

**DIGITAL
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C
Language
Programming Guide
for CP/M-68K™

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Foreword

The C language under CP/M-68K is easy to read, easy to maintain, and highly portable. CP/M-68K can run most applications written in C for the UNIX operating system, except programs that use the UNIX `fork()` and `exec` multitasking primitives or that read UNIX file structures.

The C Language Programming Guide for CP/M-68K is not a tutorial. This manual describes how to program in C under the CP/M-68K operating system, and is best used by programmers familiar with the C language as described in *The C Programming Language* (Kernighan and Ritchie, 1978).

The commonly accepted standard for C language programming is the Portable C Compiler (PCC), written by Stephen C. Johnson. Many versions of the UNIX operating system use PCC, including the Zilog, ONYX, XENIX, Berkeley UNIX, and UNIQ systems.

The CP/M-68K C compiler differs from PCC on the following points:

- o The CP/M-68K C `int` (default) data type is 16 bits long. Pointers are 32 bits long. All function definitions and function calls that use long (32-bit ints) and pointer parameters must use the proper declarations.
- o long, int, and char register variables are assigned to D registers. Five such registers are available in each procedure.
- o Any register variable used as a pointer is assigned to an A register. There are three such registers available in each procedure.
- o All local declarations in a function body must precede the first executable statement of the function.
- o The CP/M-68K C compiler handles structure initialization as if the structure were an array of short integers, as in UNIX version 6.
- o The first eight characters of variable and function names must be unique. The first seven characters of external names must be unique.
- o The CP/M-68K C compiler does not support floating point,
- o The CP/M-68K C compiler does not support structure assignment, structure arguments, and structures returned from procedures.
- o The CP/M-68K C compiler does not support initialization of automatic variables.
- o The CP/M-68K C compiler does not support enumeration types.

Section 1 of this manual describes the conventions of using C language under CP/M-68K. Section 2 discusses C language compatibility with UNIX version 7 and provides a dictionary of C library routines for CP/M-68K. Section 3 presents a style guide for coding C language programs.

Appendix A is a table of CP/M-68K error codes. Appendix B discusses compiler components, tells you how to operate the compiler, and suggests ways to conserve the disk space used for compiling. Appendix C presents sample C modules that are written and documented according to the style conventions outlined in Section 3.

Table of Contents

1	Using C Language Under CP/M-68K	
1.1	Compiling a CP/M-68K C Program	1-1
1.2	Memory Layout	1-1
1.3	Calling Conventions	1-2
1.4	Stack Frame	1-4
1.5	Command Line Interface	1-5
1.6	I/O Conventions	1-5
1.7	Standard Files	1-6
1.8	I/O Redirection	1-7
2	C Language Library Routines	
2.1	Compatibility with UNIX V7	2-1
2.2	Library Functions under CP/M-68K	2-2
	abort	2-3
	abs	2-4
	access	2-5
	atol, atol	2-6
	brk,sbrk	2-7
	calloc, malloc, realloc, free	2-8
	chmod, chown	2-9
	close	2-10
	creat, creat, creatb	2-11
	ctype	2-12
	end, etext, edata Locations	2-14
	exit, -exit	2-15
	fclose, fflush	2-16
	feof, ferror, clearerr, fileno	2-17
	fopen, freopen, fdopen	2-18
	fread, fwrite	2-20
	fseek, ftell, rewind	2-21
	getc, getchar, fgetc, getw, getl	2-22
	getpass	2-24

Table of Contents (continued)

getpid	2-25
gets, fgets	2-26
index, rindex	2-27
isatty	2-28
Iseek, tell	2-29
mktemp	2-30
open, opena, openb	2-31
perror	2-32
printf, fprintf, sprintf	2-33
putc, putchar, fputc, putw, putl	2-35
puts, fputs	2-37
qsort	2-38
rand, srand	2-39
read	2-40
scanf, fscanf, sscanf	2-41
setjmp, longjmp	2-43
signal	2-44
strcat, strncat	2-46
strcmp, strncmp	2-47
strcpy, strncpy	2-48
strlen	2-49
swab	2-50
ttyname	2-51
ungetc	2-52
unlink	2-53
write	2-54
3 C Style Guide	
3.1 Modularity	3-1
3.1.1 Module Size	3-1
3.1.2 Intermodule Communication	3-1
3.1.3 Header Files	3-2

Table of Contents (continued)

3.2	Mandatory Coding Conventions	3-2
3.2.1	Variable and Constant Names	3-3
3.2.2	Variable Typing	3-3
3.2.3	Expressions and Constants	3-4
3.2.4	Pointer Arithmetic	3-5
3.2.5	String Constants	3-6
3.2.6	Data and BSS Sections	3-6
3.2.7	Module Layout	3-7
3.3	Suggested Coding Conventions	3-8

Table of Contents (continued)

Appendixes

A	CP/M-68K Error Codes	A-1
B	Customizing the C Compiler	B-1
	B.1 Compiler Operation	B-1
	B.2 Supplied submit Files	B-3
	B.3 Saving Disk Space	B-3
	B.4 Gaining Speed	B-4
C	Sample C Module	C-1
D	Error Messages	D-1
	D.1 C068 Error Messages	D-1
	D.1.1 Diagnostic Error Messages	D-1
	D.1.2 Internal Logic Errors	D-12
	D.2 C168 Error Messages	D-13
	D.2.1 Fatal Diagnostic Errors	D-13
	D.2.2 Internal Logic Errors	D-14
	D.3 CP68 Error Messages	D-15
	D.3.1 Diagnostic Error Messages	D-15
	D.3.2 Internal Logic Errors	D-20
	D.4 C-Run-time Library Error Messages	D-20

Table of Contents (continued)

Tables

1-1. Standard File Definitions	1-6
2-1. ctype Functions	2-12
2-2. Conversion Operators	2-34
2-3. Valid Conversion Characters	2-42
2-4. 68000 Exception Conditions	2-44
3-1. Type Definitions	3-4
3-2. Storage Class Definitions	3-4
A- 1. CP/M-68K Error Codes	A-1
D- 1. C068 Diagnostic Error Messages	D-2
D-2. C168 Fatal Diagnostic Errors	D-13
D-3. CP68 Diagnostic Error Messages	D-15

Figures

1-1. Memory Layout	1-2
1-2. C Stack Frame	1-4

Section 1

Using C Language Under CP/M-68K

1.1 Compiling a CP/M-68K C Program

To compile a C program under CP/M-68K, use the `c.sub` and `clink.sub` command files. You can separately compile files with these commands. You must type the commands as shown in the command line. To invoke the compiler, use the following command form:

```
[submit] c file
```

where `file.c` is the filename. The `submit` command is optional. The compiler produces `file.o` as the object. To invoke the linker, use the following command form:

```
[submit] clink file
```

The command file automatically includes all libraries and header files. You can specify multiple files. For example, the following commands compile and link files `a.c`, `b.c`, and `c.c`:

```
A>submit c a  
A>submit c b  
A>submit c c  
A>submit clink a b c
```

The output goes to file `A.68K`.

1.2 Memory Layout

The memory layouts of C programs in CP/M-68K are similar to those of UNIX C programs. The program comprises three segments: text instructions, initialized data, and BSS, which is uninitialized data. Automatic variables are allocated on the stack. These segments are arranged in memory as illustrated in Figure 1-1.

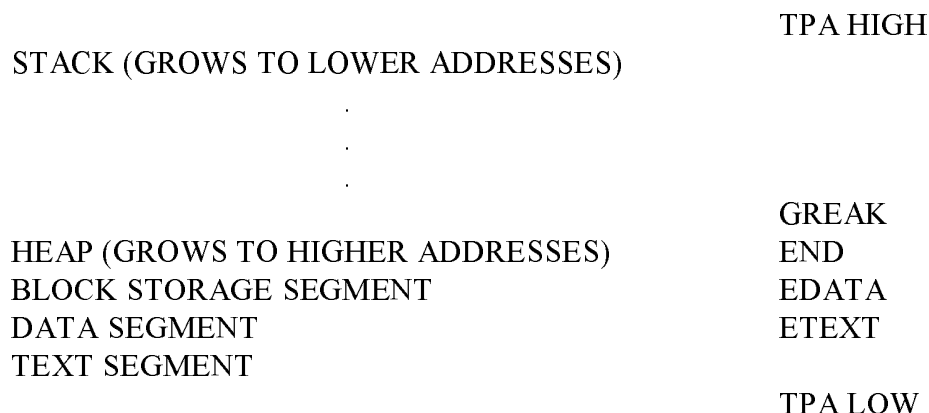


Figure 1-1 Memory Layout

There are two dynamic memory areas: the stack and the heap. Procedure calls and automatic variables use the stack. The `brk`, `sbrk`, `malloc`, and `free` procedures manage the heap. Dynamically growing data structures, such as symbol tables, use the heap.

