above shows you a possible use of the `DefineID` and `FindID` commands. The examples assume a programming/development environment that allows only one ARexx script, one job respectively, to be executed at the time. The example can easily be extended to do the same for more than one source code.

`RESULT` None.

`RC` Error status code.

See also `FindID` and `GetID`.

EndOfAssembly

This command tells ASX that the current assembly job is finished. The daemon process is then quitted, and all the memory and resources used is returned to the system.

The `EndOfAssembly` command should be used if the job has finished and the error list managed by ASX is not used anymore. In a programming/development environment this may have to be managed differently. You can define the same ID for all assembly jobs started by this environment (using the `DefineID` command), and then instead of quitting each job separately, you can write a function that quits all jobs at once. This has the advantage that the error lists stored by ASX are still available until all jobs are ended.

`RESULT` None.

`RC` Error status code.

See also `BefOfAssembly`.

FirstError

This command returns the first error or warning message reported by ProAsm to ASX.

`RESULT` Error or warning message. If neither an error nor a warning message is reported, an empty string is returned.

`RC` Error status code.

See also `NextError` and `PrevError`.

GetID

The `GetID` command returns the ID string of the current assembly job.

`RESULT` ID string.

`RC` Error status code.

See also `DefineID` and `FindID`.

GetLineNumber

The `GetLineNumber` command returns the number of the line that is currently processed by ProAsm.

`RESULT` Line number.

`RC` Error status code.

NextError

This command returns the next error or warning message in the error list reported by ProAsm. `NextError` begins with the first reported message, except the `FirstError` command was executed before.

`RESULT` Error or warning message. An empty string is returned, if the end of the message list has been reached.

`RC` Error status code.

See also `FirstError` and `PrevError`.

PrevError

This command returns the previous error or warning message in the error list reported by ProAsm.

`RESULT` Error or warning message. An empty string is returned, if the start of the message list has been reached.

`RC` Error status code.

See also `FirstError` and `NextError`.

8.1.5 The `asx.library`

With the `asx.library` you have access on the basic capabilities of ASX: assemble, manage the residently loaded files, include pathes, and the sources from the source manager.

This library is added to the system only when the asx.library gadget in the main window of ASX is selected. This can be done by using the graphical user interface, or , at startup, by suppressing the `NOLIBRARY` command line argument, tooltype respectively (the library is installed by default).

Using the library function, you can build your own user interface for ProAsm. These library functions are quite similar to their ARexx equivalent.

In the following you find an alphabetical list of all `asx.library` functions:

asx_Assemble()

```
result := asx_Assemble(ArgStr, SpecialList)
  d0                     a0,        a1
```

The `asx_Assemble()` function executes the ProAsm assembler, with the *ArgStr* and the *SpecialList* as Arguments.

Input:

`a0` *ArgStr* - is a pointer to the command line arguments. Any command line arguments supported by ProAsm will be accepted. For Example:

```
                lea     ArgStr(pc),a0
                ...
        ArgStr: DC.B    "-W -F",0
                EVEN
```

`a1` *SpecialList* - refer to '`asx.i`' for further information about this structure. To work properly, only two fields must be set: the `ax_Source` and `ax_StdOut` field.

Result:

`d0` This register contains a boolean value whether the function succeeded (true) or not (false). The result of the assembly, if succeeded, is returned in the `ax_Errors`, `ax_Warnings`, ... fields of the *SpecialList*.

Take also a look at the '`Pro68.s`' source code as an example for the use of this function.

asx_AddIncDir()

```
result := asx_AddIncDir(path)
  d0                      a0
```

This function adds the specified *path* to the list of pathes stored in ASX.

Input:

`a0` *path* - pointer to a pathname that should be stored by ASX. ASX makes a copy of the supplied pathname.

Result:

`d0` A boolean value is returned: true if succeeded, false (0) otherwise.

asx_AddResident()

```
result := asx_AddResident(filename)
  d0                        a0
```

The `asx_AddResident()` function loads the specified *file* to ASX's resident list.

Input:

`a0`	*filename* - pointer to the name of the file that should be loaded residently by ASX.

Result:

`d0`	A boolean value is returned: true if succeeded, false (0) otherwise.

asx_AddSource()

```
result := asx_AddSource(string)
  d0                      a0
```

This function adds the name of the specified *string* to the source name list of ASX's source manager.

Note that *string* can be a string of any format.

Input:

`a0`	*filename* - pointer to a *filename* or a string that should be copied to ASX source manager's source list.

Result:

`d0`	A boolean value is returned: true if succeeded, false (0) otherwise.

asx_FlushIncDir()

```
asx_FlushIncDir()
```

This function deletes all entries in the include directory list stored in ASX.

asx_FlushResident()

```
asx_FlushResident()
```

The `asx_FlushResident()` function deletes all residently loaded include files in the ASX's resident list.

asx_FlushSource()

```
asx_FlushSource()
```

This function deletes all entries in the source name list of ASX's source manager.

asx_IsIncDir()

```
          result := asx_IsIncDir(path)
            d0                   a0
```

The `asx_IsIncDir` function searches for the given *path* in the include directory list stored in ASX.

Input:

`a0` *path* - pointer to the pathname to search for.

Result:

`d0` A boolean value is returned: true if *path* could be found, false (0) otherwise.

asx_IsResident()

```
     result := asx_IsResident(filename)
       d0                        a0
```

This function searches for the given *file* in the list of residently loaded include files.

Input:

`a0` *filename* - pointer to the *filename* to search for.

Result:

`d0` A boolean value is returned: true if the file could be found, false (0) otherwise.

asx_IsSource()

```
        result := asx_IsSource(string)
          d0                     a0
```

The `IsSource` function searches for the given *string* in the source name list of ASX's source manager.

Input:

`a0` *string* - pointer to the *string* to search for.

Result:

`d0` A boolean value is returned: true if the *string* could be found, false (0) otherwise.

asx_RemIncDir()

```
asx_RemIncDir(path)
              a0
```

This function removes the specified *path* from the list of pathes stored in ASX. If the given *path* is not in the list, the operation will be ignored silently.

Input:

`a0` *path* - pointer to the pathname that should be removed from the include directory list of ASX.

Result:

`None.`

asx_RemResident()

```
asx_RemResident(filename)
                a0
```

This function removes the specified *file* from the resident list. If the given *file* is not in the list, the operation will be ignored silently.

Input:

`a0` *filename* - pointer to a *filename* that should be removed from the resident list.

Result:

`None.`

asx_RemSource()

```
asx_RemSource(string)
              a0
```

This function removes the specified *string* from the source name list of ASX's source manager. If the given *string* is not in the list, the operation will be ignored silently.

Input:

`a0` *string* - pointer to the *string* that should be removed from the source list.

Result:

`None.`

8.2 ProOpts - The ProAsm Configuration Program

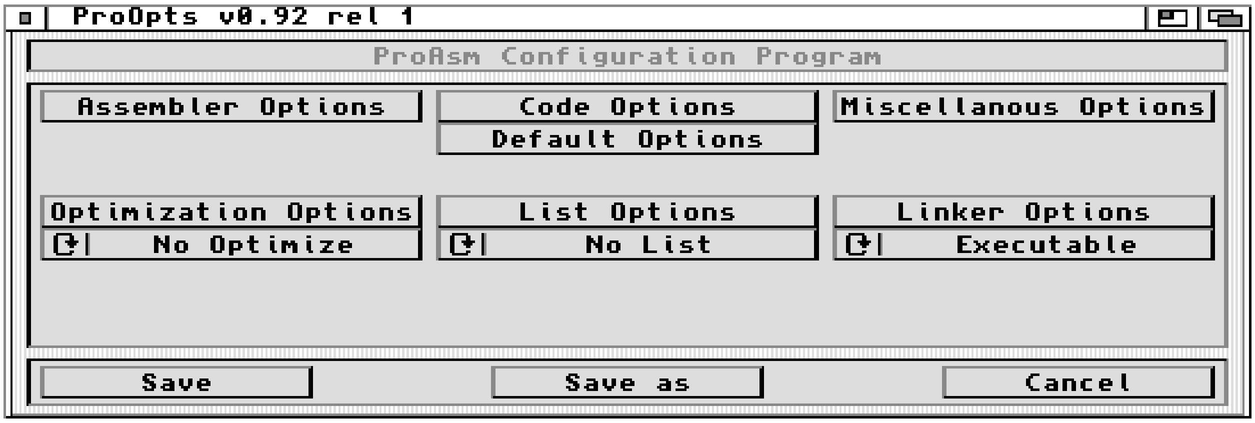
ProOpts provides a simple method of generating or changing a configuration file for the ProAsm assembler. Since ProAsm supports configuration files to be loaded each time when it is called, the user is able to customize ProAsm to suit his particular wishes and needs. The options for a project can be set by clicking on the gadget that corresponds to the option. Even options for which the ProOpts utility does not have a gadget can be specified by a special string and listview gadget.

The generated configuration file is an ASCII file that contains the specified options as assembly directives. It is similar to an include file except that it is loaded at the very beginning of each assembly. There is no restriction on the use of assembler directives or even code in the configuration file. The user can also re-edit or add options using a texteditor. Previously generated config files can be loaded into ProOpts and then be changed to the new option settings.

8.2.1 Running ProOpts

To run ProOpts, you can either double-click on its icon, or enter '`ProOpts`' on the shell command line. ProOpts requires Kickstart and Workbench 2.0 or higher to run. There is no need to use the AmigaDOS `Run` command to start ProOpts since it will automatically self-detach from the shell or CLI that it was started from.

8.2.2 Using ProOpts



If started successfully, ProOpts opens the ProOpts Index window (shown above). This window contains seven gadgets that open additional windows. Each of these windows allows you to set options sorted after their main topic. The seven windows are:

`Assembler Options`
`Code Options`
`Default Options`
`Miscellaneous Options`
`Optimization Options`
`List Options`
`Linker Options`

In addition to these topic gadgets that represent these seven windows, three cycle gadgets can be found:

`No Optimize`
`Optimize` Disables respectively enables the selected optimizations. By default, the optimizations are turned off.

`No List`
`List` Disables or enables the listing generation. By default, the listing is disabled.

`Executable`
`Linkable`

`Binary`

`Preasm`

`S-record`

`No Object` With this cycle gadget, the type of the output file can be selected. By default, the assembler creates an executable object file.

Three other action-gadgets can be found in the bottom row, that control ProOpts:

`Save` Stores the current settings to '`ENVARC:proasm.config`' and '`ENV:proasm.config`'.

`Save as` Save the current settings to a user specified file. After selecting this gadget, a file requester is opened that allows you to specify the name of the file the configuration is written to. The file requester will always appear with this command, whereas the `Save` command will assume the predefined names.

`Cancel` Simply quits ProOpts.

ProOpts has also a menu, the same for all the different windows. The following menu items can be found:

`Open...` The `Open...` (`AMIGA-O`) command allows you to load an existing configuration file using a file requester. ProOpts updates all gadgets according to the new loaded configuration file. All lines that could not be recognized by ProOpts are added to the 'Custom Lines' in the assembler options window (see Section 8.2.2.1 *Assembler Options*, page 223).

`Save` The `Save` (`AMIGA-S`) command stores the current settings to '`ENVARC:proasm.config`' and '`ENV:proasm.config`'.

`Save as...`

The `Save as...` (`AMIGA-A`) command is very similar to the `Save` command. It allows you to store the current settings to a user specified file. A file requester is opened that allows you to specify the name of the file the configuration is written to. The file requester will always appear with this command, whereas the `Save` command will assume the predefined names.

`About` The `About` (`AMIGA-?`) selection displays the copyright and version notice for ProOpts.

`Quit` The `Quit` (`AMIGA-Q`) command quits ProOpts.

`Reset To Defaults`
: This command (`AMIGA-D`) resets all settings to their default.

Types of Gadgets used

When using ProOpts, you may encounter one or more of the following basic types of gadgets:

`action`
: Action-gadgets appear as raised buttons. Normally the buttons are labeled with a small text that is written inside the gadget. Selecting such a button causes an immediate action. For example, the `Cancel` gadget in the main window causes ProOpts to quit.

`cycle`
: Cycle-gadgets look quite similar to action-gadgets, except that a small symbol of a curled arrow that points to itself is on the left side. By selection the gadget you can cycle through the available settings for that specific option. The cycle direction can be reversed by pressing the `SHIFT` key as you click the left mouse button.

`list`

`listview`
: Generally list-gadgets appear as a set of control gadgets. A small scrollbar, arrow gadgets, and a string area. ProOpts has additional control gadgets attached to its list-gadgets. These gadgets are a string-gadget, an add-gadget (in one case), del-gadget, top-, up-, down-, and a bottom-gadget. Use the scroll bar and the arrow gadgets to position the scrolling area to a specific entry. To add new entries to the list, select the add-gadget (if available) or type the new entry name into the string-gadget (below the scroll area) and press `RETURN`. Entries can be removed from the list, by selecting the entry to be cleared in the scroll area (to copy its name into the string-gadget), and selecting the del-gadget.

  The top-, up-, down-, and a bottom-gadget can be used to move the entry to the desired position in the list. Top and bottom move the item directly to either the top end or the bottom end of the list. Up and down move the selected item one position upwards or downwards in the list. Some gadgets can be disabled if they cannot be used (e.g. on empty lists).

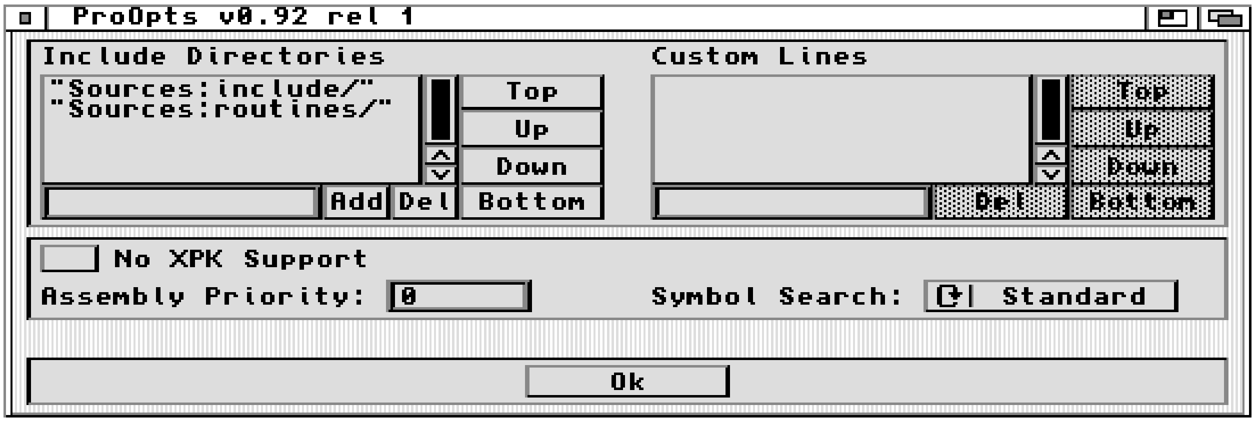
`string`
: String-gadgets appear as raised ridge around a text area. Any string can be entered by clicking (activating) within the text area and typing your string. When you have finished typing, press the `RETURN` key to confirm or the `TAB` key to confirm and jump to the next string-gadget.

`integer`
: Integer-gadgets are in function and look identical to the string-gadgets. But they accept only decimal integer numbers as input.

`check` Check-gadgets appear as small rectangular raised buttons, labeled with a text on the left or the right side of the gadget. When the gadget is selected, a small checkmark appears, or disappears when unselected.

The rest of this section describes all the different windows that ProOpts offers to set and change the assembler options. Everything in these windows should be fairly self-explanatory. The individual options are not described to their last details, since they all can be found somewhere else in this manual. The discussed options carry references that leads you to their descriptions in this manual. The saved configuration file will be used the next time ProAsm is run.

8.2.2.1 Assembler Options



`Include Directories`

Include search pathes tell the assembler where to look for files to be included by the `INCLUDE` or `INCBIN` directives, or their synonyms. A new path can be added by either selecting the `Add` gadget that opens a file requester to select the directory, or its name can be typed into the string-gadget. You do not have to enclose the path name in double or single quotes if it contains one or more whitespaces. ProOpts encloses automatically all entries with double quotes if needed.

When the settings are stored, these include directories are all written as arguments of the `INCDIR` directive to the configuration file. See `INCDIR`, page 50.

`Custom Lines`

When a configuration file is loaded at startup or via the `Open...` menu item, all lines that could not be recognized by ProOpts are put in this list. See Appendix E *ProOpts Directives Summary*, page 295, for a list of all valid directives.

The custom lines list can also be used to add directives to the configuration file that are not supported by ProOpts. You may even put complete macro definitions into the list. Awkward, but it works.