The linkage editor defines the locations `etext`, `edata`, and `end`. The locations determine the ending addresses of the text, data, and BSS segments. The break location is the first free location following the heap area.

1.3 Calling Conventions

The jump to subroutine (JSR) instruction calls procedures in C. Register A6 acts as the frame pointer for referencing local storage. Arguments are pushed in reverse order onto the A7 stack. Word and character arguments to functions occupy 16 bits on the stack. Long and pointer arguments occupy 32 bits. The function value return register is always D0. Functions that declare no return value return an undefined value.

For example, the following sequence

```
xyz( ) {
    long      a;
    int       b;
    char      x;
    register  y;
    .
    .
    .
    b = blivot(x,a) ;
}
```

generates the following code:

```
_xyz :
    link      a6 ,#-8      * Space For a,b,x
    movem.l   d6-d7,-(a7) * d7 used For y
    .
    .
    .
    move.l    -4(a6) ,(a7) * Load Parameter a
    move.b    -8(a6),d0    * Load parameter x
    ext.w     d0           * Extend to word size
    move.w    d0,-(a7)    * Push it
    jsr      _blivot      * Call subroutine
    add.l     #2,a7        * Pop argument list
    move.w    d0,-6(a6)   * Store return Parameter
    tst.l     (a7)+       * Purge longword
    movem.l   (a7)+,d7    * Unsave registers
    unlk     a6           * Restore Frame Pointer
    rts      * Return to caller
```

C code, in which all arguments are the same length, might not work without modification because of the varying length of arguments on the stack.

The compiler adds an underline character, `_`, to the beginning of each external variable or function name. This means that all external names in C must be unique in seven characters.

The compiler-generated code maintains a long word at the top of the stack for use in subroutine calls. This shortens the stack-popping code required on return from a procedure call. The `movem.l` instruction, which saves the registers, contains an extra register to allocate this space.

The compiler uses registers D3 through D7, and A3 through A5, for register variables. A procedure called from a C program must save and restore these registers, if they are used. The compiler-generated code saves only those registers used. Registers D0 through D2, and A0 through A2, are scratch registers and can be modified by the called procedure.

1.4 Stack Frame

Figure 1-2 illustrates the standard C stack frame.

```

A7    --->  LONGWORD FOR PROCEDURE CALLS
        SAVED REGISTERS
        LOCAL VARIABLE AREA
A6    --->  PREVIOUS VALUE OF A6
        RETURN ADDRESS
        ARGUMENT 1
        ARGUMENT 2
        .
        .
        .
        .

```

Figure 1-2. C Stack Frame

Arguments are either 2 or 4 bytes, depending on argument type. The compiler-generated code uses A6 to reference all variables on the stack.

1.5 Command Line Interface

The standard C argc/argv interface for arguments typed on the command line also works under CP/M-68K. For example, the command form

```
command arg1 arg2 arg3 ... argn
```

causes the following interface setup:

```
argc          n + 1
argv[0]       "C Runtime"
argv[1]       "arg1"
argv[2]       " a rg2
.
.
.
argv[n]       argn
```

You cannot obtain the command name under CP/M-68K. Therefore, the argv[0] argument is always incorrect.

1.6 I/O Conventions

UNIX C programs use two types of file and device I/O: regular files and stream files. A unique number, called a file descriptor, identifies regular files. In CP/M-68K, this number is 'in the range 0 to 15. The address of a user control block in the run-time system identifies stream files. Unlike regular files, stream files use some form of intermediate buffering, making single-byte I/O more efficient.

Under UNIX, you can reference peripheral devices, such as terminals and printers, as files, using the special names /dev/tty for terminal and /dev/lp for printer. Under CP/M-68K, CON: is for the console device, and LST: is for the listing device.

CP/M-68K stores ASCII files with a carriage return line-feed after each line. A CTRL-Z (Ox I a) character indicates end-of-file. C programs usually end lines with only a line-feed. This means that in CP/M-68K C, read and write operations to ASCII files must insert and delete carriage-return characters. The CTRL-Z must be deleted on read and inserted on close for such files. These operations are not desirable for binary files. CP/M-68K C includes an extra entry point to all file open and creat calls to distinguish between ASCII and binary files.

1.7 Standard Files

C programs begin execution with three files already open: the standard input, standard output, and standard error files. You can access these files as either stream or regular files in the C program. The following definitions are available from the <stdio.h> file:

Table 1-1. Standard File Definitions

File	File Descriptor	Stream Name
standard input	STDIN	stdin
standardoutput	STDOUT	stdout
standard error	STDERR	stderr

The usual library routines close and reopen these standard files. In addition, you can redirect I/O from the command line.

1.8 I/O Redirection

You can redirect the C program standard I/O with the < and > characters. No space is allowed between the < or > and the filename. You cannot redirect the standard error file.

For example, the command

```
test <a>lst: c d e f
```

executes the file test.68K, with the standard input coming from disk file a and the standard output going to the listing device. The argument list is c d e f.

End of Section I

Section 2

C Language Library Routines

The CP/M-68K C library is a collection of routines for I/O, dynamic memory allocation, system traps, and data conversion.

2.1 Compatibility with UNIX V7

The C library is compatible with UNIX version 7, allowing programs to move easily from UNIX to CP/M-68K. CP/M-68K C simulates many UNIX operating system calls and features. However, CP/M-68K does not support the following C functions that UNIX implements:

- o the fork/exec, kill, lock, nice, pause, ptrace, sync, and wait primitives
- o the acct system call
- o the alarm function, or the stime, time, ftime, and times system calls
- o the dup and dup2 duplicate file descriptor functions
- o the getuid, getgid, geteuid, getegid, setuid, and setgid functions
- o the indir indirect system call
- o the loctl, stty, and gtty system calls
- o the link system call
- o the chdir, chroot, mknod, mount, umount, mpx, pipe, pkon, pkoff, profil, sync, stat, fstat, umask, and utime system calls
- o the phys system call

The following UNIX library functions are not available under CP/M-68K:

- o Assert
- o Crypt
- o DBM
- o Getenv
- o Getgrent, getlogin, getpw, and getpwent functions
- o l3tol, ltol3
- o monitor
- o ttom, madd, msub, mult, mdlv, min, mout, pow, gcd, and rpow
- o nlist
- o pkopen, pkclose, pkread, pkwrite, and pkfail
- o plot
- o popen, pclose
- o sleep
- o svstem
- o ttystot

The CP/M-68K C language library does not contain the floating-point routines available under UNIX.

Entry points have been added to file open and creat calls to distinguish between ASCII and binary files. Byte level end-of-file is unavailable for binary files. ASCII files, however, are compatible with UNIX, and with the CP/M-68K text editors and utilities that use ASCII files.

The C Programming Guide for CP/M-68K does not separate the UNIX system calls and library functions; all calls are library functions under CP/M-68K.

2.2 Library Functions under CP/M-68K

The remainder of this section lists alphabetically the library routines that C supports under CP/M-68K. The C compiler accepts entry in both upper- and lower-case- however, you must type all library routines in lower-case, as shown in the calling sequences.

The abort Function

The abort function terminates the current program with an error. The error is system dependent. The 68000 uses an illegal instruction trap. This invokes DDT-68K if the debugger is loaded with the object program.

Calling Sequence:

```
WORD code;
```

```
abort(code);
```

Arguments:

code loads into register D0 before abort

Returns:

The abort function never returns.

The abs Function

The abs function takes the absolute value of a single argument. This function is implemented as a macro in `<stdio.h>`; arguments with side effects do not work as you expect. For example, the call

```
a = abs(*x + +);
```

increments `x` twice.

Calling Sequence:

```
WORD val;  
WORD ret;  
  
ret = abs(val);
```

Arguments:

val	the input value
-----	-----------------

Returns:

ret	the absolute value of val
-----	---------------------------

The access Function

The access function checks whether the invoking program can legally access a file. Under CP/M-68K, the file is accessible if it exists.

Calling Sequence:

```
BYTE *name;  
WORD mode;  
WORD ret;  
  
ret = access(name,mode);
```

Arguments:

name	points to the null-terminated filename
mode	4 to check read access 2 to check write access 1 to check exec access 0 to check directory path access (CP/M-68K ignores this argument)

Returns:

0	access allowed
-1	access not allowed

Note:

CP/M-68K checks only to see if the file exists.

The atoi, atol Functions

The atol and atol functions convert an ASCII string to an integer or long binary number, respectively. Strings converted by atoi and atol have the following format:

```
[... ][-][ + ]dddddd ....
```

The functions ignore leading spaces and permit one leading sign.

Calling Sequence:

```
BYTE      *string;  
WORD      ival;  
LONG      lval,atol();
```

```
ival = atoi(string);  
lval = atol(string);
```

Arguments:

atol is not a default value and must be declared. String is a null-terminated string containing the number to be converted. Conversion proceeds until the digits are exhausted. Zero returns if no digits remain.

Returns:

Converted value as ival (int), or lval (long).

Note:

The atol and atol functions do not detect or report overflow. You cannot limit the number of contiguous digits processed or determine the number of digits actually processed.

The brk, sbrk Functions

The brk and sbrk functions extend the heap portion of the user program. The brk function sets the upper bound of the program, called the break in UNIX terminology, to an absolute address. The sbrk function extends the program by an incremental amount.

Calling Sequence:

```
WORD    brk();
BYTE    *addr,*sbrk();
WORD    ret;
BYTE    *start;
```

```
ret = brk(addr);
start = sbrk(incr)
```

Arguments:

addr	the desired new break address
incr	the incremental number of bytes desired

Returns:

0	success (brk)
-1	failure (brk)
start	begins the allocated area (sbrk)
0	failure (sbrk)

The calloc, malloc, realloc, free Functions

The calloc, malloc, realloc, and free functions manage the dynamic area between the region and the stack.

The malloc function allocates an area of contiguous bytes aligned on a word boundary and returns the address of this area. malloc uses the sbrk function to allocate additional heap space, if necessary.

The calloc function allocates space for an array of elements, whose size is given in bytes.

The realloc function changes the size of a block. The address of the block returns.

The free function releases a block previously allocated by malloc.

Calling Sequence:

```
WORD      size,number;  
BYTE      *addr,*malloc(),*calloc(),*realloc();
```

```
addr = malloc(size);  
addr = calloc(number,size);  
addr = realloc(addr,size);  
free(addr);
```

Arguments:

size	the number of bytes desired
number	the number of elements desired
addr	points to the allocated region

Returns:

Address of the allocated region if successful, 0 if unsuccessful.

Note:

Freeing a bogus address can be disastrous.

The chmod, chown Functions

Under UNIX, the chmod and chown system calls allow you to change the protection and owner ID of an existing file. CP/M-68K treats these calls as NO-OPS if the file exists.

Calling Sequence:

```
BYTE      *name;  
WORD      mode,owner,group,ret;
```

```
ret = chmod(name,mode);  
ret = chown(name,owner,group);
```

Arguments:

name	the affected filename (null-terminated)
mode	the new mode for the file
owner	the new owner of the file
group	the new group number

Returns:

ret	0 if the file exists -1 if the file does not exist
-----	---

The close Function

The close function terminates access to a file or device. This routine acts on files opened with the open or creat functions. Specify a file descriptor, not a stream, for the operation. The fclose function closes stream files.

Calling Sequence:

```
WORD fd,ret;  
  
ret = close(fd);
```

Arguments:

fd	the file descriptor to be closed
----	----------------------------------

Returns:

0	successful close
-1	unknown file descriptor

The creat, create, creatb Functions

The creat function adds a new file to a disk directory. The file can then be referenced by the file descriptor, but not as a stream file. The creat and creatb functions create an file. The creatb function creates a binary file.

Calling Sequence:

```
BYTE      *name;  
WORD      mode,fd;
```

```
fd = creat(name,mode)-  
fd = creatb(name,mode);  
fd = creatb(name,mode);
```

Arguments:

name	the filename string, null-terminated
mode	the UNIX file mode, ignored by CP/M-68K

Returns:

fd	The file descriptor for the opened file. A file descriptor is an int quantity that denotes an open file In a read, write or lseek call.
-1	Returned if there are any errors.

Note:

UNIX programs that use binary files compile successfully, but execute improperly.

The ctype Functions

The file `<ctype.h>` defines a number of functions that classify ASCII characters. These functions indicate whether a character belongs to a certain character class, returning nonzero for true and zero for false. The following table defines ctype functions.

Table 2-1. ctype Functions

Function	Meaning
<code>isalpha(c)</code>	<code>c</code> is a letter.
<code>isupper(c)</code>	<code>c</code> is upper-case.
<code>islower(c)</code>	<code>c</code> is lower-case.
<code>isdigit(c)</code>	<code>c</code> is a digit.
<code>isalnum(c)</code>	<code>c</code> is alphanumeric.
<code>isspace(c)</code>	<code>c</code> is a white space character.
<code>ispunct(c)</code>	<code>c</code> is a punctuation character.
<code>isprint(c)</code>	<code>c</code> is a printable character.
<code>isctrl(c)</code>	<code>c</code> is a control character.
<code>isascii(c)</code>	<code>c</code> is an ASCII character ($< 0x80$).

The white space characters are the space (0x20), tab (0x09), carriage return (0x0d), line-feed (0x0a), and form-feed (0x0c) characters. Punctuation characters are not control or alphanumeric characters. The printing characters are the space (0x20) through the tilde (0x7e). A control character is less than a space (0x20).

Calling Sequence:

```
#Include <ctype.h>
```

```
WORD ret;
```

```
BYTE c- /* or WORD c-
```

```
ret = isalpha(c);
```

```
ret = isupper(c);
```

```
ret = islower(c);
```

```
ret = isdigit(c);
```

```
ret = isalnum(c);
```

```
ret = isspace(c);
```

```
ret = ispunct(c);
```

```
ret = isprnt(c);
```

```
ret = iscntrl(c);
```

```
ret = isasci(c);
```

Arguments:

c the character to be classified

Returns:

ret = 0 for false
ret <>0 for true

Note:

These functions are implemented as macros; arguments with side effects, such as *p ++, work incorrectly in some cases. Bogus values return if arguments are not ASCII characters. For example, >0x7f.

The end, etext, edata Locations

The linkage editor defines the labels `end`, `etext`, and `edata` as the first location past the BSS, text, and data regions, respectively. The program-break location, which is the last used location, is initially set to `end`. However, many library functions alter this location. `sbrk(0)` can retrieve the break.

The exit, -exit Functions

The exit function passes control to CP/M-68K. An optional completion code, which CP/M-68K ignores, might return. exit deallocates all memory and closes any open files. exit also flushes the buffer for stream output files.

The -exit function immediately returns control to CP/M-68K, without flushing or closing open files.

Calling Sequence:

WORD code;

exit(code);

-exit(code);

Arguments:

code optional return code

Returns:

no returns.

The fclose, fflush Functions

The fclose and fflush functions close and flush stream files. The stream address identifies the stream to be closed.

Calling Sequence:

```
WORD ret;  
FILE *stream;  
  
ret = fclose(stream);  
ret = fflush(stream),
```

Arguments:

stream	the stream address
--------	--------------------

Returns:

0	successful
-1	bad stream address or write failure

The feof, ferror, clearerr, fileno Functions

These functions manipulate file streams in a system-independent manner.

The feof function returns nonzero if a specified stream is at end-of-file, and zero if it is not.

The ferror function returns nonzero when an error has occurred on a specified stream. The clearerr function clears this error. This is useful for functions such as putw, where no error indication returns for output failures.

The fileno function returns the file descriptor associated with an open stream.

Calling Sequence:

```
WORD ret;  
FILE      *stream;  
WORD      fd;  
  
ret = feof(stream);  
ret = ferror(stream);  
clearerr(stream);  
fd = fileno(stream);
```

Arguments:

stream	the stream address
--------	--------------------

Returns:

ret	a zero or nonzero indicator
fd	the returned file descriptor

The fopen, freopen, fdopen Functions

The fopen, freopen, and fdopen functions associate an I/O stream with a file or device.

The fopen and fopena functions open an existing ASCII file for I/O as a stream. The fopenb function opens an existing binary file for I/O as a stream.

The freopen and freopena functions substitute a new ASCII file for an open stream. The freopenb function substitutes a new binary file for an open stream.

The fdopen function associates a file that file descriptor opened, using open or creat, with a stream.