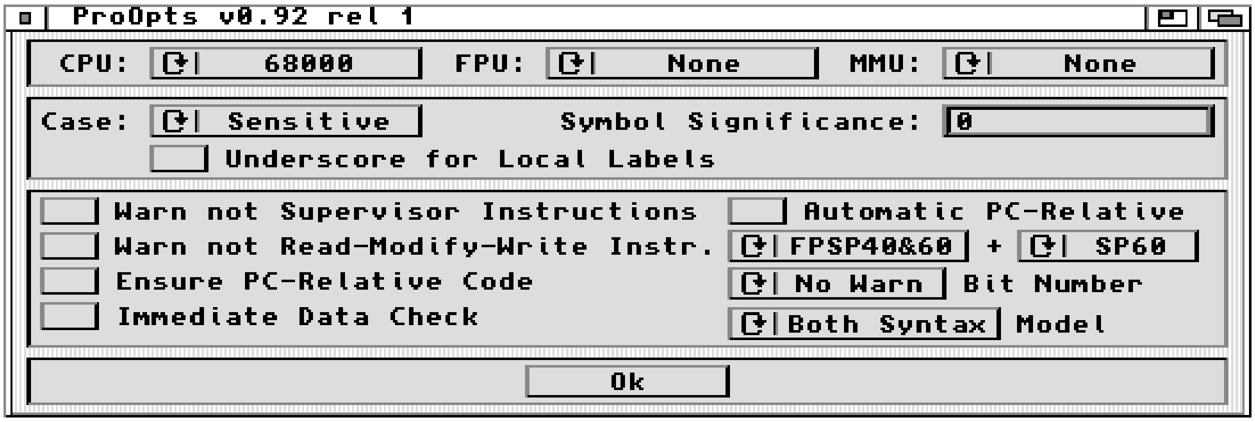
`No XPK Support`
: This check-gadget controls the XPK support. XPK support is disabled when the gadget is set. See `OPT NOXPK`, page 160.

`Assembly Priority`
: Using the integer-gadget you have the possibility to set the task priority of the assembler while running (see `ASMPRI`, page 164).

  Note that ProOpts does not check the range of the entered value to its validity. The range of the priority are the integers from -128 to 127. The CLI and the most other tasks have a priority of 0, and it is suggested that you do not set the priority higher than 10. A priority higher than zero means that the assembler will not be slowed down as much by other tasks. Setting the priority lower than 0 will prevent ProAsm from slowing down other programs with normal priority.

`Symbol Search`
: With this cycle-gadget you can select an appropriate symbol search algorithm for your source codes. You can choose between `Standard` (default), `ESS1`, `ESS2`, and `ESS3`. See `OPT ESS1`, page 161, for more details.

8.2.2.2 Code Options



`CPU`
: This cycle-gadget specifies the processor to be programmed for. See `Processor Type`, page 86, for more information.

  Note that the cycle-gadget entry '`Any`' represents the `MCRELAX` directive.

`FPU`
: This cycle-gadget allows you to specify the floating-point coprocessor you want to program for to allow its instruction set. See `MC68881`, page 86, for more details.

  Note that the MC68040 and MC68060 processor have built-in FPU. Their FPU instruction sets are automatically allowed when the specific processor is selected (see the `CPU` gadget above).

`MMU` This cycle-gadget only toggles between '`None`', for no MMU, and '`MC68851`'. See `MC68851`, page 86, for more details.

Note that the MC68030, MC68040, and MC68060 MMU instruction set will automatically be enabled when the specific CPU has been selected (see the `CPU` gadget above).

`Case` With this cycle-gadget you can toggle between case `sensitive` and `unsensitive` symbols. See `OPT C`, page 83, for more information.

`Symbol Significance`

Specifying a value using the integer-gadget makes the first part of symbol case sensitive or unsensitive, according to `Case` (see above). See `OPT C`, page 83, for more information.

Note that ProOpts does not perform a range check on the entered value. Valid values must be from 0 to 256, where 0 turns the symbol significance off.

`Underscore for Local Labels`

If this gadget is selected, the underscore ('`_`') rather than the dot ('`.`') is used to introduce a local label (see `OPT U`, page 83).

`Warn not Supervisor Instructions`

This check-gadget allows you to enable or disable all warnings on supervisor-only opcodes. The warnings are disabled when the gadget is selected. See `SUPER`, page 90, for more details.

`Warn not Read-Modify-Write Instr.`

You can suppress all warnings for read/modify/write instructions by selecting this check-gadget. See `READMODWRITE`, page 90.

`Ensure PC-Relative Code`

Selecting this check-gadget forces the assembler to report a '`relocation not allowed`' error on any instructions that require relocation. See `OPT P`, page 85, for more information.

`Immediate Data Check`

All absolute addresses will be checked for missing pound signs ('`#`'), when this check-gadget is selected (see `OPT I`, page 84).

`Automatic PC-Relative`

In selected state this gadget forces the assembler to use the PC-relative addressing mode where possible instead of the absolute long addressing mode. See `OPT AUTOPC`, page 93, for more information.

`Control software-supported instructions`

These two cycle-gadgets allow you to control the use of software-supported instructions.

The first cycle-gadget enables or disables the software-supported floating-point instructions of either the MC68040, the MC68060, or both processors. The second gadget controls only the use of the MC68060 software-supported integer instructions.

See `OPT FPSP40`, page 88,and `OPT SP60`, page 89, for more detailed information.

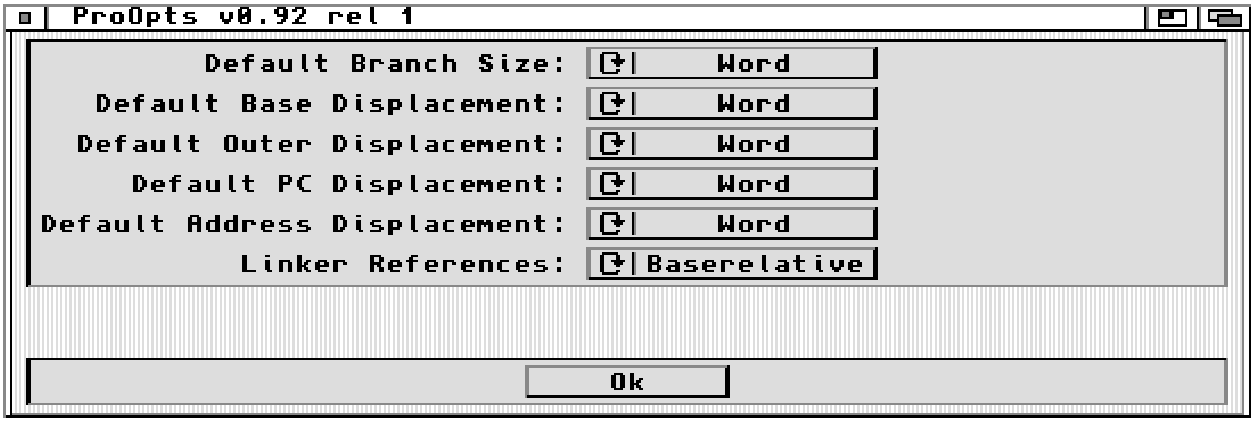
`Bit Number`

Using this cycle-gadget you can decide whether a warning, no warning, or an error should be reported if ProAsm encounters a bit number that is not in bounds. See `OPT CHKBIT`, page 107.

`(Syntax) Model`

This gadget can be used to determine whether the assembler should accept the new syntax model, the old one, or both. See `NEWSYNTAX`, page 84.

8.2.2.3 Default Options



In the default options window you have the possibility to define the default behaviour of ProAsm. Refer to `Assembly Options`, page 91, for more details on these and possible settings. ProOpts uses the `DEFAULT` directive for all these cycle-gadgets when saved to the configuration file. See `DEFAULT`, page 91, for information about this directive and its arguments. The cycle-gadgets let you specify the *mode* arguments of the `DEFAULT` directive.

`Default Branch Size`

Corresponds to `DEFAULT _BRANCH,`*mode*.

`Default Base Displacement`

Corresponds to `DEFAULT _BASEDISP,`*mode*.

`Default Outer Displacement`

Corresponds to `DEFAULT _OUTERDISP,`*mode*.

`Default PC Displacement`

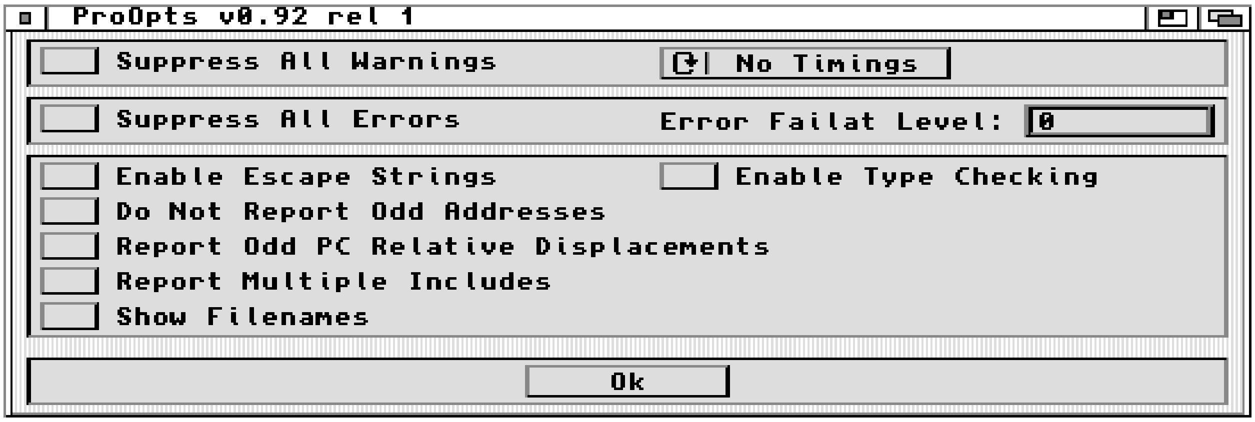
Corresponds to `DEFAULT _PCBASEDISP,`*mode*.

`Default Address Displacement`

Corresponds to `DEFAULT _ADRBASEDISP,`*mode*.

`Linker References`
: Corresponds to `DEFAULT _LINKREF,`*mode*.

8.2.2.4 Miscellaneous Options



`Suppress All Warnings`
: This check-gadget lets you suppress all warning messages (see `OPT NOWARN`, page 104).

`Timing Information`
: Using this cycle-gadget you can select the way the assembler should report timing information and their quantity. See `VERBOSE`, page 164.

`Suppress All Errors`
: This check-gadget lets you suppress all error messages (see `OPT E`, page 104).

`Error Failat Level`
: The value in the integer-gadget specifies the maximum number of errors to be reported before aborting assembly. A value of zero sets the limit to unlimited number of errors. See `FAILAT`, page 104.

`Enable Escape Strings`
: This check-gadget controls the allowance of escape sequences withing strings. If it is selected, escape sequences are allowed. See `ESCAPESTR`, page 162.

`Enable Type Checking`
: Select this check-gadget to enable type checking. Refer to `Type Checking`, page 85, for more detailed information.

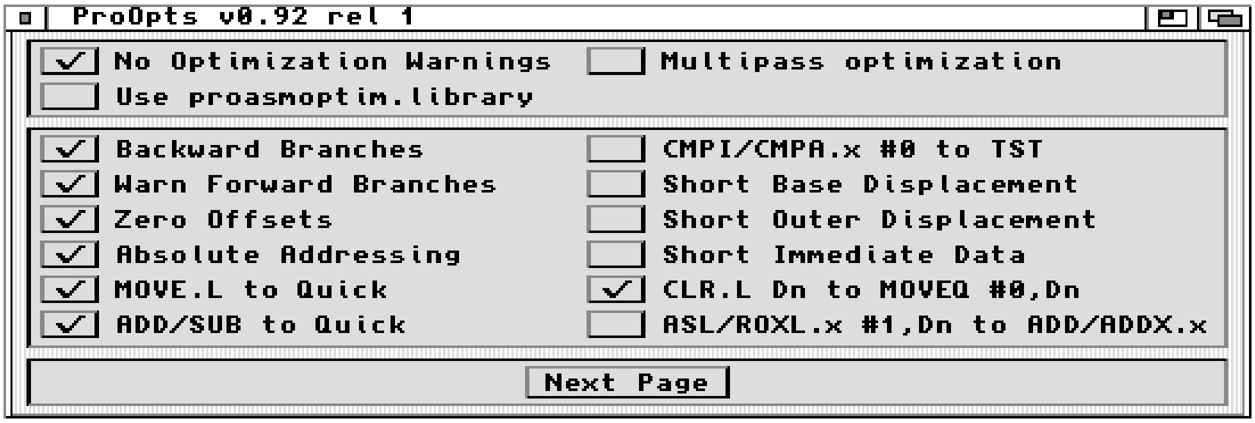
`Do Not Report Odd Addresses`
: If you select this check-gadget, all misalignment and odd access checks are disabled and no errors will be issued (see `ODDOK`, page 105).

`Report Odd PC Relative Displacements`
: By selecting this check-gadget additional misalignment and odd access checks are performed by the assembler. See `ODD2ERROR`, page 106.

`Report Multiple Includes`
: This check-gadget can be used to tell the assembler to report multiple includes, instead of ignoring them. See `OPT Y`, page 48.

`Show Filenames`
: Select this check-gadget to let the assembler report the name of all loaded include files (see `OPT F`, page 107).

8.2.2.5 Optimization Options



The optimization options are spread over two windows. The descriptions of the individual options can be found by either the `OPT O` option (see `OPT O`, page 94), or the `OPT Q` (see `OPT Q`, page 98), unless otherwise noted. In the following tables you find only the options the gadgets correspond to.

`No Optimization Warnings`
: This gadget disables all warnings that are generated by optimizations. See `OPT OW`, page 104.

`Multipass optimization`
: If this check-gadget is selected, multipass optimization is enabled (see `MULTIPASS`, page 101).

`Use proasmoptim.library`
: This gadget enables the use of the optimizer library (see `OPT OPTIMLIB`, page 102).

`Backward Branches`
: Corresponds to the `OPT O1+` option.

`Warn Forward Branches`
Corresponds to the `OPT O6+` option.

`Zero Offsets`
Corresponds to the `OPT O2+` option.

`Absolute Addressing`
Corresponds to the `OPT O3+` option.

`MOVE.L to Quick`
Corresponds to the `OPT O4+` option.

`ADD/SUB to Quick`
Corresponds to the `OPT O5+` option.

`CMPI/CMPA.x #0 to TST`
Corresponds to the `OPT O9+` option.

`Short Base Displacement`
Corresponds to the `OPT O13+` option.

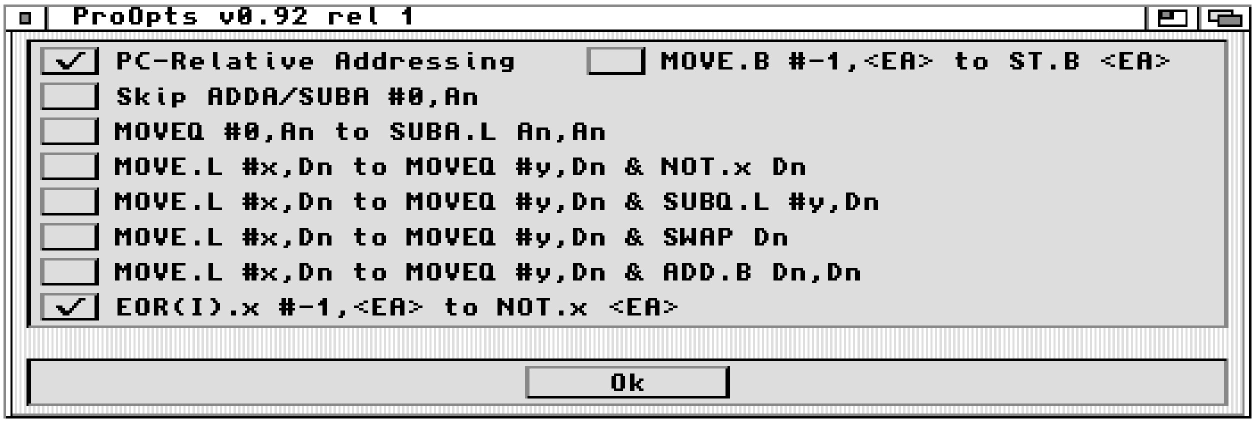
`Short Outer Displacement`
Corresponds to the `OPT O14+` option.

`Short Immediate Data`
Corresponds to the `OPT O8+` option.

`CLR.L Dn to MOVEQ #0,Dn`
Corresponds to the `OPT Q1+` option.

`ASL/ROXL.x #1,Dn to ADD/ADDX.x`
Corresponds to the `OPT Q2+` option.

`Next Page` By pressing this gadget, you change to the next optimization page.



`PC-Relative Addressing`
: Corresponds to the `OPT O7+` option.

`MOVE.B #-1,<EA> to ST.B <EA>`
: Corresponds to the `OPT Q11+` option.

`Skip ADDA/SUBA #0,An`
: Corresponds to the `OPT Q4+` option.

`MOVEQ #0,An to SUBA.L An,An`
: Corresponds to the `OPT Q3+` option.

`MOVE.L #x,Dn to MOVEQ #y,Dn & NOT.x Dn`
: Corresponds to the `OPT Q5+` option.

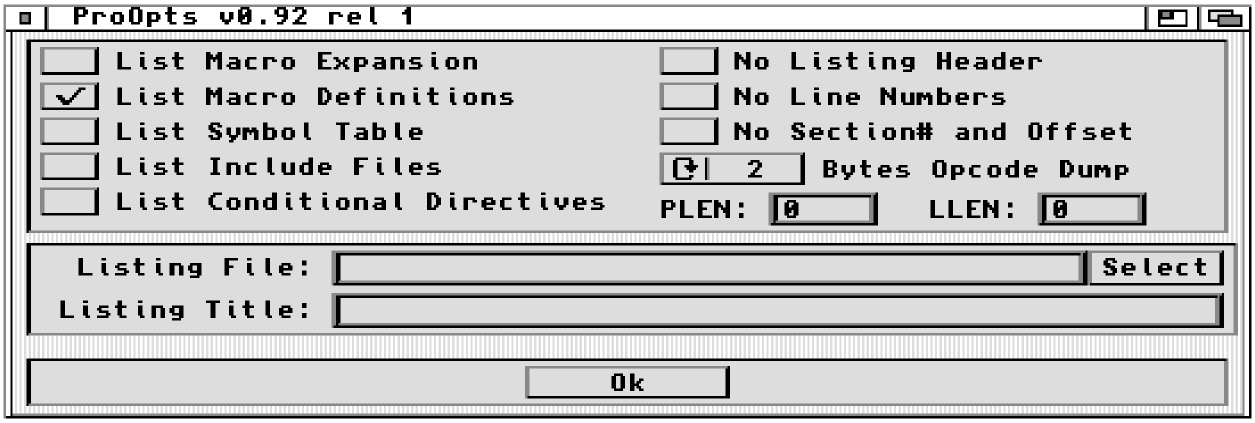
`MOVE.L #x,Dn to MOVEQ #y,Dn & SUBQ.L #y,Dn`
: Corresponds to the `OPT Q7+` option.

`MOVE.L #x,Dn to MOVEQ #y,Dn & SWAP Dn`
: Corresponds to the `OPT Q8+` option.

`MOVE.L #x,Dn to MOVEQ #y,Dn & ADD.B Dn,Dn`
: Corresponds to the `OPT Q9+` option.

`EOR(I).x #-1,<EA> to NOT.x <EA>`
: Corresponds to the `OPT Q12+` option.

8.2.2.6 List Options



`List Macro Expansion`
: If this gadget is selected, the complete macro text for all macro expansions is included in the listing. See `OPT M`, page 149.

`List Macro Definitions`
: Macro definitions are included in the listing when this gadget is selected. See `OPT MD`, page 148.

`List Symbol Table`
: By selecting this gadget you tell the assembler to add a symbol listing to the listing file. See `Symbol listing`, page 149.

`List Include Files`
: The contents of included files is included in the listing when this gadget is selected (see `FORMAT`, page 151).

`List Conditional Directives`
: Select this gadget to include conditional assembly directives in the listing file (see `OPT CL`, page 149).

`No Listing Header`
: This gadget can be used to suppress all titles and subtitles. See `FORMAT`, page 151, for more information.

`No Line Numbers`
: If this gadget is selected, no line numbers are written to the listing. See `FORMAT`, page 151.

`No Section# and Offset`
: The section numbering and program counter offset are suppressed when this gadget is selected (see `FORMAT`, page 151).

`Bytes Opcode Dump`
: This cycle-gadget allows you to specify the width of the hexdump field in bytes. The range of the width is from 2–22 bytes, or '`No`' to suppress the hexdump field completely. See `FORMAT`, page 151.

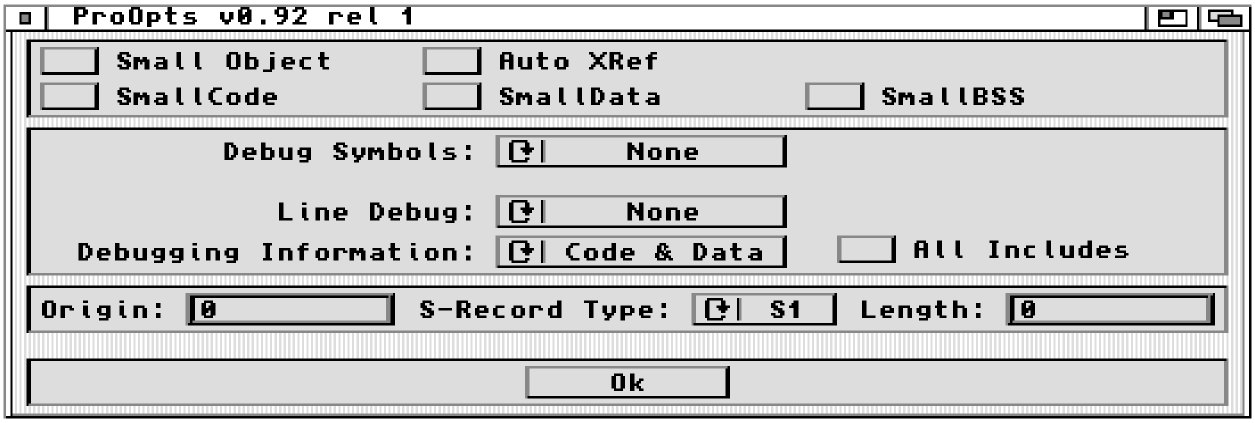
`PLEN`
: The `PLEN` integer-gadget can be used to set the page length for the assembly listing. The page length may be a value between 12 and 255. See `PLEN`, page 150.

`LLEN`
: By entering a value into the integer-gadget, you can set the line length for the listing. The line length should be from 38 to 255. A value of zero instructs ProOpts not to write the line length to the configuration file. See `LLEN`, page 150, for more details.

`Listing File`
: Using the string-gadget you can specify the filename of the listing file (see Section 5.10 *Auxiliary Output Files*, page 145). The name can be set by either typing it into the string-gadget, or by using the file requester that opened when the `Select` gadget was pressed. See `LISTFILE`, page 148.

`Listing Title`
: You can specify a page title by typing it into this string-gadget (see `TTL`, page 152).

8.2.2.7 Linker Options



`Small Object`
: Select this gadget when you want to have all hunks merged into one single `CODE` hunk. See `SMALLOBJ`, page 137, for more details.

`Auto XRef`
: When this gadget is selected, the assembler treats all undefined symbols as external symbols (see `AUTOXREF`, page 143).

`SmallCode`
: When this check-gadget is selected, all code hunks are merged into one single hunk (see `SMALLCODE`, page 137).

`SmallData`
: When this check-gadget is selected, all data hunks are merged into one single hunk (see `SMALLDATA`, page 137).

`SmallBSS`
: When this check-gadget is selected, all bss hunks are merged into one single hunk (see `SMALLBSS`, page 137).

`Debug Symbols`
: With this cycle-gadget you can particularize the way symbol information is written to the object file. You can choose between:

  ‘`None`’ for no symbol information,

  ‘`All`’ when the symbol information for all defined symbols should be written to object file (see `ADDSYM`, page 139), or

  ‘`Exports Only`’
  that restricts the symbol information generation to the exported (`XDEF`) symbols only (see `OPT X+`, page 140).

`Line Debug`
: This gadget allows you to set the format of the debugging information. See `DEBUG`, page 138, for more detailed information, especially for the `LINE` and `HCLN` keywords.

`Debugging Information`
: You can specify the type of debugging information to be produced. See `DEBUG`, page 138.

`All Includes`
: When this check-gadget is set, debugging information for all included files is generated (see `DEBUG`, page 138, for the `ALL` keyword).

`Origin`
: This integer-gadget can be used to set the load address for the S-record file (see `SREC`, page 132).

`S-Record Type`
: This cycle-gadget allows you to set the Motorola Record format type for the S-record file. See `SREC`, page 132.

`Length`
: You can set the record length of the S-record file by typing the value into the integer-gadget. The value must be from 16 to 255. See `SREC`, page 132, for more information.

8.3 Utilities

This section discusses the additional utilities that come along with the ProAsm assembler. You will find the description of the following utilities in this section:

`Profiler` Small run-time statistic utility.

`ProHunk` 680x0/688xx hunk analyzer and disassembler.

`Pre2Src` Converts ProAsm generated preasm files into a readable source files.

`MMUInfo` Displays information on the MMU.

`FD2LVO` Tool to convert fd-files to _LVO equate files.

`CLICalc` Simple CLI calculator.

`FCalc` CLI IEEE double precision calculator.

`StripD` Strips debugging information from a load file.

`FCmp` Simple file compare utility.

`Bin2DC` Converts any (binary) files into an assembler source using the `DC` directive.

`BDiff` Small binary file compare program.

`Unbdiff` Small binary un-bdiff program.

These utilities may be useful while developing software. They all must be run from the shell, except otherwise noted. All of them are driven by keyword options in any order indicating the action to be performed. Quite all utilities display also a command line usage notice when they are run with no parameters or a question mark ('?') as parameter.

For example:

```
1> profiler ?
Profiler - small run-time statistics utility v1.03
Copyright  1993,1994 by Daniel Weber

Usage: Profiler [options] <program> [<program arguments>]

Options: -n <num>  display entries with more than <num> hits.
         -s        display symbol listing.
         -t <num>  set time interval to <num> milliseconds (def: 2000).
         -z        permit displaying entries with zero hits.

Example: Profiler -s -n 50 foo foo_arguments
```

8.3.1 Profiler

Profiler [*options*] *program* [*program arguments*] small run-time statistic utility

The `Profiler` utility displays the run-time statistics for a given *program* with its optionally given *program arguments*. It records the amount of time spent in each routine that is called while the *program* runs. When your *program* ends, `Profiler` displays the resulting run-time statistic.

In a line of the statistic output you find (in this order):

- the name of the particular routine,
- the hunk number where the routine is located,
- an offset value that describes the begin of the routine relative to the hunk start,
- the number of hits `Profiler` counted while the *program* was running,
- the average percentage of time that was spent in this routine, compared with the whole *program*,
- and the location of the routine in your source code.

To use `Profiler` with your program, you have to assemble your program with the debug option and symbol information turned on (e.g. `DEBUG LINE,ALL,CODE,ADDSYM`, see Section 5.9.3.2 *Debugging Information*, page 138, for more details).

`Profiler` supports the following command line options:

`-n` *num*
: Tells `Profiler` to display only routines in the run-time statistic with more than *num* hits. (Where *num* is a decimal number.)

`-s`
: This option forces `Profiler` to display a symbol listing.

`-t` *num*
: Using this option you can specify the time interval, in milliseconds, between the statistic checks `Profiler` does on your program. If no time interval is given, `Profiler` defaults to 2000. (Where *num* is a decimal number higher or equal to 100.)

`-z`
: To keep the statistic information as compact as possible, `Profiler` does not list routines with zero hits. However, this option forces `Profiler` to display these routines also.

Note that a sequence of options can be written separately (e.g. '`-s -z -t 1000`') or together (e.g. '`-szt 1000`').

8.3.2 ProHunk

ProHunk *object file* [*options*] 680x0/688xx Hunk Analyzer

`ProHunk` is an Amiga object file analyzer that issues the binary hunk structure of a load or linkable *object file*. All hunks up to the operating system version 3.1 (v40) are supported. See *The AmigaDOS Manual*, 3rd Edition, Bantam Computer Books, for more information about AmigaDOS hunk formats.

Next to the hunk information, `ProHunk` can also display optionally the contents of code hunks in disassembled form and data hunks as hexdump. The disassembler supports all Motorola processors up to the MC68040, the MC68881 and MC68882 floating-point coprocessors, and the MC68851 PMMU coprocessor.

The given *object file* is the name and complete path of the file that is to be analyzed. The *options* are optional and should be one or more of the following:

`-d` Output the contents of all data hunks as hexdump.

`-c` Output the contents of all code hunks in disassembled form.

`-i` Show contents of all debug hunks (hunk_debug) as hexdump.

`-i0` Show contents of all known debug hunks (hunk_debug) in a line/offset format.

`-q` Quiet, send no output to StdOut.

`-v` Verbose, display all entries in symbol (hunk_symbol) and hunk_ext hunks.

Note that a sequence of options can be written separately (e.g. '`-i -c`') or together (e.g. '`-ic`').

Example:

```
1> ProHunk ProHunk
ProHunk - 680x0/688xx Hunk Analyzer v1.80
Copyright  1991-1996 by Daniel Weber - All Rights Reserved
analyzing file ProHunk, ok...

hunk_header
     number of hunks: 1  (lo:0, hi:0)
     hunk #0: $0000444C (17484) bytes  (loadtype: public)
hunk_code
     (hunk #0, size: 15704, bss: 1780)
hunk_end
```

8.3.3 Pre2Src

Pre2Src *preasm file output file* Convert preasm files into equate files

`Pre2Src` generates an assembler equate file (*output file*) out of a given *preasm file*.

```
1> Pre2Src myProg.pre myProg.equ
```

The following error messages can be reported by `Pre2Src`:

'`Couldn't load file '`*filename*`''`
: An AmigaDOS error occurred while loading the specified file (*filename*).

'`Couldn't open file '`*filename*`''`
: `Pre2Src` could not open the specified file (*filename*). Check the spelling of *filename* and that the supplied pathname is correct.

'`Not a valid preasm file`'
: The file given as *preasm file* is not a correct preasm file. Check if the correct file was given.

'`Unsupported preasm file entry encountered`'
: `Pre2Src` encountered an unsupported entry while processing the preasm file. This error only occurs if the specified *preasm file* is crippled.

'`Unsupported preasm file version`'
: You tried to load an unsupported version of a preasm file.

8.3.4 MMUInfo

MMUInfo [-*option address*] Display information on the MMU

`MMUInfo` displays various information about the current MMU settings and registers, or on a supplied address.

`MMUInfo` supports memory management unit of the MC68030, MC68040, and the MC68851 processors. For more information about the memory management unit (MMU) refer to the manuals for the specific microprocessors.

If `MMUInfo` is run without any parameters, it reports the current settings of the MMU and its registers contents.

If an option and an *address* is given, `MMUInfo` displays the translation and the page attributes of this *address* according to the given option. *Address* is the hexadecimal address of the memory location the information is requested for.

The following two options are supported by `MMUInfo`:

`-d` Use the `-d` option to perform a data space access on the given *address*.

`-i` Use the `-i` option to perform an instruction space access on the given *address*.

For example:

```
1> MMUInfo -d $fc0000
```

The following error messages can be reported by `MMUInfo`:

'`CPU must be 68020/30/40!`'
: `MMUInfo` expects a MC68020 or higher processor to run. Supported are the memory management unit of the MC68030, MC68040, and the MC68851 processors.

'`no PMMU found!`'
: No memory management unit found.

8.3.5 FD2LVO

FD2LVO [*input path*] *output file* [*options*] Convert fd-files to _LVO equate files

The `FD2LVO` utility generates equate listings with library vector offsets using fd files.

The utility can be started from the CLI/Shell in three different ways:

`FD2LVO` *input file output file*
: The fd-file *input file* is parsed and converted to library vector offsets and written to the equate listings (*output file*).

`FD2LVO` *input path output file* `-a`
: All valid fd-files in the given directory (*input path*) are parsed and converted to library vector offsets and then written to the equate listings (*output file*).

`FD2LVO` *output file* `-a`
: If no *input path* is given `FD2LVO` scans the `FD:` assign. All valid fd-files are parsed and converted to library vector offsets and then written to the equate listings (*output file*).

The following error message can occur while processing the fd-files:

'`No output generated.`'
: No output is generated if an error occurred while `FD2LVO` processes a fd-file.

'`Couldn't open file '%s' (DOS error: %ld).`'
: `FD2LVO` cannot open the specified file. Check the spelling of *input file* and *output file*. The *DOS error code* may give you additional information why the assembler could not open the file (see Appendix C *AmigaDOS Error Codes*, page 285).

'`Output file crippled.`'
: An error occurred while writing data to the *output file*. The output file may be crippled.

8.3.6 CLICalc

CLICalc *expression* Simple CLI calculator

CLICalc allows you to evaluate a given *expression* in an easy way. The returned result will be displayed as signed hexadecimal, unsigned hexadecimal, decimal, binary number, as ascii chars, and as octal number.

The following operators are supported, sorted after their priority (see also Section 4.2.3 *Operators*, page 30):

7	()	parentheses
6	-	unary minus
	$\sim$	complement (logical NOT)
5	<<	logical shift left
	>>	logical shift right
	$\ll$	arithmetical left shift
	$\gg$	arithmetical right shift
	$\ll\ll$	rotate left
	$\gg\gg$	rotate right
4	*	multiplication
	/	division
	\	modulo
3	&	logical AND
	$\vert$	logical OR
	!	logical EOR
2	+	addition
	-	subtraction
1	<>	not equal
	><	not equal
	=	equal
	<=	lower or same
	>=	greater or equal
	>	less
	<	greater

`CLICalc` supports the following forms for numbers (see also Section 4.2.1.1 *Integer Constants*, page 24 for more details about integer constants and their formats):

`$`*d*

`0x`*d* Hexadecimal number.

d

#*d* Decimal number.

`%`*ddd* Binary number.

`@`*d*

`0`*d* Octal number.

`'c'`

`"c"` ASCII string.

`CLICalc` works in the decimal mode, meaning that you do not have to write the pound sign (‘`#`’) in front of each decimal number in the expression.

For example:

```
1> CLICalc 14*2-(33/$a)&%011010
=$1A  =$1A  =#26  =%00000000.00000000.00000000.00011010
='....' =@32
1>
```

If an error had occurred while evaluating the given *expression*, an error message is reported. Below you find a complete list of possible error messages:

‘`calcbuffer overflow`’
: This error should not occur.

‘`divide by zero`’
: During the evaluation of the expression `CLICalc` encountered a division by zero. Check the expression for any division by zero.

‘`illegal value`’
: The expression evaluator could not find a valid value (a constant or an expression).

‘`invalid number`’
: An invalid digit was encountered in a number. For example, using a ‘`2`’ or ‘`3`’ in a binary number:

```
move.l  #%1010201,d0
```

‘`missing close brackets`’
: An unmatched open bracket (‘`(`’) was found in an expression.