Calling Sequence:

FILE	*fopeno, fopenao, fopenbo;
FILE	*freopeno, freopao, freopbo;
FILE	*fdopeno;
FILE	*stream;
BYTE	*name, *access;
WORD	fd;

```
stream = fopen(name,access);
stream = fopena(name,access);
stream = fopenb(name,access);
stream = freopen(name,access,stream);
stream = freopena(name,access,stream);
stream = freopenb(name,access,stream);
stream = fdopen(fd,access);
```

Arguments:

name	the null-terminated filename string
stream	the stream address
access	the access string: r read the file w write the file a append to a file

Returns:

stream	successful if stream address open
0	unsuccessful

Note:

UNIX programs that use fopen on binary files compile and link correctly, but execute improperly.

The fread, fwrite Functions

The fread and fwrite functions transfer a stream of bytes between a stream file and primary memory.

Calling Sequence:

```
WORD      nitems;  
BYTE      *buff;  
WORD      size;  
FILE      stream;
```

```
nitems = fread(buff,size,nitems,stream  
nitems = fwrite(buff,size,nitems,stream);
```

Arguments:

buff	the primary memory buffer address
size	the number of bytes in each item
nitems	the number of items to transfer
stream	an open stream file

Returns:

nitems	the number of items read or written
0	error, including EOF

The fseek, ftell, rewind Functions

The fseek, ftell, and rewind functions position a stream file.

The fseek function sets the read or write pointer to an arbitrary offset in the stream. The rewind function sets the read or write pointer to the beginning of the stream. These calls have no effect on the console device or the listing device.

The ftell function returns the present value of the read or write pointer in the stream. This call returns a meaningless value for nonfile devices.

Calling Sequence:

```
WORD      ret;
FILE      * stream;
LONG      offset,ftell();
WORD      ptrname;
```

```
ret = fseek(stream,offset,ptrname);
ret = rewind(stream);
offset = ftell(stream);
```

Arguments:

stream	the stream address
offset	a signed offset measured in bytes
ptrname	the interpretation of offset:

```
0 => from beginning of file
1 => from current position
2 => from end of file
```

Returns:

ret	0 for success, -1 for failure
offset	present offset in stream

Note:

ASCII file seek and tell operations do not account for carriage returns that are eventually deleted. CTRL-Z characters at the end of the file are correctly handled.

The getc, getchar, fgetc, getw, getl Functions

The getc, getchar, fgetc, getw, and getl functions perform input from a stream.

The getc function reads a single character from an input stream. This function is implemented as a macro in `<stdio.h>`, and arguments should not have side effects.

The getchar function reads a single character from the standard input. It is identical to `getc(stdin)` in all respects.

The fgetc function is a function implementation of getc, used to reduce object code size.

The getw function reads a 16-bit word from the stream, high byte first. This is compatible with the read function call. No special alignment is required.

The getl function reads a 32-bit long from the stream, in 68000 byte order. No special alignment is required.

Calling Sequence:

WORD	ichar;
FILE	*stream;
WORD	lword;
LONG	ilong, getl();

```
ichar = getc(stream);
ichar = getchar;
ichar = fgetc(stream);
iword = getw(stream);
ilong = getl(stream);
```

Arguments:

stream	the stream address
--------	--------------------

Returns:

ichar	character read from stream
word	word read from stream
ilong	longword read from stream
-1	on read failures

Note:

Error return from `getc` is incompatible with UNIX prior to version 7. Error return from `geti` or `getw` is a valid value that might occur in the file normally. Use `feof` or `ferror` to detect end-of-file or read errors.

The getpass Function

The `getpass` function reads a password from the console device. A prompt is output, and the input read without echoing to the console. A pointer returns to a 0- to 8 -character null-terminated string.

Calling Sequence:

```
BYTE *prompt;  
BYTE *getpass;  
BYTE *pass;  
  
pass = getpass(prompt);
```

Arguments:

`prompt` a null-terminated prompt string

Returns:

`pass` points to the password read

Note:

The return value points to static data whose content is overwritten by each call.

The getpid Function

The getpid function is a bogus routine that returns a false process ID. This routine is strictly for UNIX compatibility; serves no purpose under CP/M-68K. The return value is unpredictable in some implementations.

Calling Sequence:

```
WORD pid;
```

```
pid = getpid();
```

Arguments:

no arguments.

Returns:

pid false process ID

The gets, fgets Functions

The gets and fgets functions read strings from stream files. fgets reads a string including a newline (line-feed) character. gets deletes the newline, and reads only from the standard input. Both functions terminate the strings with a null character.

You must specify a maximum count with fgets, but not with gets. This count includes the terminating null character.

Calling Sequence:

```
BYTE      * addr;  
BYTE      * s;  
BYTE      *gets(), * fgets();  
WORD      n ;  
FILE      " stream;
```

```
addr = gets(s);  
addr = fgets(s,n,stream);
```

Arguments:

```
s          the string buffer area address  
n          the maximum character count  
stream     the input stream
```

Returns:

```
addr       the string buffer address
```

The index., rindex Functions

The index and rindex functions locate a given character in a string. index returns a pointer to the first occurrence of the character. rindex returns a pointer to the last occurrence.

Calling Sequence:

```
BYTE c;  
BYTE *s;  
BYTE *ptr;  
BYTE *indexo, 'rindexo;
```

```
ptr = index(s,c);  
ptr = rindex(s,c);
```

Arguments:

s	a null-terminated string pointer
c	the character for which to look

Returns:

ptr	the desired character address
0	character not in the string

The isatty Function

A CP/M-68K program can use the isatty function to determine whether a file descriptor is attached to the CP/M-68K console device (CON:).

Calling Sequence:

```
WORD fd;  
WORD ret;  
  
ret = isatty(fd);
```

Arguments:

fd	an open file descriptor
----	-------------------------

Returns:

1	fd attached to CON:
0	fd not attached to CON:

The lseek, tell Functions

The lseek function positions a file referenced by the file descriptor to an arbitrary offset. Do not use this function with stream files, because the data in the stream buffer might be invalid. Use the fseek function instead.

The tell function determines the file offset of an open file descriptor.

Calling Sequence:

```
WORD fd;  
WORD ptrname,  
LONG offset, lseeko, tell(), ret;  
  
ret = lseek(fd, offset, ptrname);  
ret = tell (fd);
```

Arguments:

fd	the open file descriptor
offset	a signed byte offset in the file
ptrname	the interpretation of offset:
	0 > from the beginning of the file
	1 => from the current file position
	2 => from the end of the file

Returns:

ret	resulting absolute file offset
-1	error

Note:

Incompatible with versions 1 through 6 of UNIX.

The mktemp Function

The mktemp function creates a temporary filename. The calling argument is a character string ending in 6 X characters. The temporary filename overwrites these characters.

Calling Sequence:

```
BYTE *string,  
BYTE *mktempo;  
  
string  mktemp(string)
```

Arguments:

string the address of the template string

Returns:

string the original address argument

The open, opena, openb Functions

The open and opena functions open an existing ASCII file by file descriptor. The openb function opens an existing binary file. The file can be opened for reading, writing, or updating.

Calling Sequence:

```
BYTE *name;  
WORD mode;  
WORD fd;  
  
fd = Open(name,mode);  
fd = opena(name,mode);  
fd = openb(name,mode);
```

Arguments:

name	the null-terminated filename string
mode	the access desired: 0 => Read-Only 1 => Write-Only 2 => Read-Write (update)

Returns:

fd	the file descriptor for accessing the file
-1	open failure

Note:

UNIX programs that use binary files compile correctly, but execute improperly.

The perror Function

The perror function writes a short message on the standard error file that describes the last system error encountered. First an argument string prints, then a colon, then the message.

CP/M-68K C simulates the UNIX notion of an external variable, errno, that contains the last error returned from the operating system. Appendix A contains a list of the possible values of errno and of the messages that perror prints.

Calling Sequence:

```
BYTE *s;  
WORD err;  
  
err = perror(s);
```

Arguments:

s the prefix string to be printed

Returns:

err value of "errno" before call

Note:

Many messages are undefined on CP/M-68K.

The printf, fprintf, sprintf Functions

The printf functions format data for output. The printf function outputs to the standard output stream. The fprintf function outputs to an arbitrary stream file. The sprintf function outputs to a string (memory).