‘`missing quote`’
: An unmatched quote (single or double quote) was found in a string. Make sure the string is correctly enclosed in quotes. You may not mix single and double quotes.

‘`not enough memory`’
: There is not enough memory available for `CLICalc` to complete its task.

‘`no value given`’
: No term given, or the expression evaluator could not find a valid term. A constant or expression might be invalid.

'`overflow`'

This error is reported if an overflow occurs while evaluating an expression. In other words, the result of the evaluated expression is larger than $ffffffff, +$7fffffff, or -$80000000.

'`too many close brackets`'

Too many close brackets ('`)`') are found. Either more open brackets have to be inserted or the superfluous close brackets have to be removed to get properly balanced brackets.

8.3.7 FCalc

FCalc *expression* CLI IEEE double precision calculator

`FCalc` is a command line oriented calculator for IEEE double precision numbers. The returned result will be displayed as a double precision number.

See Section 4.2.1.2 *Floating-point Constants*, page 25, for details about the format of the floating-point numbers.

The following operators are supported, sorted after their priority:

6	()	parentheses
5	-	unary minus
4	^	power
3	*	multiplication
	/	division
2	+	addition
	-	subtraction

Next to the operators listed above, the following standard functions can be used:

1	SIN()	sine
	COS()	cosine
	TAN()	tangent
	COT()	cotangent
1	ASIN()	arc sine
	ACOS()	arc cosine
	ATAN()	arc tangent
1	SINH()	hyperbolic sine
	COSH()	hyperbolic cosine
	TANH()	hyperbolic tangent
	COTH()	hyperbolic cotangent
1	EXP()	exponential of e
	LN()	natural logarithm
	LOG10()	logarithm base 10
	ABS()	absolute value
	SQRT()	square root
	INV()	1/x
1	DEG()	convert to degree (x/pi*180)
	RAD()	convert to radian (x/180*pi)

Examples:

```
1> FCalc 1.0e2*14
1.4E3

1> FCalc (3.14e1+2.17e2)*4
9.936E2

1> FCalc sin(2.2346)
7.87654426210142E-1

1> FCalc ln(abs(tan(7.87654426210142E-1)))
4.51254094014066E-3
```

If an error had occurred while evaluating the given *expression*, an error message is reported. Below you find a complete list of possible error messages:

‘`calcbuffer overflow`’
    This error should not occur.

'`illegal value`'
: The expression evaluator could not find a valid value (a constant or an expression).

'`invalid number`'
: A number was encountered that is not a valid floating-point number. See Section 4.2.1.2 *Floating-point Constants*, page 25.

'`missing close brackets`'
: An unmatched open bracket ('`(`') was found in an expression.

'`not enough memory`'
: There is not enough memory available for `FCalc` to complete its task.

'`no value given`'
: No term given, or the expression evaluator could not find a valid term. A constant or expression might be invalid.

'`too many open brackets`'
: Too many close brackets ('`)`') are found. Either more open brackets have to be inserted or the superfluous close brackets have to be removed to get properly balanced brackets.

'`unknown function`'
: `FCalc` encountered an unknown function in the expression. Use `FCalc ?` to display a list of valid functions.

8.3.8 StripD

StripD *source destination* Strips debugging information from a load file

`StripD` is a small utility that removes all symbol and debug information from the object file given as *source*. The stripped file will then be written to *destination*.

The following error messages can be reported by `StripD` while processing a file:

'`couldn't open file '`*filename*`' (DOS error: `*DOS error code*`).`'
: `StripD` cannot open the specified file. Check the spelling of *filename* and that the supplied pathname is correct. The *DOS error code* may give you additional information why the assembler could not open the file (see Appendix C *AmigaDOS Error Codes*, page 285).

'`DOS error` *DOS error code* `occurred during processing file - abroted.`'
An AmigaDOS error occurred while processing a file (see Appendix C *AmigaDOS Error Codes*, page 285). The operation is aborted. There may exist a crippled output file *destination*.

8.3.9 FCmp

FCMP *firstfile secondfile* File compare utility

`FCmp` is a small file compare utility that compares two given files and reports the first found difference.

When a difference is found `FCmp` displays an appropriate message that informs you at what offset the files differ. The offset, relative to the start of the files, is given as a hexadecimal and a decimal number.

The following messages can be reported by `FCmp`:

'`first difference at offset $`*x* `(`*d*`)`'
This message is reported when a difference is found. It informs you at what offset the first difference is found. The offset, relative to the start of the files, is given as a hexadecimal (*x*) and as a decimal number (*d*).

'`length of file differs`'
When the file lengths differ `FCmp` generates this message. No further comparisons will be made. Since the file lengths differ the files are definitely not equal.

'`error reading file!`'
An error occurred while writing the source file. Check if another program makes write accesses to the file.

'`invalid parameter line`'
The parameter line has not the requested format. `FCmp` accepts only the names of the two files that are to be compared.

'`could not open file` *filename*'
`FCmp` cannot open the specified file. Check the spelling of *filename* and that the supplied pathname is correct.

8.3.10 Bin2DC

Bin2DC *file output source* [*options*]

`Bin2DC` generates an assembler source code out of a given *file* using the `DC` directive (see Section 5.7.1 *Initialized Data*, page 113). The assembler source is then written to *output source*.

One of the following *options* can be used to format the source code:

‘`-b`’ Use `DC.B` in the source code.

‘`-w`’ Use `DC.W` in the source code.

‘`-l`’ Use `DC.L` in the source code.

`DC.L` is used as default (if no *option* was specified).

Example:

```
1> Bin2DC Bin2DC ram:bin2dc_source.s -b
```

8.3.11 BDiff and Unbdiff

BDiff *oldfile newfile* [*options*] small binary file compare program

The `BDiff` program determines the differences in contents between two files and describes these changes in a special output file (bdiff file). The output file will only be generated if any changes were found.

The produced bdiff file can be used later to reconstruct the *newfile* out of the *oldfile* or vice versa, except if the `-s` option was used while these files were compared.

`BDiff` supports the following options:

`-n` *nnn* This option sets the minimum number of bytes to *nnn* that must be identical to be considered a match. By default this value is set to 8 bytes.

`-o` *filename*
: Sends the output to the specified file (*filename*). The output is either a bdiff file, that contains the description of all differences, or the file generated out of an input and a bdiff file.

`-s`
: This option can be used to reduce the quantity of information stored in the resulting difference file. Only the update information from the *oldfile* to the *newfile* will be stored. Hence only the *newfile* can be reconstructed.

`-t1`

`-t2`
: `BDiff` normally determines by itself which file must be generated out of an input file and a bdiff file. However, if `BDiff` aborts an operation with a '`file checksums are equal -- use -t1 or -t2 option.`' error message, you have to use one of these options to tell `BDiff` what file you want to have generated. `-t1` forces the *oldfile* to be produced and `-t2` the *newfile*.

`-u`
: This option tells `BDiff` to reconstruct a file according to the given input file and bdiff file. `BDiff` determines by itself if either the former *oldfile* or the former *newfile* is to be rebuilt (see also the description of the `-t1` and `-t2` options). Using this option, `BDiff` expects the input file given as first argument (*oldfile*) and the bdiff file as second argument (*newfile*). The `-o` option must also be used to specify the resulting output file.

`-x`
: Since the generated bdiff file, that contains the descriptions of all differences, is no ASCII text file, you cannot read it using a text viewer or similar utilities. The `-x` option analyzes and disassembles a given bdiff file, and writes the output to the StdIO in an almost human readable format. It looks similar to the following example:

```
(4C) offset#1: 290/290, length#1: 1; offset#2: 290/290, length#2: 2
(0C) offset#1: 318/27, length#1: 1; offset#2: 319/27, length#2: 3
(4C) offset#1: 1840/1521, length#1: 4; offset#2: 1843/1521, length#2: 50
```

The first number, the hexadecimal number within the brackets, describes the internal code number and can be ignored. Offset#1 is the current offset in the first file, and consequently, offset#2 describes the offset in the second file. The second number in the offset field is the number of bytes from the end of the last difference to the beginning of the current difference. The length fields contain the number of bytes that do not match. See at the third line of the example above. There, length#1 is four and length#2 is 50 bytes. For example you want to generate the second file out of this information, this tells you that the four byte sequence at offset#1 has to be replaced by the 50 bytes starting at offset#2.

`-y` *nnn* This sets the I/O buffer size to the value specified by *nnn*. The default buffer size is 4096 bytes and its maximum is limited by the amount of available memory.

The following error messages can be reported by `BDiff`:

'`couldn't open file '`*filename*`' (`*DOS error code*`)`'
: `BDiff` cannot open the specified file. Check the spelling of *filename* and that the supplied pathname is correct. The *DOS error code* may give you more detailed information why the assembler could not open the file (see Appendix C *AmigaDOS Error Codes*, page 285).

'`error occurred during processing files`'
: An AmigaDOS error occurred while the files were compared.

'`error occurred during writing file`'
: An AmigaDOS error occurred while the output file was written.

'`file checksums are equal -- use -t1 or -t2 option`'
: If the checksums of the former *oldfile* and *newfile* were equal, `BDiff` is not capable to decide whether the *oldfile* or the *newfile* should be rebuilt. Use the `-t1` or `-t2` option to tell `BDiff` which file has to be reconstructed.

'`invalid output file checksum -- file may be corrupt`'
: After a file is rebuilt (see `-u` option), `BDiff` checks its checksum. An invalid checksum indicates that the produced file may be corrupt. This error can occur when a wrong input file is given that, unfortunately, has the same checksum as one of the former compared input files (*oldfile* or *newfile*).

'`invalid parameter line`'
: The parameter line has not the requested format, or one or more unknown parameters have been encountered. Start `BDiff` with the question mark ('`?`') as only argument to get a small usage information displayed.

'`invalid source file checksum`'
: When a file has to be rebuilt, `BDiff` checks the checksum of the input file (source file) to assure that the input file can be used with the given bdiff file. Check if the correct source file was given.

'`not a valid BDiff file`'
: The given bdiff file may be corrupt or invalid.

UnBDiff *input file bdiff file* **`-o`***output file* small binary un-bdiff

The `UnBDiff` program can be used to reconstruct a file according to the given *input file* and *bdiff file*. `UnBDiff` determines by itself if either the former oldfile or the former newfile is to be rebuilt.

`UnBDiff` expects the *input file* given as first argument and the *bdiff file* file as second argument. The `-o` option must also be used to specify the resulting *output file*.

This utility performs the same job as `BDiff` *input file bdiff file* `-u -o`*output file* does (see its description above). `UnBDiff` is simpler to use with its fixed command line usage, and can therefore be useful for software and update distributions.

The following error messages can be reported by `UnBDiff`:

'`couldn't open file '`*filename*`' (`*DOS error code*`)`'
: `UnBDiff` cannot open the specified file. Check the spelling of *filename* and that the supplied pathname is correct. The *DOS error code* may give you more detailed information why the assembler could not open the file (see Appendix C *AmigaDOS Error Codes*, page 285).

'`error occurred during writing file`'
: An AmigaDOS error occurred while the output file was written.

'`invalid output file checksum -- file may be corrupt`'
: After a file is rebuilt `UnBDiff` checks its checksum. An invalid checksum indicates that the produced file may be corrupt. This error can occur when a wrong input file is given.

'`invalid parameter line`'
: The parameter line has not the requested format, or one or more unknown parameters have been encountered. Start `UnBDiff` with the question mark ('`?`') as only argument to get a small usage information displayed.

'`invalid source file checksum`'
: When a file has to be rebuilt, `UnBDiff` checks the checksum of the *input file* to assure that the *input file* can be used with the given *bdiff file*. Check if the correct *input file* was given.

'`not a valid BDiff file`'
: The given *bdiff file* may be corrupt or invalid.

Appendix A Errors

This appendix lists in alphabetical order the error messages ProAsm generates, and describes their cause and how to fix the problem.

'`.W or .L as index size expected`'
: The size specifier of an index register in an indirect addressing mode with index must be either word or long word. (See Section 4.4 *Addressing Modes*, page 36).

'`absolute expression must evaluate`'
: The expression supplied with the `RORG` directive is too small. The program counter cannot be set to the new location, because it would overwrite already generated code. As shown in the following example:

```
...
movem.l (a7)+,d1-a6
moveq   #0,d0
rts

RORG    4               ; ⇒ error
...
```

To ensure a correct argument for the `RORG` directive, the expression '*argument* `-` *current program counter*' must always be positive.

'`absolute not allowed`'
: The operation will not allow the absolute addressing mode.

'`abuse of textual symbol (equr/equstr)`'
: You tried to use a textual symbol defined with the `EQUR` or `EQUSTR` directives (see `EQUR`, page 73) in a situation in which they are not allowed, such as within a `\*LEFT()`, `\*RIGHT()`, or `\*MID()` directive (see Section 5.2.1 *Substituting subsections of strings*, page 60). To fix this, simply "wrap" the textual symbol name in a `\*STRING()` directive (see Section 5.2.1 *Substituting textual symbols in symbol names*, page 58).

'`additional LABSEG on pass 2`'
: An additional `LABSEG` directive was encountered in pass 2, but not in pass 1. Possibly caused by a misuse of the `IF1` or `IF2` directive.

'`additional symbol found`'
'`additional symbol on pass 2`'
: A symbol was defined in pass 2, but not in pass 1. Possibly caused by a misuse of the `IF1` or `IF2` directive.

'`addressing mode not allowed`'
: The specified addressing mode is not allowed for this instruction. Refer to Motorola's Programmer's Reference Manual (see Appendix F *Bibliography*, page 299) for detailed information about the instruction and its addressing modes.

`addressing mode not recognized`

ProAsm could not recognize the addressing mode used for an assembly language instruction. Make sure the instruction's operands conform to one of the valid addressing modes in Section 4.4 *Addressing Modes*, page 36.

`address register expected`

An address register direct was expected as effective address.

`bad address size, .W or .L expected`

As valid sizes for absolute addressing modes only word and longword sizes are accepted. If no size is given, the assembler defaults to longword size. (See Section 4.4 *Addressing Modes*, page 36, for more details about the absolute addressing modes.)

Example:

```
move.l  (4).W,a6
lea     $dff000.l,a6
```

`bad arguments`

The supplied argument for a directive is not valid. To fix this, refer to the description of the directive that caused this error message. Example:

```
FILEPROTECT     +PX   ; ⇒ error, 'X' is an invalid argument
```

`bad character in expression`

An unexpected character was encountered in the expression.

`bad line length`

This error should not occur. If it does, please report it.

`bad macro name`

The specified macro name contains an invalid character. A macro name is like an ordinary symbol name, with the exception that the point (`.`) is not accepted as a valid character.

`bad operation size for FPU instruction`

The specified operation size for the floating-point instruction is not valid. Refer to the *M68000 Family Programmer's Reference Manual* or the *MC68881/MC68882 Floating-Point Coprocessor User's Manual*, for the correct operation sizes.

For example:

```
fmovem.l (a7)+,fp0-fp7  ; ⇒ error

fmovem.x (a7)+,fp0-fp7  ; ⇒ ok
```

`bad operation size for register`

The specified operation size for the instruction is not valid for the used register. Usually, valid operation sizes for registers are only byte, word, or longword.

Refer to the *M68000 Family Programmer's Reference Manual*, for the correct operation sizes.

`bad register`

The instruction that caused this error expected another register.

```
MC68030
pflush  a0,0   ; ⇒ error, either sfc, dfc,
...            ; or a data register expected
```

'`bad scale factor`'

Only the numbers 1,2,4, or 8 are allowed for the scaling factor. (See Section 4.4 *Addressing Modes*, page 36).

'`bad size, .B or .W expected`'
'`bad size, long expected`'

These errors occur if the specified operation size is not valid for the instruction. These error messages display also all valid size specifiers for that specific instruction.

For example:

```
move.d  d0,d7
; ⇒ error, 'bad size, .B, .W or .L expected'

add.b   d0,a2
; ⇒ error, 'bad size, .W or .L expected'
```

'`bit field offset/width out of range`'

The specified field offset or field width were out of range. The value of the offset field must be in the range of 0–31, and the value of the width field in the range of 1–32 (a width field of zero specifies a width of 32).

'`bit number must be from 0-7`'
'`bit number must be from 0-31`'

These error messages only occur when `OPT CHKBIT` was selected. `OPT CHKBIT` forces the assembler to be more strict when checking the immediate bit number for the bit manipulating instructions (`bclr`, `bchg`, `bset`, and `btst`). The accepted bit number depends on the destination addressing modes specified. If the destination is a data register, the bit numbering is from 0 to 31. For memory location, the bit numbers are from 0 to 7.

Generally this additional check is not needed, since the processor uses the bit number modulo 8 respectively 32. But it may be useful if you want to generate a "correct" code. (See `OPT CHKBIT`, page 107, for the descriptions of `OPT CHKBIT`, and refer to *M68000 Family Programmer's Reference Manual* for detailed information on the bit manipulating instructions.)

Example:

```
OPT     CHKBIT
btst    #10,foo(a5)
```

'`branch out of range (by` *number* `bytes)`'

A branch was specified outside of the range that can be reached by two bytes (-32768–32767).

'`byte displacement out of range (by` *number* `bytes)`'

The byte displacement of an "address register indirect with index (8 bit displacement)" or "program counter with index (8 bit displacement)" addressing mode is out of range.

'`calculator buffer overflow`'

This error should not occur. If it does, please report it.

'`cannot nest MACRO definitions`'

The assembler has found a macro definition within another macro definition (a `MACRO` directive was found inside a macro definition). (See Section 5.2 *Macros*, page 52, for more details about defining macros.)

'`closing brace '}' expected`'

The assembler expected a closing brace '`}`' but did not find one. Braces are used by a bitfield selection ('`{offset:width}`'. You should check the bitfield selection perhaps it was improperly declared.

'`colon expected`'

A colon ('`:`') is used within a bitfield selection ('`{offset:width}`', to separate the higher and lower long word of a quad word ('`highlong:lowlong`'), and to represent a pair of registers as used by certain instructions. These instructions are:

```
cas2 Dc1:Dc2,Du1,Du2,(Rn1):(Rn2)
divs.l <ea>,Dr:Dq
divsl.l <ea>,Dr:Dq
divu.l <ea>,Dr:Dq
divul.l <ea>,Dr:Dq
muls.l <ea>,Dh:Dl
mulu.l <ea>,Dh:Dl
fsincos <ea>,FPc:FPs
fsincos FPm,Fpc:FPs
```

(Dc1, Dc2 ,Du1 ,Du2, Dr, Dq, Dh, Dl any data registers; Rn1, Rn2 any data or address registers; FPc, FPs, FPm any floating-point data registers). Refer to *M68000 Family Programmer's Reference Manual* for detailed information about these instructions.

Examples:

```
bfclr    (a0){3:16}                   ; bitfield selection
pmove    #$007e0004:$80200000,crp     ; quadword
divu.l   foo(pc),d0:d1                ; 64-bit dividend in d0:d1
```

'`comma expected`'

The operand field of an instruction or directive may contain multiple operands. These operands must be separated by commas.

```
move.l  (a0) (a2)
; the assembler expects a comma between the two addressing modes
```

Whitespaces may be used within the operands field, but only within quoted strings:

```
move.l  #"opt ",d0
dc.b    "Hello world!"
```

'`could not examine file '`*filename*`''`

The assembler cannot get the information concerning the file *filename*. Check the spelling of *filename* and that the supplied pathname is correct.

'`could not open asl.library or req.library.`'

ProAsm uses the ASL file requester if you have Kickstart version 2.04 or later, or the REQ file requester on an earlier version of Kickstart. None of these libraries could be found. Install one of these libraries (according to your Kickstart version), or try not to run ProAsm with the `-F/FILEREQ` command line option set.

'`could not open file`'
'`could not open file '`*filename*`' (`*DOS error code*`)`'

The assembler cannot open the specified file. Check the spelling of *filename* and that the supplied pathname is correct. The *DOS error code* may give you more detailed information why the assembler could not open the file (see Appendix C *AmigaDOS Error Codes*, page 285).

'`could not open xpkmaster.library`'

The '`xpkmaster.library`' could not be found. The `XPK Data Compression Package` is probably not installed to your system. To fix the problem, you can either remove the option (`OPT XPK`) or install the XPK software package to your system. (Refer to `OPT XPK`, page 160 for further details about the XPK package.)

'`could not read file (`*DOS error code*`)`'

While reading the main source file, an AmigaDOS error occurred. Refer to the AmigaDOS error codes listed below for detailed information (Appendix C *AmigaDOS Error Codes*, page 285).

'`data register expected`'

An operand that should be a data register is not a data register.

For example:

```
moveq   #0,(a0)    ; ⇒ error
```

'`data too large`'

A given operand is larger than it is allowed to be. To fix this, refer to the description of the directive that caused this error message to get details about operand ranges etc.

For example:

```
DS.B    -2,0     ; ⇒ error
```

If an instruction causes this error message, refer to the *M68000 Family Programmer's Reference Manual* for detailed information about this instruction.

'`divide by zero`'

During the evaluation of an expression the assembler encountered a division by zero. Check the concerning expression for any division by zero, you may also have to look at the symbol values. For example:

```
foo EQU 0
...
move.l #2*(bar/foo),d0
```

'`DX only in executable object files allowed`'

The use of the `DX` directive is only in executable object files allowed. In other object files the use of `DS` is recommended. (See Section 5.7.3 *Declaring Data Blocks*, page 116, for more detailed information about these directives).

'`DX section cannot contain data or code`'

The `DX` directive must be at the end of a section (unless within a BSS section) and no other code or data generating directive is allowed after a `DX` directive.

'`ENDR/UNTILcc changed by mistake`'

The `REPT - ENDR` loop and the `REPEAT - UNTIL`*cc* loop are two different kind of loops. This error is caused, because either their loop introducers (`REPT`, `REPEAT`) or their loop terminators (`ENDR`, `UNTIL`*cc*) are changed by mistake. (See Section 5.4 *Repeating Text*, page 68, for more information about this directives.)

'`error while writing source file '`*filename*`' (`*DOS error code*`)`'

An AmigaDOS error occurred while writing the source file. Refer to the AmigaDOS error codes listed below for detailed information (Appendix C *AmigaDOS Error Codes*, page 285).

'`fatal error: unable to open window`'

ProAsm is unable to open an output window. Try to use other window dimensions if any were given. Another way to force ProAsm to send all its output to a window is to redirect it to a CON-window:

```
pro >CON:0/0/640/200/ProAsm_output mySource.s
```

This version has the disadvantage, that it does not wait for a keystroke after the assembly job has finished.

'`file load error (`*DOS error code*`)`'

An AmigaDOS error occurred while loading a file. (See Appendix C *AmigaDOS Error Codes*, page 285, for a list of the AmigaDOS error codes.)

'`fatally out of memory!`'

There is not enough memory available for the assembler to complete its task. This error occurs only if there is not enough memory to start the assembly or if the memory for the object code could not be allocated.

'`floating-point number value error`'

This error occurs if a floating-point constant has not the correct format. ProAsm accepts two notations for floating-point numbers: the pure fractional number and the engineering (exponential) notation. (See Section 4.2.1.2 *Floating-point Constants*, page 25, for more details about the floating-point constants and their formats.)

For example:

```
foo     FEQU    .E1         ; ⇒ error
        fmove.x #1.1.2,fp0 ; ⇒ error
```

'`flow of assembly changed`'

This error should not occur except by the abuse of the `IF1` or `IF2` directive. Check all the `IF1` and `IF2` conditional statements in your source code. None of them should contain code- or data-generating instructions or directives, or macro definitions.

This example below causes the assembler to report this error message:

```
        IF1
foo     MACRO
        ...
        ENDM
        ENDC

        IF2
foo     MACRO
        ...
        ENDM
        ENDC
```

This construct is not valid, because the assembler finds one macro name with two different definitions.

'`forward reference not allowed (OPT A+)`'

A forward reference was found while the automatic PC-relative addressing mode was enabled. When this mode is turned on (by using the `OPT A+` or `OPT AUTOPC` options, see `OPT AUTOPC`, page 93), the assembler transforms all absolute long addressing modes into PC-relative addressing modes. This error is only reported if the assembler transformed a forward referenced absolute long addressing mode only in the first pass, since in the second pass this reference may be out of range for the PC-relative addressing mode. To bypass this transformation you can append the '`.L`' size specifier to the absolute long addressing mode. (See `OPT AUTOPC`, page 93, and Section 4.4 *Addressing Modes*, page 36, for more details.)

'`FPU data register expected`'

An operand that should be a floating-point data register is not a floating-point data register. For example:

```
        fadd.x  fp0,(a0)  ; a FPU data register is expected
                          ; as destination operand
```

'`FPU register expected`'

An operand that should be a floating-point register is not a floating-point register.

For example:

```
lreg    EQUR    FP0
```

```
lregn   EQU     1
        ...
        fmove   (a0),lregn
        ; probably symbol names changed by mistake
```

'garbage following instruction'

The assembler issues this error when something unexpected follows an instruction or operand. For example:

```
        SECTION __OldSection,    ; ⇒ error
```

'illegal address mode for CPU type'

This error occurs if you try to use an addressing mode that is only valid on 68020 and higher processors while in MC68000 or MC68010 mode. If you want the code to run on any M68000 processor, fix the instruction to use a simpler addressing mode (see Section 4.4 *Addressing Modes*, page 36). Otherwise, set the processor type appropriately with one of the MC... directives (see Section 5.6.2 *Processor Options*, page 86).

'illegal arithmetic on xref symbol'

External symbol operations are limited in their combinations. This error is reported if an illegal arithmetic operation is performed on an external symbol. Refer to the table in the section Operators (Section 4.2.3 *Operators*, page 30) for an overview on all allowed operations and combinations with external symbols.

'illegal BSR.S'

The destination of the BSR.S is the following instruction, which is an illegal branch offset for the short (1-byte) form of BSR. To branch to the following instruction, you must use BSR.W. For example:

```
        bsr.s   foo
foo:    ...
```

'illegal directive inside INCEQU file'

Files included using the INCEQU directive have restrictions on their content, because they are read and processed in the first pass only. Only symbol and macro definitions should be used in a file loaded by the INCEQU directive. Code or data generating directives and temporary symbols are not allowed in such a file.

'illegal instruction for processor options'

The selected processor type does not support the opcode specified. (See Section 5.6.2 *Processor Type*, page 86.)

'illegal operator'

Check the operand field for a bad operator. (See Section 4.2.3 *Operators*, page 30, for a list of all operators that ProAsm recognizes.)

'illegal public symbol (xdef) definition'

You try to declare a symbol as externally visible (using XDEF) that is neither a label nor a numeric symbol. Check all symbols in the operand field of the particular XDEF directive for their types. Not allowed as arguments of the XDEF directive are symbols of the following types: any local symbols, register lists masks, textual symbols (`EQUR`), external references (`XREF`), floating-point constants, and undefined symbols.

'`illegal symbol name`'
: A symbol with an illegal name was encountered. Check the spelling of the symbol in question (you may refer to Section 4.1.1 *Labels*, page 19 for more details about symbols and their formats).

'`illegal type combination`'
: An attempt was made to combine quarrelsome symbol types and/or constants in an arithmetical expression. Consider the following example:

```
foo     FEQU    2
bar     EQU     8

        move.l  #foo*bar,d0     ; ⇒ error
```

Check all symbols and constants in the expression for their correct type.

'`illegal use of external reference (xref)`'
: An operation will not allow an external symbol to be used as operand. Refer to the description of the particular directive or instruction for more information about its usage.

'`illegal use of inside 'incequ' defined symbol`'
: Files included using the `INCEQU` directive have restrictions on their content, so have symbols defined in these files. These restrictions come from the concept of the `INCEQU` directive. Files included into the main source code using `INCEQU` are read and processed in the first pass only. If you try to change an inside 'incequ' defined symbol, this symbol cannot be set back to the initial value during the next pass. (See `INCEQU`, page 49).

Use the `INCLUDE` directive if you have to redefine symbols defined in external files.

'`illegal value`'
: The expression evaluator could not find a valid value: a symbol, constant, or an expression. An invalid prefix to a number or a bad symbol name in an operand may also generate this error message. For example:

```
        move.l  #14+),d0     ; ⇒ error
        move.l  ##14,d0      ; ⇒ error
        move.l  #{2+3}*4,d0  ; ⇒ error
```

'`immediate value expected`'
: Some instructions of the M68000 family require immediate data as source operand. The value is specified by the expression following the pound sign '`#`'. Either the pound sign is missing or the wrong instruction is used. The following examples generate this message:

```
        subq.l  3,d0
        trap    #8
        andi    %1101011,d2
```

'`invalid argument for this keyword`'

An argument of a keyword is invalid. Refer to the description about this keyword to get more details about what type of argument is requested.

Consider the following example:

```
foo     MACRO
        dc.b    \*STRING(\1),0 ; textual symbol as argument expected
        EVEN
        ENDM

        foo     1              ; ⇒ error
```

'`invalid default mode`'

A `DEFAULT` directive was encountered with an invalid *mode* argument that cannot be combined with the given *type* argument.

Refer to the description of the `DEFAULT` directive for more detailed information about the default types and their accepted modes.

'`invalid k-factor`'

The k-factor of the `FMOVE.P` instruction or the `SETKFACTOR` directive is out of range. The range of a k-factor must be from -64 to +63. (See `SETKFACTOR`, page 90).

'`invalid number`'

An invalid digit was encountered in a number. For example, using a '2' or '3' in a binary number:

```
move.l  #%1010201,d0
```

'`invalid option`'

The options specified does not exist. (See `OPT`, page 156, for an overview of all supported options.)

'`invalid parameter`'

A directive was encountered with one or more invalid parameters in its operand field. See the description of the directive that generated this message for full details about the accepted parameters.

'`invalid parameter line, consult ProAsm manual for more details.`'

The parameter line has not the requested format, or one or more unknown parameters have been encountered. Start ProAsm with the question mark ('`?`') as only argument to get a small usage information displayed, or refer to Section 3.1 *Invoking*, page 9 for a complete list of all supported command line parameters and the accepted command line format.

'`invalid section memory requirement`'

Only `CHIP`, `FAST`, `PUBLIC`, `MEMF`, and `ADVISORY` are allowed as valid section memory requirements. (Refer to `SECTION`, page 133 for more detailed information about these memory requirements.)

'`invalid section type`'

Only `CODE`, `DATA`, and `BSS` are allowed as valid section types. (Refer to `SECTION`, page 133 for more details.)

'`invalid size`'

An instruction has either no size at all or it does not support the used size. Example:

```
add.p    #12,d0   ; invalid size 'packed' for the add
                  ; instruction
```

'`label from other section`'

This error occurs if you try to make PC relative references to another section. To fix this error avoid PC relative references, try to use absolute addressing modes

Consider the following example:

```
        SECTION "bar",code
        jsr     foo(pc) ; relative jump ⇒ error,
        ...             ; use jsr foo instead.

        bra     foo     ; relative jump ⇒ error,
        ...             ; use jmp foo instead.

        SECTION "foobar",code
foo:
```

'`label value changed between passes`'

This indicates an assembler error where the label does not have the same value on pass 2 as it does on pass 1.

This error may also be caused by a misuse of the `IF1` or `IF2` directive (see `IF1`, page 65).

'`line malformed`'

The line that caused this error message has not the prescribed form. Each line has the following general layout:

label mnemonic operands comment

(For more details about the line format see Section 4.1 *Source Line Format*, page 19.)

'`linker format restriction`'

This error occurs only if the linkable object file format was changed to `_RELATIVE` (see `DEFAULT`, page 91) and a 32-bit data section relative relocation (hunk_dreloc32) should be generated.

Since the linker reference mode `_RELATIVE` is implemented only for compatibility with some older (non-standard) linkers, this error message should not be a problem at all. These linkers do not support the hunk_dreloc32 hunk format.

If you are using either `ALINK` (the Amiga standard linker) or `BLINK` (the replacement linker from 'The Software Distillery') the linker reference mode should be set to `_BASERELATIVE` (with `DEFAULT _LINKREF,_BASERELATIVE`).

Note that ProAsm defaults to `_BASERELATIVE`.

`local label not allowed`
: The directive that caused this error does not allow local labels as arguments. Refer to the description of this directive for more detailed information.

For example:

```
            linkable
            xdef    .foo,1$     ; local symbols cannot be exported.
            ...
      .foo:
      1$:
```

`locked symbol used`
: A symbol that was marked previously as "locked" using the `LOCKSYM` directive is used within an expression or addressing mode. Check why the symbol is "locked", or unlock it using the `UNLOCKSYM` directive (see `UNLOCKSYM`, page 166).

`macro defined twice`
: The macro label name is multiply defined in the same program. You will need to change at least one of them to a unique name.

`MC68040 software-supported instruction used`
: A floating-point instruction is used that has to be emulated by Motorola's floating-point software package on the MC68040 processors to ensure complete compatibility to the floating-point coprocessors.

You can either enable the software-supported instructions using the `OPT FPSP40` option (see `OPT FPSP40`, page 88) or remove this instruction and replace it by a subroutine (or whatever).

Note that by default all MC68040 software-supported instructions are enabled.

`MC68060 software-supported instruction used`
: A integer or floating-point instruction is used that has to be emulated by Motorola's software package on the MC68060 processors to ensure complete compatibility to older processor models and the floating-point coprocessors.

You can use the `OPT SP60` option (see `OPT SP60`, page 89) to enable the MC68060 integer instruction emulation, or the `OPT FPSP60` option (see `OPT FPSP60`, page 88) to enable the floating-point software-supported instructions.

Note that by default all MC68060 software-supported instructions are enabled.

`misplaced ELSE/ELSEIF encountered`
: An ELSE or ELSEIF directive was encountered when not currently in conditional assembly.

`misplaced ENDIF/ENDC encountered`
: An `ENDC` or `ENDIF` directive was encountered when not currently in conditional assembly.

`missing close bracket`
: An unmatched open bracket (`(`) was found in an expression.

'missing ENDIF/ENDC'

An IF directive is encountered without a matching ENDIF/ENDC directive. This error commonly occurs if an END directive within a matching IF - ENDC block was found.

For example:

```
foo     EQU     0
        ...
        IFEQ    foo
                ...
                END             ; ⇒ error
        ENDC
```

(See Section 5.3 *Conditional Assembly*, page 61, for more information about conditional assembly directives and their use.)

'missing quote'

An unmatched quote (single or double quote) was found in a string. Make sure the string is correctly enclosed in quotes. You may not mix single and double quotes.

Remember you must use the sequence '''' or '""' to represent a single respectively a double quote inside a string. If escape sequences are allowed (see ESCAPESTR, page 162), a quote can also be represented by either '\'' for a single or '\"' for a double quote.