Calling Sequence:

```

WORD      ret;
BYTE      *fmt;
FILE      *stream;
BYTE      *string;
BYTE      *sprintf (),rs;
/* Args can be any type

ret = printf (fmt,arg1,arg2 ...);
ret = fprintf(stream,fmt,arg1,arg2 ...);
rs = sprintf(string,fmt,arg1,arg2 ...);

```

Arguments:

fmt	format string with conversion specifiers
argn	data arguments to be converted
stream	output stream file
string	buffer address

Returns:

ret	number of characters output -1 if error
rs	buffer string address null if error

Conversion Operators

A percent sign, %, in the format string indicates the start of a conversion operator. Values to be converted come in order from the argument list. Table 2-2 defines the valid conversion operators.

Table 2-2. Conversion Operators
Meaning

Operator	Meaning
d	Converts a binary number to decimal ASCII and inserts in output stream.
o	Converts a binary number to octal ASCII and inserts in output stream.
x	Converts a binary number to hexadecimal ASCII and inserts in output stream.
c	Uses the argument as a single ASCII character.
s	Uses the argument as a pointer to a null-terminated ASCII string, and inserts the string into the output stream.
u	Converts an unsigned binary number to decimal ASCII and inserts in output stream.
%	Prints a % character.

You can insert the following optional directions between the % character and the conversion operator:

- o A minus sign justifies the converted output to the left, instead of the default right justification.
- o A digit string specifies a field width. This value gives the minimum width of the field. If the digit string begins with a 0 character, zero padding results instead of blank padding. An asterisk takes the value of the width field as the next argument in the argument list.
- o A period separates the field width from the precision string.
- o A digit string specifies the precision for floating-point conversion, which is the number of digits following the decimal point. An asterisk takes the value of the precision field from the next argument in the argument list.
- o The character l or L specifies that a 32-bit long value be converted. A capitalized conversion code does the same thing.

The putc, putchar, fputc, putw, putl Functions

The putc, putchar, fputc, putw, and putl functions output characters and words to stream files.

The putc function outputs a single 8-bit character to a stream file. This function is implemented as a macro in <stdio.h>, so do not use arguments with side effects. The fputc function provides the equivalent function as a real function.

The putchar function Outputs a character to the standard output stream file. This function is also implemented as a macro in <stdio.h>. Avoid using side effects with putchar.

The putw, function outputs a 16-bit word to the specified stream file. The word is output high byte first, compatible with the write function call.

The putl function outputs a 32-bit longword to the stream file. The bytes are output In 68000 order, as with the write function call.

Calling Sequence:

BYTE	c;
FILE	*stream;
WORD	w,ret;
LONG	lret,putl(),l;

```
ret = putcc(stream);
ret = fputc(c,stream);
ret = putchar(c);
ret = putw(w,stream);
lret = putl(l,stream);
```

Arguments:

c	the character to be output
stream	the output stream address
w	the word to be output
l	the long to be output

Returns:

ret	the word or character output
lret	the long output with putl
-1	an output error

Note:

A -1 return from putw or putl is a valid integer or long value. Use ferror to detect write errors.

The puts, fputs Functions

The puts and fputs functions output a null-terminated string to an output stream.

The puts function outputs the string to the standard output, and appends a newline character.

The fputs function outputs the string to a named output stream. The fputs function does not append a newline character.

Neither routine copies the trailing null to the output stream.

Calling Sequence:

```
WORD      ret;  
BYTE      *s;  
FILE      * stream;
```

```
ret = puts(s);  
ret = fputs(s, stream);
```

Arguments:

s	the string to be output
stream	the output stream

Returns:

ret	the last character output
-1	error

Note:

The newline incompatibility is required for compatibility with UNIX.

The qsort Function

The qsort function is a quick sort routine. You supply a vector of elements and a function to compare two elements, and the vector returns sorted.

Calling Sequence:

```
WORD    ret;  
BYTE    *base;  
WORD    number;  
WORD    size;  
WORD    compares;
```

```
ret = qsort (base, number, size, compare);
```

Arguments:

base	the base address of the element vector
number	the number of elements to sort
size	size of each element in bytes
compare	the address of the comparison function

This function is called by the following:

```
ret = compare(a,b);
```

The return is:

```
< 0 if a < b  
= 0 if a = b  
> 0 if a > b
```

Returns:

```
0    always
```

The rand, srand Functions

The rand and srand functions constitute the C language random number generator. Call srand with the seed to initialize the generator. Call rand to retrieve random numbers. The random numbers are C int quantities.

Calling Sequence:

```
WORD seed;  
WORD rnum;  
  
rnum = srand(seed);  
rnum = rand
```

Arguments:

seed	an int random number seed
------	---------------------------

Returns:

rnum	desired random number
------	-----------------------

The read Function

The read function reads data from a file opened by the file descriptor using open or creat. You can read any number of bytes, starting at the current file pointer.

CP/M-68K, the most efficient reads begin and end on 128-byte boundaries.

Calling Sequence:

```
WORD    ret;  
WORD    fd;  
BYTE    *buffer;  
WORD    bytes ,
```

```
ret = read (fd, buffer, bytes)
```

Arguments:

fd	a file descriptor open for read
buffer	the buffer address
bytes	the number of bytes to be read

Returns:

ret	number of bytes actually read error
-----	--

The scanf, fscanf, sscanf Functions

The scanf functions convert input format. The scanf function reads from the standard input, fscanf reads from an open stream file, and sscanf reads from a null-terminated string.

Calling Sequence-

```

BYTE          *format,*string;
WORD          nitems;
FILE          *stream;
/* Args can be any type

```

```

nitems = scanf(format,arg1,arg2 ...);
nitems = fscanf(stream,format,arg1,arg2 ..);
nitems = sscanf(str'tng,format,arg1,arg2 ...);

```

Arguments:

format	the control string
argn	pointers to converted data locations
stream	an open input stream file
string	null-terminated input string

Returns:

nitems	the number of items converted
-1	I/O error

Control String Format

The control string consists of the following items:

- o Blanks, tabs, or newlines (line-feeds) that match optional white space in the input.
- o An ASCII character (not %) that matches the next character of the input stream.
- o Conversion specifications, consisting of a leading %, an optional * (which suppresses assignment), and a conversion character. The next input field is converted and assigned to the next argument, up to the next inappropriate character in the input or until the field width is exhausted.

Conversion characters indicate the interpretation of the next input field. The following table defines valid conversion characters.

Character	Meaning
%	A single % matches in the input at this point; no conversion is performed.
d	Converts a decimal ASCII integer and stores it where the next argument points.
o	Converts an octal ASCII integer.
x	Converts a hexadecimal ASCII integer.
s	A character string, ending with a space, is input. The argument pointer is assumed to point to a character array big enough to contain the string and a trailing null character, which are added.
c	Stores a single ASCII character, including spaces. To find the next nonblank character, use %1s.
[Stores a string that does not end with spaces. The character string is enclosed in brackets. If the first character after the left bracket is not the input is read until the scan comes to the first character not within the brackets. If the first character after the left bracket is -, the input is read until the first character within the brackets.

Note:

You cannot determine the success of literal matches and suppressed assignments.

The setjmp, longjmp Functions

The setjmp and longjmp functions execute a nonlocal GOTO. The setjmp function initially specifies a return location. You can then call longjmp from the procedure that invoked setjmp, or any subsequent procedure. longjmp simulates a return from setjmp in the procedure that originally invoked setjmp. A setjmp return value passes from the longjmp call. The procedure invoking setjmp must not return before longjmp is called.

Calling Sequence:

```
#include    <setjmp.h>
WORD       xret,ret;
jmp-buf    env;
```

```
xret = setjmp(env);
```

```
longjmp(env,ret);
```

Arguments:

env	contains the saved environment
ret	the desired return value from setjmp

Returns:

xret	0 when setjmp invoked initially copied from ret when longjmp called
------	--

Note:

awkward

The signal Function

The signal function connects a C function with a 68000 exception condition. Each possible exception condition is indicated by a number. The following table defines exception conditions.

Number	Condition
4	Illegal instruction trap. Includes illegal instructions, privilege violation, and line A and line F traps.
5	Trace trap.
6	Trap instruction other than 2 or 3; used by BDOS and BIOS.
8	Arithmetic traps: zero divide, CHK instruction, and TRAPV instruction.
10	BUSERR (nonexistent memory) or addressing (boundary) error trap.

All other values are ignored for compatibility with UNIX.

Returning from the procedure activated by the signal resumes normal processing. The library routines preserve registers and condition codes.