Examples:

```
        dc.b    "'Ouch!'",0         ; ⇒ 'Ouch!'
        dc.b    '''Ouch!''',0       ; ⇒ 'Ouch!'

        ESCAPESTR
        dc.b    "\'Ouch!\'",0       ; ⇒ 'Ouch!'
        dc.b    '\'Ouch!\'',0       ; ⇒ 'Ouch!'
```

'MMU register expected'

An operand that should be a MMU register is not. For example:

```
lreg    EQUR    TC
lregn   EQU     1
        ...
        pmove   (a0),lregn ; probably symbol names changed by mistake
```

'more than 2147483647 IFs nested!'

Conditional assembly directives can "only" be nested up to 2147483647 times. (See Section 5.3 *Conditional Assembly*, page 61, for more information about the conditional assembly directives.)

'negative value expected'

An operand to a NB, NW, or NL directive was positive. Change the value or use a normal DC directive instead. (See Section 5.7.2 *Initialized Data with Restricted Range*, page 115.)

`no code or data allowed ahead of the HEADER directive`

The `HEADER` directive must be at the beginning of a source code. No code or data generating directives are allowed ahead of the `HEADER` directive. To fix this error, move the directive to the top of the source code or replace it by the `INCLUDE` directive.

`no label on line`

No label was specified for the `MACRO` directive. The given label represents the macro body later in the code:

```
CALL_   MACRO
        jsr     \1
        ENDM

        dots
        CALL_   PrintTitle
        dots
```

(More about macros can be found on Section 5.2 *Macros*, page 52.)

`no MACRO definitions within REPT/REPEAT loops`

Macro definitions within repeat loops are not allowed, since the same macro would be defined more than once. Just move the macro definition outside the repeat loop.

`no relocation in binary/s-record file`

An absolute long addressing mode or a reference that needs a relocation was encountered (see Section 4.2.2.2 *Relocatable Symbols*, page 26).

To avoid relocation within binary/s-record files, you can use PC-relative addressing modes (see Section 4.4 *Addressing Modes*, page 36) or the `ORG` directive (see Section 5.6.7 *Absolute Assembly*, page 112).

See also the description of the `MEA` pseudo-opcode, that can make program counter relative assembly easier (see Section 5.8.2 *Move Effective Address*, page 127). If you do not want to use this pseudo-opcode for certain problems, you have also the possibility to split up the instruction that generated the error message in two or more instructions. Look at the following example:

```
        BINARY

        move.l  #foo,d0         ; ⇒ error

split it up to:
        pea     foo(pc)
        move.l  (a7)+,d0
```

`no size expected`

An unsized instruction was assembled with a size specifier. For example:

```
nop.l ; ⇒ error
```

'`not allowed in binary/s-record file`'

The directive that caused this error is not allowed if a binary or s-record output file is generated. Refer to the description of the particular directive for more detailed information.

'`not a valid effective address`'

A `MOVEM` or `FMOVEM` instruction was encountered with an invalid effective address. Refer to the description of the instruction to get details about the allowed addressing modes.

A misuse of the given register lists may also generate this error message. Consider for example:

```
foo     REG     d0-d7/a2
bar     REG     d0-a6

        movem.l bar,foo(a5)
```

'`not a valid FPU control register list`'

The control register list in a `FMOVEM` instruction or `FREG` directive is malformed. A register list must contain one or more FPU control registers (`fpcr`, `fpiar`, `fpsr`). The registers must be separated by a slash ('`/`') or a minus sign ('`-`').

'`not a valid FPU register list`'

The register list in a `FMOVEM` instruction or `FREG` directive is malformed. A register list must contain one or more FPU data registers (`fp0`-`fp7`). The registers must be separated by a slash ('`/`') or a minus sign ('`-`').

'`not a valid register list`'

The register list in a `MOVEM` instruction or `REG` directive is malformed. A register list must contain one or more registers. The registers must be separated by a slash ('`/`') or a minus sign ('`-`'). Consider the following example:

```
foo     REG     d0/d2-d4/d7-a2/a4-a5
```

The symbol `foo` is a register list mask for the registers `d0`,`d2` through `d4`, `d7` through `a2`, `a4`, and `a5`.

'`no value given`'

No term given, or the expression evaluator could not find a valid term. A symbol, constant, or expression might be invalid.

'`no XPK archives supported`'

You tried to load an XPK archive file using a file including directive (such as `INCLUDE`). ProAsm accepts only normal source files or XPK packed files to be included into the program source.

'`object filename already specified`'

More than one `OUTPUT` or `OBJFILE` directive was present in the source code, specifying conflicting filenames. Find the conflicting directives and eliminate one of them, or change the filenames to match.

'`object size differs between passes`'

The object size does not have the same value after pass 2 as it had after pass 1.

This error may be caused by a misuse of the `IF1` or `IF2` directive (see `IF1`, page 65).

'`odd address`'

Instructions of the M68000 Family must always be on a word (even) address. Use the alignement directives (see Section 5.7.5 *Alignment Padding*, page 120) to ensure word boundary. For example:

```
DC.B     "Hello world!",0   ; 13 byte long string...
EVEN                        ; the EVEN directive ensures word alignement
moveq    #0,d0
```

'`opening brace '{' expected`'

The assembler expected a opening brace '`}`' but did not find one. Bitfield manipulating instructions expect bitfield selections straight after the last operand. This message may be generated if too many operands were given for such an instruction. For example:

```
bftst    d0,d11:6       ; too many operands for bftst
```

'`operand too large, byte expected`'

The operand, in most cases an immediate addressing mode, is too large to fit in the expected byte size. For example

```
move.b   #300,d0        ; value not within a signed 8 bit range
```

'`operand too large, word expected`'

The operand, in most cases an immediate addressing mode, is too large to fit in the expected word size. For example

```
move.w   #100000,d0     ; value not within a signed 16 bit range
```

'`option must be at beginning`'

The used option must be placed at the beginning of the source code. This error occurs if a symbol concerning option (such as `CASEON`, `OPT C`, `OPT ESS1` etc.) is used after a symbol is defined. Just move this option to a place before the first symbol is defined:

```
; begin of source code
foo:    ...
        OPT     C-              ; invalid location in the source code


; begin of source code
        OPT     C-              ; correct location in the source code
foo:    ...
```

'`out of memory`'

There is not enough memory available for the assembler to complete its task. To get more memory you probably have to quit other running applications, etc. If you still have not enough memory, cut the program into smaller portions, assemble the portions of the program separately and then bind them together using a linker.

'overflow'

This error is reported if an overflow occurs while evaluating an expression. In other words, the result of the evaluated expression is larger than $ffffffff, +$7fffffff, or -$80000000.

For example:

```
move.l  #$7fffffff+1,d0 ; ⇒ overflow
```

'PC value changed between passes!'

This error message occurs rarely and indicates an inconsistency; mostly by abusing the `IF1` and `IF2` directives. No code or data generating instruction or directive should be inside a `IF1`/`IF2` condition statement (see `IF1`, page 65). Consider the following example:

```
IF2
DC.L "this text is placed very unhappily"
ENDC
```

It is also unwise to make constructions as shown in the following example:

```
IF1
DS.B  8,0
ENDC

IF2
DS.B  8,$20
ENDC
```

No error message will be reported by the assembler, since the program counter does not differ. However, such hacks may complicate the task of finding any bugs in the code.

'positive value expected'

An operand to a `PB`, `PW`, or `PL` directive was negative. Change the value or use a normal `DC` directive instead. (See Section 5.7.2 *Initialized Data with Restricted Range*, page 115).

'preasm file expected'

You tried to load a file using the `MACLIB` directive that is not a preassembled file. The `MACLIB` directive is used to import symbol and macro definitions only from preassembled files. (See `MACLIB`, page 50, for more information about this directive.)

'premature end byte reached'

An end of file (EOF) was encountered while the assembler expected more source code. This error occurs also if a null byte was found in the source file. Examples:

```
addq.l  #2,<NULL>d0
move.l  #12<EOF>
```

'probably immediate addressing mode'

An absolute addressing mode as source operand was given where it was not supposed to be. This error will only reported when the `OPT I+` option is selected. There is probably a pound sign '`#`' missing. You can force the assembler to use absolute addresses by appending one of the absolute address size specifiers '`.L`' or '`.W`'.

Example:

```
OPT     I+
move.l  4,a6          ; no error will be reported
add.l   $100,d0       ; immediate addressing mode was probably meant
move.l  $f80000.L,d0  ; no error will be reported
```

'`quite a heap of code (PC overflow!)`'

The code you tried to generate was greater than 4294967295 bytes. (Since the Amiga is a 32 bit machine you cannot access more than 4 GBytes of memory.) You probably used one or more `DS` directives (or its synonyms) with too large arguments.

Consider for example:

```
...
rts

ds.b $7fffffff,0      ; ⇒ error
```

'`register or immediate value expected`'

An operand that should be a register or immediate value is not.

For example:

```
MC68851

pflushs (a0),#0        ; ⇒ error
```

In the example above, the first operand should be either a data register, a `sfc`, or a `dfc` register, instead of the address register indirect addressing mode ('`(a0)`').

If an instruction causes this error message, refer to the *M68000 Family Programmer's Reference Manual* for detailed information.

'`relative not allowed`'

The operation requires that the operand is not relative (not a label).

'`relocation not allowed (OPT P+/A+/T+, DSEG)`'

An instruction or directive was encountered that produced a relocation (absolute addressing modes, etc.).

Check the use of the `OPT P+`, `OPT A+`, or `OPT T+` options and/or the `DSEG` directive. These options and this directive dictate the assembler a certain behaviour when a relocation is encountered.

Remove these options and directive or avoid relocation. To avoid relocation you can use PC-relative addressing modes (see Section 4.4 *Addressing Modes*, page 36), or the `ORG` directive if you want to produce absolute code (see Section 5.6.7 *Absolute Assembly*, page 112).

See also the description of the `MEA` pseudo-opcode that can make program counter relative assembly easier (see Section 5.8.2 *Move Effective Address*, page 127). If you do not want to use this pseudo-opcode for certain problems, you also have the possibility to split up the instruction that generated the error message into two or more instructions. Look at the following example:

```
                BINARY

                move.l  #foo,d0         ; ⇒ error

      split it up to:
                pea     foo(pc)
                move.l  (a7)+,d0
```

'`reserved register`'
A processor register name was used as a symbol name. (Refer to Section 4.3 *Registers*, page 35, for an overview of all supported processor registers.)

'`reserved symbol`'
You tried to redefine a reserved symbol such as `__DATE`. (See Chapter 6 *Special Symbols*, page 171.)

'`short branch out of range (by` *number* `bytes)`'
A short branch was specified outside of the range that can be reached by one byte (-128–127). Use a branch or jump instruction which can access a larger range.

'`source and object files are the same`'
The name of the specified output file is identical to the name of the processed source file. This is to prevent the source file from been overwritten.

'`source expired prematurely`'
An `END` directive or a zero byte (end of source code) was found during conditional assembly within a macro body or a repeat loop. In most cases an `ENDC`, `ENDM`, `ENDR`, or an `UNTIL`*cc* directive is missing.

'`spurious APOPM encountered`'
An `APOPM` pseudo opcode was encountered without matching `APUSHM`.

'`spurious ENDORG encountered`'
An `ENDORG` directive is encountered when not currently in absolute assembly mode (see Section 5.6.7 *Absolute Assembly*, page 112).

'`spurious ENDR or UNTILcc encountered`'
An `ENDR` or `UNTIL`*cc* directive is encountered outside a repeat loop (see Section 5.4 *Repeating Text*, page 68).

'`spurious REXIT encountered`'
A `REXIT` directive is encountered outside a repeat loop (see Section 5.4 *Repeating Text*, page 68).

'`string expected`'
An operand that should be a string is not a string. Refer to the description of the directive that caused this error for more information.

'`string too long`'

This error occurs if a given string is longer as expected by the directive. See the description of the particular directive for more information.

'`symbol defined twice`'

You tried to use the same symbol name in two different places in the same program. You will need to change at least one of them to a unique name.

If you find yourself accidentally reusing symbols often, you may want to use local symbols more often (see Section 4.1.1.1 *Local Labels*, page 20). Using local symbols as much as possible can greatly reduce the number of symbols you have to keep track of throughout your program.

'`symbol expected`'

No symbol was specified for a directive that must have one. Refer to the description of the directive that caused this error message for more information.

'`symbol not defined`'

A symbol is used that is not defined in the source code.

'`symbol name too long`'

The symbol name was longer than 256 characters.

'`too many close brackets`'

Too many close brackets ('`)`') are found. Either more open brackets have to be inserted or the superfluous close brackets have to be removed to get properly balanced brackets.

'`too many brackets`'

The assembler supports brackets to be nested up to 255 levels. This error occurs if more brackets are nested within an expression, than accepted by the assembler.

'`too many sections (max 256)`'

The assemblers allows the definition of maximal 256 different sections. This error occurs if you try to define more sections as allowed. (See `SECTION`, page 133, for more information about defining sections.)

'`unable to define preassembled symbol '`*symbol name*`''`'

The symbol '*symbol name*' in the preassembled file may be already defined or has an illegal name. (Refer to Section 4.1.1 *Labels*, page 19 for more details about symbols and their formats.)

Check your source code for any, already defined, symbols that are named as *symbol name*.

'`unable to define symbol`'

This error is reported when a symbol is not correctly defined via command line parameters (`-S/DEFINE` and `-T/STRING`, Section 3.1 *Invoking*, page 9)

Check the spelling of the symbol in question (you may refer to Section 4.1.1 *Labels*, page 19 for more details about symbols and their formats), and ensure the correct use of the command line parameters.

'`unable to import symbol`'
An attempt was made to import a symbol (using the `XREF` directive) that is already defined or has an illegal name. (You may refer to Section 4.1.1 *Labels*, page 19 for more details about symbols and their formats.)

'`unable to open list file '`*filename*`' (`*DOS error code*`)`'
An AmigaDOS error occurred while trying to open the listing file. Refer to the AmigaDOS error codes listed below for detailed information.

'`undefined symbol`'
You tried to use a symbol that has not been defined in the program. Check if the symbol is not misspelled in either its definition or its reference.

One common cause of this error is referencing a symbol with different case than it is defined while case sensitivity is turned on, as this example demonstrates:

```
Foo:
                ...
                bsr     foo     ; Error: 'Undefined symbol'
```

To fix this, turn case sensitivity off (see Section 5.5.3 *Case Sensitivity*, page 83) or change the symbol names to match exactly.

Another common cause of this error is trying to reference a local label "across" a global label. This often happens just after inserting a new global label in the middle of existing code. In the following example, an entrypoint '`bar`' has just been inserted into the routine '`foo`':

```
foo:
                ...
.loop:
                ...
bar:
                ...
                bra     .loop   ; Error: 'Undefined symbol'
```

To fix this, turn the global label ('`bar`' in this example) into a local label, or turn the local label ('`.loop`') into a global label.

'`unexpected ENDM or MEXIT encountered`'
An `ENDM` or `MEXIT` directive was encountered when not inside a macro definition.

'`unknown keyword for this directive`'
A directive with an unknown keyword was encountered. See the description of the directive that generated this error message for information about the allowed keywords.

'`unrecognized default mode`'
This error is reported if the *mode* argument of the `DEBUG` directive is not recognized by the assembler. Check the spelling of the *mode* argument. (See also `DEFAULT`, page 91, for more information about the `DEFAULT` directive and its arguments.)

`unrecognized default type`

This error is reported if the *type* argument of the `DEBUG` directive is not recognized by the assembler. Check the spelling of the *type* argument. (See also `DEFAULT`, page 91, for more information about the `DEFAULT` directive and its arguments.)

`unrecognized instruction`
`unrecognized instruction '`*instruction*`'`

The assembler did not recognize the instruction mnemonic. Check the spelling of the instruction or the macro.

`unresolved symbol '`*symbol*`' found`

This error is reported if circular references are found while multi-pass optimization is enabled.

`unsupported preasm file entry encountered`

An unsupported entry is encountered while processing the preasm file. This error only occurs if the included preasm file is crippled.

Try the same assembly job with a new generated preasm file. (See `PREASM`, page 130, for more information about this directive.)

`unsupported preasm file version`

You tried to load an unsupported version of a preasm file.

Try the same assembly job with a new generated preasm file. (See `PREASM`, page 130, for more information about this directive.)

`user error`

The `FAIL` directive was assembled (see `FAIL`, page 103, for more details).

`value between 1 and 8 expected`

An operand has to be within the range of 1–8. Refer to the description of the particular directive for more information. If an instruction causes this error message, refer to the *M68000 Family Programmer's Reference Manual* for detailed information about this instruction.

`value must be zero`

An operand that should result in a value of zero is not. Refer to the description of the directive that caused this error for more information.

For example:

```
...
DX.B    6,4     ; ⇒ error, DX.B 6,0 expected.
```

`value not in bounds`

An operand is not within valid bounds as dictated by the directive. Refer to the description of the particular directive for information about the range of accepted values.

'`word displacement out of range (by` *number* `bytes)`'

A word displacement, as for address register indirect with displacement and program counter indirect with displacement addressing modes, is not within the range of -32768–32767 by *number* of bytes. (See Section 4.4 *Addressing Modes*, page 36, for more information about word displacements and addressing modes.)

'`XPK error,` *XPK specific error message*'

This error is displayed when the XPK software package returns an error to ProAsm. Refer to the XPK software documentation for more information about errors and their causes.