Calling Sequence:

```
WORD ret, sig;  
WORD func ();  
  
ret = signal (Sig, func);
```

Arguments:

Sig	the signal number given above
func	the address of a C function

Returns:

ret	0 if no error, -1 if sig out of range
-----	---------------------------------------

The strcat, strncat Functions

The strcat and strncat functions concatenate strings. The strcat function concatenates two null-terminated strings. The strncat function copies a specified number of characters.

Calling Sequence:

```
BYTE *s1,*s2,*ret;  
BYTE -'strcat,'strncat;  
WORD n;
```

```
ret = strcat(s1,s2)-,  
ret = strncat(s1,s2,n);
```

Arguments:

s1	the first string
s2	the second string, appended to s1
n	the maximum number of characters in s1

Returns:

ret	a pointer to s1
-----	-----------------

Note:

The strcat (s1,s1) function never terminates and usually destroys the operating system because the end-of-string marker is lost, so strcat continues until it runs out of memory, including the memory occupied by the operating system.

The strcmp, strncmp Functions

The strcmp and strncmp functions compare strings. The strcmp function uses null termination, and strncmp limits the comparison to a specified number of characters.

Calling Sequence:

```
BYTE   *s1,*s2;  
WORD   val,ri;  
  
val = strcmp(s1,s2);  
val = strncmp(s1,s2,n);
```

Arguments:

s1	a null-terminated string address
s2	a null-terminated string address
n	the maximum number of characters to compare

Returns:

val	the comparison result: < 0 => s1 < s2 = 0 => s1 = s2 > 0 => s1 > s2
-----	--

Note:

Different machines and compilers interpret the characters as signed or unsigned.

The strcpy, strncpy Functions

The strcpy and strncpy functions copy one null-terminated string to another. The strcpy function uses null-termination, while strncpy imposes a maximum count on the copied string.

Calling Sequence:

```
BYTE      *s1, *s2, *ret;  
BYTE      *strcpy  strncpy  
WORD      n;
```

```
ret = strcpy(s1,s2);  
ret = strncpy(s1,s2,n);
```

Arguments:

s1	the destination string
s2	the source string
n	the maximum character count

Returns:

ret	the address of s1
-----	-------------------

Note:

If the count is exceeded in strncpy, the destination string is not null-terminated.

The strlen Function

The strlen function returns the length of a null-terminated string.

Calling Sequence:

```
BYTE    *s;  
WORD    len;
```

```
len = strlen(s);
```

Arguments:

```
s        the string address
```

Returns:

```
len      the string length
```

The swab Function

The swab function copies one area of memory to another. The high and low bytes in the destination copy are reversed. You can use this function to copy binary data from a PDP-11_m or VAX_m to the 68000. The number of bytes to swap must be even.

Calling Sequence:

```
WORD    ret;  
BYTE    *from, *to;  
WORD    nbytes;
```

```
ret = swab(from, to, nbytes);
```

Arguments:

from	the address of the source buffer
to	the address of the destination
nbytes	the number of bytes to copy

Returns:

ret	always 0
-----	----------

The ttyname Function

The ttyname function returns a pointer to the null-terminated filename of the terminal device associated with an open file descriptor.

Calling Sequence:

```
BYTE *name, *ttynameo;  
WORD fd;  
  
name = ttyname(fd);
```

Arguments.

fd an open file descriptor

Returns:

A pointer to the null-terminated string CON: if the file descriptor is open and attached to the CP/M-68K console device. Otherwise, zero (NULL) returns.

The ungetc Function

The ungetc function pushes a character back to an input stream. The next getc, getw, or getchar operation incorporates the character. One character of buffering is guaranteed if something has been read from the stream. The fseek function erases any pushed-back characters. You cannot ungetc EOF (-1).

Calling Sequence:

```
BYTE      c;  
FILE      *stream;  
WORD      ret;
```

```
ret = ungetc(c,stream);
```

Arguments:

c	the character to push back
stream	the stream address

Returns:

ret	c if the character is successfully pushed back
-1	error

The unlink Function

The unlink function deletes a named file from the file system. The removal operation fails if the file is open or nonexistent.

Calling Sequence:

```
WORD ret;  
BYTE * name;  
  
ret = unlink(name);
```

Arguments:

name	the null-terminated filename
------	------------------------------

Returns:

0	success
-1	failure

The write Function

The write function transfers data to a file opened by file descriptor. Transfer begins at the present file pointer, as set by previous transfers or by the lseek function. You can write any arbitrary number of bytes to the file. The number of bytes actually written returns. If the number of bytes written does not match the number requested, an error occurred.

Under CP/M-68K, the most efficient writes begin and end on 128-byte boundaries.

Calling Sequence:

```
WORD fd;  
BYTE  'buffer;  
WORD  bytes;  
WORD  ret;  
  
ret = write(fd,buffer,bytes);
```

Arguments:

fd	the open file descriptor
buffer	buffer the starting buffer address
bytes	bytes the number of bytes to write

Returns:

ret	the number of bytes actually written
-1	errors

Note:

Due to the buffering scheme used, all data is not written to the file until the file is closed.

End of Section 2

Section 3

C Style Guide

To make your C language programs portable, readable, and easy to maintain, follow the stylistic rules presented in this section. However, no rule can predict every situation; use your own judgment in applying these principles to unique cases,

3.1 Modularity

Modular programs reduce porting and maintenance costs. Modularize your programs, so that all routines that perform a specified function are grouped in a single module. This practice has two benefits: first, the maintenance programmer can treat most modules as black boxes for modification purposes; and second, the nature of data structures is hidden from the rest of the program. In a modular program, you can change any major data structure by changing only one module.

3.1.1 Module Size

A good maximum size for modules is 500 lines. Do not make modules bigger than the size required for a given function.

3.1.2 Intermodule Communication

Whenever possible, modules should communicate through procedure calls. Avoid global data areas. Where one or more compilations require the same data structure, use a header file.

3.1.3 Header Files

In separately combined files, use header files to define types, symbolic constants, and data structures the same way for all modules. The following list gives rules for using header files.

- o Use the '#include "file.h"' format for header files that are project-specific. Use '#Include <file.h>' for system-wide files. Never use device or directory names in an include statement.
- o Do not nest include files.
- o Do not define variables other than global data references in a header file. Never initialize a global variable in a header file.
- o When writing macro definitions, put parentheses around each use of the parameters to avoid precedence mix-ups.

3.2 Mandatory Coding Conventions

To make your programs portable, you must adhere strictly to the conventions presented in this section. Otherwise, the following problems can occur:

- o The length of a C int variable varies from machine to machine. This can cause problems with representation and with binary I/O that involves int quantities.
- o The byte order of multibyte binary variables differs from machine to machine. This can cause problems if a piece of code views a binary variable as a byte stream.
- o Naming conventions and the maximum length of identifiers differ from machine to machine. Some compilers do not distinguish between upper- and lower-case characters.
- o Some compilers sign-extend character and short variables to int during arithmetic operations; some compilers do not.
- o Some compilers view a hex or octal constant as an unsigned int; some do not. For example, the following sequence does not always work as expected:

```
LONG data;  
.  
.  
.  
printf("%ld\n", (data & 0xffff));
```


The `printf` statement prints the lower 16 bits of the long data item data. However, some compilers sign-extend the hex constant `0xffff`.

- o You must be careful of evaluation-order dependencies, particularly in compound `BOOLEAN` conditions. Failure to parenthesize correctly can lead to incorrect operation.

3.2.1 Variable and Constant Names

Local variable names should be unique to eight characters. Global variable names and procedure names should be unique to six characters. All variable and procedure names should be completely lower-case.

Usually, names defined with a `#define` statement should be entirely upper-case. The only exceptions are functions defined as macros, such as `getc` and `isascii`. These names should also be unique to eight characters.

You should not redefine global names as local variables within a procedure.

3.2.2 Variable Typing

Using standard types is unsafe in programs designed to be portable due to the differences in C compiler standard type definitions. Instead, use a set of types and storage classes defined with `typedef` or `#define`. The following tables define C language types and storage classes.

Table 3-1. Type Definitions

Type	C Base Type	
LONG	signed long	(32 bits)
WORD	signed short	(16 bits)
UWORD	unsigned short	(16 bits)
BOOLEAN	short	(16 bits)
BYTE	signed char	(8 bits)
UBYTE	unsigned char	(8 bits)
VOID	void (function return)	
DEFAULT	int	(16/32 bits)

Table 3-2. Storage Class Definitions

Class	C Base Class
REG	register variable
LOCAL	auto variable
MLOCAL	module static variable
GLOBAL	global variable definition
EXTERN	global variable reference

Additionally, you must declare global variables at the beginning of the module. Define local variables at the beginning of the function in which they are used. You must always specify the storage class and type, even though the C language does not require this.