'`** error occurred trying to create error file '`*filename*`' (`*DOS error code*`)`'

An AmigaDOS error occurred while creating the error file *filename*. (See Appendix C *AmigaDOS Error Codes*, page 285, for a list of the AmigaDOS error codes.)

'`** Panic! premature end byte reached`'

An unexpected null byte (end of file) is encountered while the assembler expected more source code. Please check your source code for any misplaced null bytes or crippled instructions at the end of the source code.

'`INTERNAL:` ...'

These are internal error messages which should never occur. If the assembler does report one of them, please report it. Please provide as many details as possible about the situation in which the error occurred; this will greatly aid correcting the problem (see `ERRFLAG`, page 166, to get more information about the error).

Appendix B Warnings

This appendix lists in alphabetical order the warning messages generated by ProAsm, and describes their cause and meaning. Although you can often safely ignore warning messages, sometimes they indicate a problem; in general you should at least examine each warning once and make sure you understand it. Fixing the code, so the warning is not generated at all is usually better, though.

'`ADDA/SUBA #0,An instruction skipped`'
: This warning is generated when the assembler skipped an `adda` or `suba` instruction with an immediate source operand of zero. This optimization is only made if the `Q4` option is turned on (see Section 5.6.4 *Optimization*, page 93).

  These instructions can be skipped unproblematically, since they do not affect the condition codes and an addition or subtraction of zero has no effect to the address register.

'`absolute long address mode made short`'
: The assembler optimized an absolute long address to its short form (absolute word address). Only absolute addresses are optimized.

  This optimization is only made if the `O3` option is turned on (see Section 5.6.4 *Optimization*, page 93).

'`absolute short address mode possible`'
: The assembler encountered a forward referenced absolute long address that can be shortened to absolute word. You may optimize it yourself to save two bytes. This optimization possibility is only reported if the `O18` option is turned on (see Section 5.6.4 *Optimization*, page 93).

'`APUSHM and APOPM directives converted to (two) NOPs each`'
: The assembler encountered a pair of `APUSHM` and `APOPM` pseudo-opcodes with empty register lists and replaced each of them with two `nop` instructions.

  (See Section 5.8.1 *Stack Manipulation*, page 125, for the descriptions of the `APUSHM` and `APOPM` pseudo-opcodes.)

'`ASL/ROXL #1,Dx converted to ADD/ADDX Dx,Dx`'
: This warning is issued when the assembler could convert a `asl.y #1,d`*x* instruction to `add.y d`*x*`,d`*x*, or a `roxl.y #1,d`*x* instruction to `addx.y d`*x*`,d`*x*. This optimization is only made if the `Q2` option is enabled (see Section 5.6.4 *Optimization*, page 93).

'`AUTOXREF only in linkable files allowed`'
: You used the `AUTOXREF` directive while generating non-linkable output, like an executable. (See Section 5.9.5 *Defining and Referencing External Symbols*, page 141, for the description of the `AUTOXREF` directive.)

`base displacement shortened`

The assembler reports this message when a base displacement within the range of -32768–32767 is optimized from long to word size. This optimization is only made if the `O13` option is enabled (see Section 5.6.4 *Optimization*, page 93).

To suppress this optimization you may add a longword size specifier (`.L`) to the base displacement.

`bit number should be from 0-7`
`bit number must be from 0-31`

These warning messages only occur when `OPT WARNBIT` was selected. `OPT WARNBIT` forces the assembler to be more strict when checking the immediate bit number for the bit manipulating instructions (`bclr`, `bchg`, `bset`, and `btst`). The accepted bit number depends on the destination addressing modes specified. If the destination is a data register, the bit numbering is from 0 to 31. And for memory location, the bit numbers are from 0 to 7.

Generally this additional check is not needed, since the processor uses the bit number modulo 8, respectively 32. But it may be useful if you want to be informed where immediate bit numbers are "out of range."

Example:

```
        OPT     WARNBIT
        btst    #10,foo(a5)
```

(See `OPT WARNBIT`, page 107, for the descriptions of this option, and refer to *M68000 Family Programmer's Reference Manual* for detailed information on the bit manipulating instructions.)

`branch made short`

A branch was optimized to its short form (see Section 5.6.4 *Optimization*, page 93, for information about the `O1` option).

`CLR.L converted to MOVEQ`

The assembler converted a `clr.l d`*n* instruction to `moveq #0,d`*n*, where `d`*n* is a valid data register. (See Section 5.6.4 *Optimization*, page 93, for more information on the `Q1` option.)

`CMPI.x #0,<EA> converted to TST.x <EA>`

If the `O9` option is turned on (`OPT O9+`), the assembler converts `cmp`, `cmpi`, and `cmpa` instructions with an immediate source operand of zero to a `tst` instruction. (See Section 5.6.4 *Optimization*, page 93.)

`code ahead of the ORG directive`

The assembler found code or data ahead of the `ORG` directive. Using the `ORG` directive while generating executable or linkable object code is not recommended (see Section 5.6.7 *Absolute Assembly*, page 112). However, this warning message can be ignored when the use of absolute code within executable or linkable code is desired.

'`code/data is not allowed in preasm files, ignored`'

Since a preasm file contains only the symbol and macro table, all code and data generating directives are useless and therefore ignored by the assembler. Only their sizes are taken into account to update the program counter. (See `PREASM`, page 130, for the description of this directive.)

'`DX statement in empty hunk found`'

This warning message is reported when a `DX` directive is found within an empty code or data hunk. A code or data hunk that contains only `DX` directives, is in its function equivalent to a bss hunk. You may use a bss hunk instead. (See *The AmigaDOS Manual* for more information about AmigaDOS hunk formats.)

'`EOR(I).x #-1,<EA> converted to NOT.x <EA>`'

The assembler converted an `eor` or an `eori` instruction with an immediate source operand of zero to a `not` instruction. This conversion is only made if the `Q12` option is turned on (see Section 5.6.4 *Optimization*, page 93).

'`error file already specified, directive ignored`'

This warning is reported if more than one `ERRFILE` is present in the source code, specifying conflicting filenames for the error file. (See Section 5.10.1 *The Error File*, page 146, for more information about the use of this directive.)

'`external references (xref) only in linkable files allowed`'

You used the `XREF` directive while generating non-linkable output, like an executable. If you actually try to use the symbol defined as `XREF`, an error will occur. (See Section 5.9.5 *Defining and Referencing External Symbols*, page 141, for the description of the `XREF` directive.)

'`f-line exception will be generated!`'

This warning messages is issued when the assembler encounters a `ptest` that specifies an address translation cache search with an address register operand while the `MC68030` processor is selected. The MC68030 processor takes an F-line unimplemented instruction exception when this `ptest` instruction is executed. (Refer to the *M68000 Programmer's Reference Manual* for more details about the `ptest` instruction on a MC68030 processor.)

For example, the following code fragment generates this warning:

```
MC68030
ptestr d0,4(a2),#0,a0    ; ⇒ warning
; level 0 specifies searching the address
; translation cache only.
```

'`instruction has no effect on a MC68EC030`'

The MC68EC030 executes all instructions just as the MC68030 does, except that the MC68EC030 does not execute all memory management unit instructions. The `pflush` and `pflushn` instructions have no effect when executed. (Refer to the *M68000 Family*

Programmer's Reference Manual, for complete details on the MC68EC030 instruction set.)

'`instruction made quick`'

This warning is reported when the assembler optimized an instruction to its 'quick' form. Instructions with quick variants are: `add` (`addq`) and `sub` (`subq`). (See Section 5.6.4 *Optimization*, page 93, for more details `O5` option.)

'`invalid LINK displacement`'

The assembler found a positive or odd `link` displacement. Example:

```
link    #16,a5
```

'`long MOVEA/ADDA/SUBA converted to word`'

A `movea.l`, `adda.l`, or `suba.l` instruction with an immediate value within the range of -32768–32767 is shortened to word operation size.

This optimization is only made if the `O8` option is enabled (see Section 5.6.4 *Optimization*, page 93).

'`Motorola reserved Constant ROM offset used`'

The `fmovecr` instruction, that causes this warning, uses a Constant ROM offset that is reserved by Motorola. (Refer to the *M68000 Family Programmer's Reference Manual* for a list of valid offsets and their meanings.)

The use of reserved constants is not recommended, since they are useful only to the on-chip microcode routines and may be different on various mask sets of the floating-point coprocessor.

'`MOVEA #0,An converted to SUBA An,An`'

This warning message is reported when the assembler optimized a `movea` instruction with an immediate value of zero to `suba a`*n*`,a`*n*.

This optimization is only made if the `Q3` option is enabled (see Section 5.6.4 *Optimization*, page 93).

'`MOVE.L converted to MOVEQ`'

This warning is reported when the assembler optimized a `move.l` instruction to its 'quick' form (`moveq`).

This optimization is only performed if the `O4` option is turned on. (See Section 5.6.4 *Optimization*, page 93, for more details `O4` option.)

'`MOVE.L #n,Dx converted to MOVEQ #m,Dx & NOT`'

The assembler optimized a `move.l #n,d`*x* instruction to a shorter form by splitting it in a combination of a `moveq #m,d`*x* and a `not` instruction.

This optimization is only made if the `Q5` option is enabled (see Section 5.6.4 *Optimization*, page 93).

'`MOVE.L #n,Dx converted to MOVEQ #-128,Dx & SUBQ.L #n+128,Dx`'

This warning is issued when the assembler optimized a `move.l #n,d`*x* instruction to a shorter form by splitting it in a combination of a `moveq #-128,d`*x* and a `subq.l #n+128,d`*x* instruction.

This optimization is only made if the `Q7` option is enabled (see Section 5.6.4 *Optimization*, page 93).

'`MOVE.L #n,Dx converted to MOVEQ #m,Dx & SWAP Dx`'

The assembler optimized a `move.l #n,d`*x* instruction to a shorter form by splitting it in a combination of a `moveq #m,d`*x* and a `swap d`*x* instruction.

This optimization is only made if the `Q8` option is turned on (see Section 5.6.4 *Optimization*, page 93).

'`MOVE.L #n,Dx converted to MOVEQ #m,Dx & ADD.B Dx,Dx`'

This warning message is reported when a `move.l #n,d`*x* instruction was optimized to a shorter form by splitting it into a combination of a `moveq #m,d`*x* and a `add.b d`*x*`,d`*x* instruction.

This optimization is only made if the `Q9` option is enabled (see Section 5.6.4 *Optimization*, page 93).

'`MOVE.B #-1,<EA> converted to ST.B <EA> (CCR changed!)`'

The assembler optimized a `move.b #-1,<`*EA*`>` instruction to a `st.b <`*EA*`>` instruction. This optimization is only made if the `Q11` option is turned on (see Section 5.6.4 *Optimization*, page 93).

Caution, the `move.b #-1,<`*ea*`>` instruction affects the condition code flags, while the `st.b <`*ea*`>` instruction does not. (Refer to the *M68000 Family Programmer's Reference Manual* for more details about these instructions.) To avoid any problems you should ensure that no condition code afflicted instructions (such as `b`*cc*, `db`*cc*, and `s`*cc*) follow directly the optimized instruction.

'`no code allowed in BSS sections`'

A M68000 instruction or any other code or data generating directive was found inside a BSS section. The BSS section specifies a block of uninitialized workspace that is allocated by the AmigaDOS loader, therefore no specific data is stored in a BSS section. This warning is only reported once, even if there is more code or data generating directives inside a BSS section. The assembler ignores these directives and just uses their size to reserve the appropriate space. To reserve space inside a BSS section correctly, the following directives (or their synonyms) should be used:

`DS.`*size expression*`[,0]`

`DX.`*size expression*`[,0]`

`DC.`*size* `0`

`SB 0, SW 0, SL 0`

`PB 0, PW 0, PL 0`

`UB 0, UW 0, UL 0`

(For detailed information about these directives see Section 5.7.1 *Initialized Data*, page 113, Section 5.7.2 *Initialized Data with Restricted Range*, page 115 and Section 5.7.3 *Declaring Data Blocks*, page 116.)

'`no external references (xref) in preasm file, ignored`'

An external reference (xref) is encountered while a preasm file is generated. Such references are only allowed in linkable files. Since a preasm file contains only the symbol and macro table, all external references will be useless, and therefore ignored by the assembler. (See `PREASM`, page 130, for the description of this directive.)

'`no section statements in preasm files, ignored`'

A preasm file contains only symbol and macro definition in a preassembled form. No code and date is written to this file, therefore any section directives have no effect, and are ignored by the assembler. (See `PREASM`, page 130, for the description of this directive.)

'`object filename already specified`'

More than one `OUTPUT` or `OBJFILE` directive is present in the source code, specifying conflicting filenames. Find the conflicting directives and eliminate one of them, or change the filenames to match.

'`odd address or offset detected`'

This warning is issued if the assembler encounters a `CCNOP` directive that needs an odd pad length to obtain the desired alignement. `CCNOP` pads the program counter to the desired boundary by inserting `nop`'s. If the pad length is odd, a null-byte has to be inserted first by `CCNOP`. (See `CCNOP`, page 123).

'`offset removed`'

An address register indirect addressing mode with a displacement of zero is optimized to the address register indirect addressing mode.

This optimization is only made if the `O2` option is enabled (see Section 5.6.4 *Optimization*, page 93).

'`other case sensitivity or significance in preasm file`'

The symbols stored within the preasm file have another case dependency than you currently use. This can have unwished sideeffects: symbols that are expected to be case-sensitive can be converted to case-insensitive and vice versa. Note that case-sensitive symbols are stored in upper case in the preasm file. (See Section 5.5.3 *Case Sensitivity*, page 83, and `PREASM`, page 130.)

'`outer displacement shortened`'

The assembler reports this message if an outer displacement within the range of -32768–32767 is optimized from long to word size. This optimization is only made if the `O14` option is enabled (see Section 5.6.4 *Optimization*, page 93).

To suppress this optimization you may add a longword size specifier (`.L`) to the outer displacement.

`public symbols only in linkable files allowed`
A public symbol definition is encountered but no linkable file is generated. Refer to the description of the `PUBLIC` directive for more details (Section 5.9.5 *Defining and Referencing External Symbols*, page 141).

`Read-Modify-Write cycle opcode`
This warning is reported if a `cas`, `cas2`, or `tas` instruction was encountered. Since the system DMA can conflict with this instruction's special indivisible read-modify-write cycle. Use the `READMODWRITE` directive to control this warning (see Section 5.6.2 *READMODWRITE*, page 90).

`relative possible`
This warning is reported when the assembler encountered a forward referencing absolute long addressing mode that can be made PC-relative.

You may optimize it yourself to save two bytes. This optimization possibility is only reported if the `O16` option is turned on (see Section 5.6.4 *Optimization*, page 93).

`relocation converted to relative`
This warning message is issued if a backward referencing absolute long addressing mode (within the range of -32768–0) is optimized to PC-relative addressing mode. This optimization is only made if the `O7` option is enabled (see Section 5.6.4 *Optimization*, page 93).

To suppress this optimization you may add a longword size specifier (`.L`) to the absolute long address.

`relocs won't be written in binary file!`
A binary file is a raw binary image without any structures attached to it, like hunks, etc.. Consequently any reloc information cannot be stored in such a file. Note that relocation may be needed by your code. A binary file generation that produced this warning message may not work properly.

To avoid this warning try to use relative addressing modes for instructions. For relocatable data structures you may use offset oriented data.

`short branch converted to NOP`
The destination of a short branch was the following instruction, which is an illegal branch offset. The branch was replaced by a `nop` instruction.

`short branch possible`
The assembler encountered a forward referenced branch instruction that can be shortened. You may optimize it yourself to save two bytes. This optimization possibility is only reported if the `O6` option is turned on (see Section 5.6.4 *Optimization*, page 93).

`sign-extended operand`

A `moveq` instruction is encountered with a positive immediate value within the range of 128–255. The `moveq` instruction expects an 8-bit (-128–127) immediate value that, during execution, is sign-extended to long (32-bit). Thus any 8-bit number greater than 127 will automatically become negative when sign-extended to long. To suppress this warning you have to add a longword size specifier (`.L`).

(Refer to the *M68000 Programmer's Reference Manual* for the description of the `moveq` instruction.)

`size should be word`

A branch instruction with a longword operation size is encountered while assembling code for the MC68000 (or MC68010) processor.

It is recommended to change the operation size to word (or to remove the size specifier), since long branches are not supported by the MC68000 and MC68010 processors. This can avoid conflicts when you once decide to use also code for later processors (MC68020 or higher).

`supervisor only opcode`

This warning is reported if a privileged instruction was encountered. Use the `SUPER` directive (or its synonyms) to control this warning (see `SUPER`, page 90).

`this section will be empty`

This warning message informs you that the assembler encountered an empty section (no code and data). An empty section is a code, data or bss section with no size. In all cases such a section is useless and can be removed from the object file.

`unable to load the proasmoptim.library - option ignored`

The `proasmoptim.library` could not be found. The library is probably not correctly installed to your system. (See Section 7.3 *The proasmoptim.library*, page 179, for more information. The option (`OPT OPTIMLIB`) is ignored.)

`user warning`

The `WARN` directive was assembled. (See `WARN`, page 103, for details.)

`XDEF is not allowed in preasm files, ignored`

A `XDEF` directive is encountered while a preasm file is generated. Such external symbol definitions are only allowed in linkable files. Since a preasm file contains only the symbol and macro table, all external symbol definitions will be useless, and therefore ignored by the assembler. (See `PREASM`, page 130, for the description of this directive.)