3.2.3 Expressions and Constants

Write all expressions and constants to be implementation-independent. Always use parentheses to avoid ambiguities. For example, the construct

```
if(c = getchar() == '\n')
```

does not assign the value returned by `getchar` to `c`. Instead, the value returned by `getchar` is compared to `'\n'`, and `c` receives the value 0 or 1 (the true/false output of the comparison). The value that `getchar` returns is lost. Putting parentheses around the assignment solves the problem:

```
if((c = getchar()) == '\n')
```

Write constants for masking, so that the underlying int size is irrelevant. In the following example,

```
LONG data;  
.  
.  
.  
printf("%ld/n".(data & 0xffffL);
```

the long masking constant solves the previous problem for all compilers. Specifying the one's complement often yields the desired effect, for example, `-0xff` instead of `0xff00`.

For portability, character constants must consist of a single character. Place multi-character constants in string variables.

Commas that separate arguments in functions are not operators. Evaluation order is not guaranteed. For example, the following function call

```
printf("%d &d\n", i++, i++);
```

can perform differently on different machines.

3.2.4 Pointer Arithmetic

Do not manipulate pointers as ints or other arithmetic variables. C allows the addition or subtraction of an integer to or from a pointer variable. Do not attempt logical operations, such as AND or OR, on pointers. A pointer to one type of object can convert to a pointer to a smaller data type with complete generality. Converting a pointer to a larger data type can yield alignment problems.

You can test pointers for equality with other pointer variables and constants, notably NULL. Arithmetic comparisons, such as `>=`, do not work on all compilers and can generate machine-dependent code.

When you evaluate the size of a data structure, remember that the compiler might leave holes in a data structure to allow for alignment. Always use the `sizeof` operator.

3.2.5 String Constants

Allocate strings so that you can easily convert programs to foreign languages. The preferred method is to use an array of pointers to constant strings, which is initialized in a separate file. This way, each string reference then references the proper element of the pointer array.

Never modify a specific location in a constant string, as in the following example:

```
BYTE string[] = "BDOS Error On x:";
.
.
string[14] = 'A';
```

Foreign-language equivalents are not likely to be the same length as the English version of a message.

Never use the high-order bit of an ASCII string for bit flags. Extended character sets make extensive use of the characters above 0x7F.

3.2.6 Data and BSS Sections

Usually, C programs have three sections: text (program instructions), data (initialized data), and BSS (uninitialized data). Avoid modifying initialized data if at all possible. Programs that do not modify the data segment can aid the swapping performance and disk utilization of a multiuser system.

Also, if a program does not modify the data segment, you can place the program in ROM with no conversion. This means that the program does not modify initialized static variables. This restriction does not apply to the modification of initialized automatic variables.

3.2.7 Module Layout

The following list tells you what to include in a module.

- o At the beginning of the file, place a comment describing the following items:
 - the purpose of the module
 - the major outside entry points to the module
 - any global data areas that the module requires
 - any machine or compiler dependencies
- o Include file statements.
- o Module-specific #define statements.
- o Global variable references and definitions. Every variable should include a comment describing its purpose.
- o Procedure definitions. Each procedure definition should contain the following items:
 - A comment paragraph, describing the procedure's function, input parameters, and return parameters. Describe any unusual coding techniques here.
 - The procedure header. The procedure return type must be explicitly specified. Use VOID when a function returns no value.
 - Argument definitions. You must explicitly declare storage class and variable type.
 - Local variable definitions. Define all local variables before any executable code. You must explicitly declare storage class and variable type.
 - Procedure code.

Refer to Appendix C for a sample program.

3.3 Suggested Coding Conventions

The following suggestions increase program portability and make programs easier to maintain.

- o Keep source code within an 80-character margin for easier screen editing.
- o Use a standard indentation technique, such as the following:
 - Begin statements in a procedure one tab stop (column eight) from the left margin.
 - Indent statements controlled by an if, else, while, do, or for, one tab stop. If you require multiple nested indentions, use two spaces for each nesting level. Avoid going more than five levels deep.
 - Place the brackets surrounding each compound statement on a separate line, aligned with the indentation of the controlling statement. For example,

```
for(i=0;i<MAXNUM;i++)
{
    j = compute(i);
    if (j > UPPER)
        j = UPPER;
    output(j);
}
```

- Place a null statement controlled by an if, else, while, for, or do, on a separate line, indented for readability.
- o To document your code, insert plenty of comments. If your code is particularly abstruse, inserting comments helps clarify it.
- o Put all maintenance documentation in the source code itself. If you do not, the documentation will not be updated when the code changes.
- o Use blank lines, form-feeds, and white space to improve readability.

End of Section 3

Appendix A

CP/M-68K Error Codes

The perror function and the errno external variable determine the cause of an error during a CP/M-68K system call. The include file <errno.h> contains symbolic definitions for the errors that CP/M-68K returns. The following table lists error numbers, symbolic names, and messages available from perror.

Table A-1. CP/M-68K Error Codes

Number	Name	Error Message
0	-	Error Undefined on CP/M-68 K
1	-	Error Undefined on CP/M-68 K
2	ENOENT	No Such File
3	-	Error Undefined on CP/M-68K
4	-	Error Undefined on CP/M-68K
5	EIO	I/O Error
6	-	Error Undefined on CP/M-68K
7	E2BIG	Arg List too Long
8	-	Error Undefined on CP/M-68K
9	EBADF	Bad file Number
10	-	Error Undefined on CP/M-68K
11	-	Error Undefined on CP/M-68K
12	ENOMEM	Not enough core
13	EACCES	Permission denied
14	-	Error Undefined on CP/M-68K
15	-	Error Undefined on CP/M-68K
16	-	Error Undefined on CP/M-68K
17	-	Error Undefined on CP/M-68K
18	-	Error Undefined on CP/M-68K
19	-	Error Undefined on CP/M-68K
20	-	Error Undefined on CP/M-68K

Table A-1. (continued)

Number	Name	Error Message
21	-	Error Undefined on CP/M-68 K
22	EINVAL	Invalid argument
23	ENFILE	File table overflow
24	EMFILE	Too many open files
25	ENOTTY	Not a typewriter
26	-	Error Undefined on CP/M-68K
27	EFBIG,	File too big
28	ENOSPC	No space left on device
29	-	Error Undefined on CP/M-68K
30	EROFS	Read-Only file system
31	-	Error Undefined on CP/M-68K
32	-	Error Undefined on CP/M-68K
33	-	Error Undefined on CP/M-68K
34	-	Error Undefined on CP/M-68K
35	ENODSPC	No directory space

The file <errno.h> also includes the names for all errors defined with UNIX V7. Therefore, programs that reference these definitions need not be changed.

End of Appendix A

Appendix B

Customizing the C Compiler

Compiling a C program requires three compiler passes. The output of the compiler is assembly language, which must be assembled and linked to produce a program that runs. The compiler, assembler, linker load modules, C library, and the system include files need a substantial amount of disk storage space, minimizing storage space. This appendix discusses compiler operation and suggests ways to minimize the disk storage requirements for compiling.

B.1 Compiler Operation

The C compiler has three components: the preprocessor (CP68), the parser (C068), and the code generator (C168). The assembler (AS68) and the linker (LO68) also help generate an executable program. The following list tells you how these components operate.

1. The preprocessor, CP68, takes the original source file and produces a file with all #define and #Include statements resolved. The preprocessor command line takes the form:

```
CP68 [-I d:] file.C file.1
```

The -I flag indicates that the next argument is a CP/M-68K drive specification. This drive is used for all library include statements of the form #Include <file>. Drive specifications can also appear in the filename portion of an #Include statement, but this procedure is not recommended. File.C is the source file, and file.1 is the output file.

2. The parser, C068, takes the file produced by the preprocessor and creates an intermediate code file. The command line takes the form:

```
C068 file.1 file.IC file.ST
```

File.1 is the output from the preprocessor. File.IC is the intermediate code file that C168 uses. File.ST is a temporary file that collects constant data for inclusion at the end of the intermediate code file.