`XDEF only in linkable files allowed`

A `XDEF` directive is encountered while generating non-linkable output such as an executable. (See `XDEF`, page 142.)

`zero offset`

The assembler encountered a displacement of zero of an address register indirect with displacement addressing mode that can be removed. You may optimize it yourself to save two bytes. This optimization possibility is only reported if the `O17` option is turned on (see Section 5.6.4 *Optimization*, page 93).

'`zero space defined`'

A `DS` or `DX` directive is encountered that reserved no memory space. For example:

```
        DS.L    0,4
```

You may have made a typing error. Note that `DS.L 0` and `DS.W 0` with no second argument can be used to align data (see Section 5.7.5 *Alignment Padding*, page 120).

Appendix C AmigaDOS Error Codes

This appendix lists the possible AmigaDOS errors. For detailed information about the AmigaDOS and the AmigaDOS errors, refer to *The AmigaDOS Manual*, from Commodore-Amiga Inc.

'`103`'
'`Not enough memory`'
: Not enough memory in your Amiga to carry out the operation.

'`104`'
'`Process table full`'
: The limit of the maximal number of possible processes is reached.

'`114`'
'`Bad template`'
: Incorrect command line.

'`115`'
'`Bad number`'
: The program was expecting a numeric argument.

'`116`'
'`Required argument missing`'
: Invalid command line, an argument that was required was not given.

'`117`'
'`Argument after "=" missing`'
: Invalid command line.

'`118`'
'`Too many arguments`'
: Invalid command line, too many arguments given.

'`119`'
'`Unmatched quotes`'
: Invalid command line.

'`120`'
'`Argument line invalid or too long`'
: Invalid command line.

'`121`'
'`File is not an executable object`'
: Misspelled command name, or file may not be a loadable program or script file.

'`122`'

'`Invalid resident library`'

You are trying to use commands with a previous version of AmigaDOS, for example, Version 2.0 commands with Version 1.3.

'`202`'

'`Object is in use`'

The specified file or directory is already being used by other applications. If an application is reading a file, no other program can write to it and vice versa.

'`203`'

'`Object already exists`'

The specified name already belongs to another file or directory.

'`204`'

'`Directory not found`'

AmigaDOS cannot find the directory you specified. You may have made a typing or spelling error.

'`205`'

'`Object not found`'

AmigaDOS cannot find the file or directory you specified. You may have made a typing or spelling error.

'`206`'

'`Invalid window description`'

This error occurs when specifying a window size for the Output Window, a Shell, `ED` or `ICONX` window. You may have made the window too big or too small, or you may have omitted an argument. This error also occurs with the `NEWSHELL` command, if you supply a device name that is not a window.

'`209`'

'`Packet request type unknown`'

You have asked a device handler to attempt an operation it cannot do. For example, the console handler cannot rename anything.

'`210`'

'`Object name invalid`'

There is an invalid character in the filename or the filename is too long. Remember, filenames cannot be longer than 30 characters and cannot contain control characters.

'`211`'

'`Invalid object lock`'

You have used something that is not a valid lock.

`'212'`

`'Object not of required type'`

You may have specified a filename for an operation that requires a directory name or vice versa.

`'213'`

`'Disk not validated'`

If you have just inserted a disk, the disk validation process may still be in progress. It is also possible that the disk is corrupt.

`'214'`

`'Disk is write-protected'`

The plastic tab of the disk is in the write-protect position.

`'215'`

`'Rename across devices attempted'`

The `RENAME` command only changes a filename on the same volume. You can use `RENAME` to move a file from one directory to another, but you cannot move files from one volume to another.

`'216'`

`'Directory not empty'`

This error occurs if you attempt to delete a directory that contains files or subdirectories.

`'217'`

`'Too many levels'`

You have exceeded the limit of 15 soft links.

`'218'`

`'Device (or volume) not mounted'`

If the device is a floppy disk, it has not been inserted in a drive. If it is another type of device, it has not been mounted with the `MOUNT` command. It is also possible that you have made a typing error when specifying the device name.

`'219'`

`'Seek error'`

You have attempted to call Seek() with invalid arguments.

`'220'`

`'Comment is too long'`

Your filenote has exceeded the maximum number of characters (79).

`'212'`

`'Disk is full'`

There is not enough room left on the disk to perform the requested operation.

'222'
'Object is protected from deletion'
The D (deletable) protection bit of the file or directory is clear.

'223'
'File is write protected'
The W (writable) protection bit of the file is clear.

'224'
'File is read protected'
The R (readable) protection bit of the file is clear.

'225'
'Not a valid DOS disk'
The disk in the drive is not an AmigaDOS disk, it has not been formatted, or it is corrupt.

'226'
'No disk in drive'
The disk is not properly inserted in the specified drive.

'232'
'No more entries in directory'
This indicates that the AmigaDOS call ExNext() has no more entries in the directory you are examining.

'233'
'Object is soft link'
You tried to perform an operation on a soft link that should only be performed on a file or directory.

'303'
'Buffer overflow'
User or internal buffer overflow.

'304'
'Break' A break character was received.

'305'
'Not executable'
The r (readable) protection bit of the specified file is clear.

Appendix D Instruction Set Summary

This appendix provides a quick reference to the M68000 family instructions supported by ProAsm. For a complete and more detailed instruction set summary refer to the *M68000 Family Programmer's Reference Manual*, from Motorola Inc.

Instruction	68000	68010	68020	68030	68040	68060	68881/82	68851
ABCD	•	•	•	•	•	•		
ADD	•	•	•	•	•	•		
ADDA	•	•	•	•	•	•		
ADDI	•	•	•	•	•	•		
ADDQ	•	•	•	•	•	•		
ADDX	•	•	•	•	•	•		
AND	•	•	•	•	•	•		
ANDI	•	•	•	•	•	•		
ASL, ASR	•	•	•	•	•	•		
Bcc	•	•	•	•	•	•		
BCHG	•	•	•	•	•	•		
BCLR	•	•	•	•	•	•		
BFCHG			•	•	•	•		
BFCLR			•	•	•	•		
BFEXTS			•	•	•	•		
BFEXTU			•	•	•	•		
BFFFO			•	•	•	•		
BFINS			•	•	•	•		
BFSET			•	•	•	•		
BFTST			•	•	•	•		
BKPT		•	•	•	•	•		
BRA	•	•	•	•	•	•		
BSET	•	•	•	•	•	•		
BSR	•	•	•	•	•	•		
BTST	•	•	•	•	•	•		
CALLM			•					
CAS, CAS2			•	•	•	•		
CHK	•	•	•	•	•	•		
CHK2			•	•	•	•		
CINV					•	•		

Instruction	68000	68010	68020	68030	68040	68060	68881/82	68851
CLR	•	•	•	•	•	•		
CMP	•	•	•	•	•	•		
CMPA	•	•	•	•	•	•		
CMPI	•	•	•	•	•	•		
CMPM	•	•	•	•	•	•		
CMP2			•	•	•	•		
CPUSH					•	•		
DBcc	•	•	•	•	•	•		
DIVS	•	•	•	•	•	•		
DIVSL			•	•	•	•		
DIVU	•	•	•	•	•	•		
DIVUL			•	•	•	•		
EOR	•	•	•	•	•	•		
EORI	•	•	•	•	•	•		
EXG	•	•	•	•	•	•		
EXT	•	•	•	•	•	•		
EXTB			•	•	•	•		
FABS					•	•	•	
FDABS, FSABS					•	•		
FACOS					•	•	•	
FADD					•	•	•	
FDADD, FSADD					•	•		
FASIN					•	•	•	
FATAN					•	•	•	
FATANH					•	•	•	
FBcc					•	•	•	
FCMP					•	•	•	
FCOS					•	•	•	
FCOSH					•	•	•	
FDBcc					•	•	•	
FDIV					•	•	•	
FDDIV, FSDIV					•	•		
FETOX					•	•	•	
FETOXM1					•	•	•	
FGETEXP					•	•	•	
FGETMAN					•	•	•	
FINT					•	•	•	

Instruction	68000	68010	68020	68030	68040	68060	68881/82	68851
FINTRZ					•	•	•	
FLOG10					•	•	•	
FLOG2					•	•	•	
FLOGN					•	•	•	
FLOGNP1					•	•	•	
FMOD					•	•	•	
FMOVE					•	•	•	
FDMOVE, FSMOVE					•	•		
FMOVECR					•	•	•	
FMOVEM					•	•	•	
FMUL					•	•	•	
FDMUL, FSMUL					•	•		
FNEG					•	•	•	
FDNEG, FSNEG					•	•		
FNOP					•	•	•	
FREM					•	•	•	
FRESTORE					•	•	•	
FSAVE					•	•	•	
FSCALE					•	•	•	
FScc					•	•	•	
FSGLDIV					•	•	•	
FSGLMUL					•	•	•	
FSIN					•	•	•	
FSINCOS					•	•	•	
FSINH					•	•	•	
FSQRT					•	•	•	
FDSQRT, FSSQRT					•	•		
FSUB					•	•	•	
FDSUB, FSSUB					•	•		
FTAN					•	•	•	
FTANH					•	•	•	
FTENTOX					•	•	•	
FTRAPcc					•	•	•	
FTST					•	•	•	
FTWOTOX					•	•	•	
ILLEGAL	•	•	•	•	•	•		
JMP	•	•	•	•	•	•		

Instruction	68000	68010	68020	68030	68040	68060	68881/82	68851
JSR	•	•	•	•	•	•		
LEA	•	•	•	•	•	•		
LINK	•	•	•	•	•	•		
LSL, LSR	•	•	•	•	•	•		
MOVE	•	•	•	•	•	•		
MOVEA	•	•	•	•	•	•		
MOVE16					•	•		
MOVEC		•	•	•	•	•		
MOVEM	•	•	•	•	•	•		
MOVEP	•	•	•	•	•	•		
MOVEQ	•	•	•	•	•	•		
MOVES		•	•	•	•	•		
MULS	•	•	•	•	•	•		
MULU	•	•	•	•	•	•		
NBCD	•	•	•	•	•	•		
NEG	•	•	•	•	•	•		
NEGX	•	•	•	•	•	•		
NOP	•	•	•	•	•	•		
NOT	•	•	•	•	•	•		
OR	•	•	•	•	•	•		
ORI	•	•	•	•	•	•		
PACK			•	•	•	•		
PBcc								•
PDBcc								•
PEA	•	•	•	•	•	•		
PFLUSH				•	•	•		•
PFLUSHA				•				•
PFLUSHR								•
PFLUSHS								•
PLPA						•		
PLOAD				•				•
PMOVE				•				•
PRESTORE								•
PSAVE								•
PScc								•
PTEST				•	•			•
PTRAPcc								•

Instruction	68000	68010	68020	68030	68040	68060	68881/82	68851
PVALID								•
RESET	•	•	•	•	•	•		
ROL, ROR	•	•	•	•	•	•		
ROXL, ROXR	•	•	•	•	•	•		
RTD	•	•	•	•	•	•		
RTE	•	•	•	•	•	•		
RTM			•					
RTR	•	•	•	•	•	•		
RTS	•	•	•	•	•	•		
SBCD	•	•	•	•	•	•		
Scc	•	•	•	•	•	•		
STOP	•	•	•	•	•	•		
SUB	•	•	•	•	•	•		
SUBA	•	•	•	•	•	•		
SUBI	•	•	•	•	•	•		
SUBQ	•	•	•	•	•	•		
SUBX	•	•	•	•	•	•		
SWAP	•	•	•	•	•	•		
TAS	•	•	•	•	•	•		
TRAP	•	•	•	•	•	•		
TRAPcc			•	•	•	•		
TRAPV	•	•	•	•	•	•		
TST	•	•	•	•	•	•		
UNLK	•	•	•	•	•	•		
UNPK			•	•	•	•		

Appendix E ProOpts Directives Summary

This appendix provides a quick reference of all directives and options supported by ProOpts. The following table contains the name of the directives and options, the relating page numbers of their descriptions in this manual and the ProOpts windows.

Directives	Page	ProOpts Window
ADDSYM	139	Linker Options
ASMPRI	164	Assembler Options
AUTOXREF	143	Linker Options
BINARY	130	
DEBUG	138	Linker Options
DEFAULT	91	Default Options
END	47	
ESCAPESTR	162	Miscellaneous Options
EXEOBJ	129	
FAILAT	104	Assembler Options
FORMAT	151	List Options
INCDIR	50	Assembler Options
LINKABLE	130	
LISTFILE	148	List Options
LLEN	150	List Options
MC68010 MC68020 MC68030 MC68040 MC68060 MC68EC020 MC68EC030 MCRELAX	86	Code Options
MC68851 MC68881 MC68882	86	Code Options
MULTIPASS	101	Optimization Options
NEWSYNTAX	84	Code Options
NOOBJ	131	
ODD2ERROR	106	Miscellaneous Options
ODDOK	105	Miscellaneous Options
OLDSYNTAX	84	Code Options
OPT a+	93	Code Options

Directives	Page	ProOpts Window
OPT c-	83	Code Options
OPT chkbit	107	Code Options
OPT cl	149	List Options
OPT cn- OPT cn+	83	Code Options
OPT e-	104	Miscellaneous Options
OPT ess1+ OPT ess2+ OPT ess3+	161	Assembler Options
OPT f+	107	Miscellaneous Options
OPT i+	84	Code Options
OPT m+	149	List Options
OPT md	148	List Options
OPT nofpsp40 OPT nofpsp60	88	Code Options
OPT nosp60	89	Code Options
OPT noxpk	160	Assembler Options
OPT o1+ OPT o2+ OPT o3+ OPT o4+ OPT o5+ OPT o6+ OPT o7+ OPT o8+ OPT o9+ OPT o13+ OPT o14+	94	Optimization Options
OPT ow-	104	Optimization Options
OPT optimlib	102	Optimization Options
OPT p+	85	Code Options
OPT q1+ OPT q2+ OPT q3+ OPT q4+ OPT q5+ OPT q7+ OPT q8+	98	Optimization Options

Directives	**Page**	**ProOpts Window**
OPT q9+ OPT q11+ OPT q12+	98	Optimization Options
OPT s+	149	List Options
OPT t+	85	Miscellaneous Options
OPT u+	83	Code Options
OPT w-	104	Miscellaneous Options
OPT warnbit	107	Code Options
OPT x+	140	Linker Options
OPT y-	48	Miscellaneous Options
PLEN	150	List Options
PREASM	130	
READMODWRITE	90	Code Options
SMALLBSS SMALLCODE SMALLDATA	137	Linker Options
SMALLOBJ	137	Linker Options
SREC	132	Linker Options
SUPER	90	Code Options
TIMES	164	Miscellaneous Options
TTL	152	List Options
VERBOSE	164	Miscellaneous Options

Appendix F Bibliography

The following manual covers the complete M68000 family (including the MC68881, MC68882, and MC68851 coprocessors) instruction set, and is recommended to those, who wish to learn the 680x0 assembly language:

- Motorola Inc., *M68000 Family Programmer's Reference Manual*, Motorola Inc.

The following manual is an essential reference tool for all Amiga programmers, who want to take full advantage of the Amiga's impressive capabilities:

- Commodore-Amiga Inc., *AMIGA ROM Kernel Reference Manual: Includes and Autodocs*, third edition, Addison-Wesley Publishing Co.

The AmigaDOS manual describes this powerful operating system and is a comprehensive reference to the commands, functions, and innermost workings of AmigaDOS:

- Commodore-Amiga Inc., *The AmigaDOS Manual*, third edition, Bantam Books.

The user's manuals listed below contain the information on the specific microprocessors.

- Motorola Inc., *M68000 8-/16-/32-Bit Microprocessor User's Manual*, seventh edition, Prentice Hall.
- Motorola Inc., *MC68020 32-Bit Microprocessor User's Manual*, third edition, Prentice Hall.
- Motorola Inc., *MC68030 Enhanced 32-Bit Microprocessor User's Manual*, third edition, Prentice Hall.
- Motorola Inc., *MC68EC030 32-Bit Embedded Controller User's Manual*, Motorola Inc.
- Motorola Inc., *M68040/M68EC040/M68LC040 Microprocessors User's Manual*, Motorola Inc.
- Motorola Inc., *M68060/M68EC060/M68LC060 Microprocessors User's Manual*, Motorola Inc.
- Motorola Inc., *MC68881/MC68882 Floating-Point Coprocessor User's Manual*, second edition, Prentice Hall.
- Motorola Inc., *MC68851 Paged Memory Management Unit User's Manual*, Prentice Hall.

The Motorola literature can be obtained from your local Motorola Sales Office or Distributor. Local Sales offices and Distributors are listed in the back of any Motorola Master Selection Guide. If you can not find a local representative, some Motorola Literature Distributions Center addresses are listed below:

USA:

Motorola Literature Distribution
P.O.Box 20912
Phoenix, Arizona 85036

Europe:

Motorola Ltd.
European Literature Center
88 Tanners Drive
Blakelands
Milton Keynes, MK14 5BP
England

Japan:

Nippon Motorola Ltd.
4-32-1 Nishi-Gotanda
Shinagawa-ku
Tokyo 141 Japan

Asia-Pacific:

Motorola Semiconductors H.K. Ltd
Silicon Harbour Center
No. 2 Dai King Street
Tai Po Industrial Estate
Tai Po
N.T.
Hong Kong

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