3. The code generator, C168, takes the intermediate code file from C068 and produces an assembly-language source file. The command line takes the form:

```
C168 file.IC file.S [-LD]
```

File.IC is the intermediate code output from C068. File.S is the assembly-language output file. The -L flag indicates that the compilation assumes all address variables are 32 bits. The default is 16-bit addresses. The -D flag causes the compiler to include the line numbers from the source file (file.C) as comments in the generated assembly language. This is useful for debugging.

4. The assembler, AS68, translates the compiler output to a form that the linkage editor can use. The command line takes the form:

```
AS68 -L -U [-F d:] [-S d:] file.S
```

The -L option indicates to the linkage editor that addresses are considered 32-bit quantities. The -U option means that undefined symbols are considered external references. The -F option specifies a drive that the assembler uses for temporary files. The -S option specifies a drive that the assembler uses for the initialization file (AS68SYMB.DAT). File.S is the output of C168, and file.0 is produced by the assembler.

5. The linker, L068, produces an executable file from the output of one or more assembler runs. You must also include a start-up file and the C library when linking C programs. The linker command line takes the form:

```
L068 -R [-F d:] -0 file.68K S.0 file.0 clib
```

The -R option specifies that the file be relocatable. Relocatable files run on any CP/M-68K system. The -F option allows you to place linker temporary files on a disk drive other than the default. The -0 file.68K construct makes the linker place the executable output in file.68K. S.0 is the run-time start-up routine. You must include this file as the first file in every C program link. File.0 is the output of the assembler. Specify multiple files between S.0 and clib if you want separate compilation. clib is the C library file.

B.2 Supplied submit Files

CP/M-68K includes two submit files, `c.sub` and `clink.sub`, that compile and link C programs (see Section 1. 1). Usually, these files are located on the default drive. However, you can edit these files to specify different disk drives for any of the following drives:

- o The disk drive on which the compiler passes, assembler, and linker reside.
- o The disk drive that the `#Include <file>` statements in the C preprocessor reference.
- o The disk drive with the assembler initialization file.
- o The disk drive on which the assembler and linker create temporary files.
- o The disk drive containing the C library file.

B.3 Saving Disk Space

You can do the following things to conserve disk space:

- o Use the `reloc` utility on all the load modules, the compiler, assembler, linker, and editor. This significantly reduces file size and load time.
- o Place all the load modules on one disk and use another disk for sources and temporary files. This requires two drives.
- o On single-density disk systems, you must place the C library file and linker on a separate disk and swap disks before linking.

B.4 Gaining Speed

Along with the items in Section B.3, you can speed compilation by implementing the following:

- o Put the assembler temp files on a different drive from the source and object files.
- o Put the linker temp files on a different drive from the object input, C library, and load module output.
- o Use the linker -S (suppress symbol table) and -T (absolute load module) switches in place of the -R flag. If you do this, the resulting program cannot run on an arbitrary CP/M-68K system.

End of Appendix B

Appendix C

Sample C Module

The modules in this appendix are written and documented in C code that follows the style conventions discussed in Section 3.

```

/*****
/*
/*          - P r i n t f M o d u l e
/*
/*  This module is called through the single entry point "_print" to
/*  perform the conversions and output for the library functions:
/*
/*      printf = Formatted print to standard output
/*      fprintf - Formatted print to stream file
/*      sprintf = Formatted print to string
/*
/*  The calling routines are logically a part of this module, but are
/*  compiled separately to save space in the user's program when only
/*  one of the library routines is used.
/*
/*  The following routines are present:
/*
/*      _printf      Internal printf conversion / output
/*      _prnt8      Octal conversion routine
/*      _prntx      Hex conversion routine
/*      __conv      Decimal ASCII to binary routine
/*      _putstr     Output character to string routine
/*      _prntl     Decimal conversion routine
/*
/*  The following routines are called:
/*
/*      st_rien     Compute length of a string
/*      putc        Stream output routine
/*      ftoa        Floating point output conversion routine
/*
/*  This routine depends on the fact that the argument list is always
/*  composed of LONG data items.
/*
/*  Configured for Whitesmith's C on VAX.  ||putc|| arguments are
/*  reversed from UNIX.
/*
*****/

```

```

/*
 *   Include files:
 */
#include    <stdio.h>           /* Just the standard stuff */

/*
 *   Local DEFINES
 */
#define     HIBIT  31           /* High bit number of LONG */

/*
 *   Local static data:
 */
MLOCAL BYTE  *_ptrbf= 0;      /* Buffer Pointer */
MLOCAL BYTE  *__ptrst = 0;    /* => File/string (if anY) */
MLOCAL BYTE  *__fmt = 0;     /* Format Pointer */
/*

```

```

/ *****
*
*   PRINTF   INTERNAL   ROUTINE
*
*
*   Routine "_printf" is used to handle all "printf" functions, including
*   " sprintf f ", and " f print f ".
*
*   Calling Sequence:
*
*   _printf(fd,func,fmt,argl);
*
*   Where:
*
*       fd           Is the file or string pointer.
*       func         Is the function to handle output.
*       fet          Is the address of the format string.
*       argl         Is the address of the first arg.
*
*
*   Returns:
*
*       Number of characters output
*
*   Bugs:
*
*   It is assumed that args are contiguous starting at "argl", and that
*   all are the same size (LONG), except for floating point.
*
*
*****
_printf(fd ,f ,fmt ,al )           /* ***** */
    LONG      fd;                  /* Not really, but ... */
    LONG      (*f) ( ) ;          /* Function pointer */
    BYTE      *fmt ;              /* -> Format string */
    LONG      *al ;               /* -> ArS list */
{
    LOCAL BYTE c;                 /* Format character temp */
    LOCAL BYTE *s;                /* Output string pointer */
    LOCAL BYTE adj;               /* Right/left adJust flag */
    LOCAL BYTE buf[30];           /* Temporary buffer */
    /* ***** */

```

```

/*****/
LOCAL LONG      *adx;      /* Are Address temporary */
LOCAL LONG      x;        /* Arg Value temporary */
LOCAL LONG      n;        /* String Length Temp */
LOCAL LONG      m;        /* Field Length Temporary */
LOCAL LONG      width;    /* Field width */
LOCAL LONG      prec;     /* Precision for "%x.yf" */
LOCAL LONG      padchar;  /* '0' or ' ' (padding) */
LOCAL DOUBLE    zz;       /* Floating temporary */
LOCAL DOUBLE    *dblptr;  /* Floating temp. address */
LOCAL LONG      ccount;   /* Character count */
EXTERN          _putstr(); /* Reference function */
/*****/
/*****/
ccount = 0;      /* Initially no characters */
_ptrbf = buf;    /* Set buffer pointer */
adx = a1;       /* Copy address variable */
_ptrst = fd;     /* Copy file descriptor */
__fmt = fet;     /* Copy format address */
/*****/
if(*__fmt == 'L' || *__fmt == 'l') /* Skip long output */
    __fmt++; /* conversions */
/*****/
/*****/
/* This is the main format conversion loop. Load a character from the */
/* format string. If the character is '%', perform the appropriate */
/* conversion. Otherwise, Just output the character. */
/*****/
/*****/
while(c = *__fmt++ ) /* Pick up next format char */
{
    if(c != "%") /*
        {
            (*f)fd,c); /* If not '%', Just output */
            ccount++; /* Bump character count */
        }
    else /* It is a '%',
        {
            /* convert */
            x = *adx++; /* x = address of next arg */
            /*****/
            if(*__fmt == "- ") /* Check for left adjust */
            {
                /* Is left, set flag */
                __fmt++; /* Bump format pointer */
            }
            /*****/

```



```

else /* Right adJust */
    adj = 'r'; /*******/
/* */
padchar=(* __fmt=='0') ? '0' : ' '; /* Select Pad character */
/*******/
width = __conv( ); /* Convert width (if any) */
/*******/
if(* __fmt == '.' ) /* '.' means precision spec */
{ /* */
    ++__fmt; /* Bump past "." */
    prec = __conv( ); /* Convert precision spec */
} /* */
else /* None specified */
    prec = 0; /*******/
/* */
s = 0; /* Assume no output string */
switch(c = * __fmt++) /* Next char is conversion */
{ /* */
    case 'D': /* Decimal */
    case 'd': /* */
        _prtl(x); /* Call decimal print rtn */
        break; /* Go do output */
/*******/
    case 'o': /* Octal */
    case 'O': /* Print */
        _prnt8(x); /* Call octal printer */
        break ; /* Go do output */
/*******/
    case "x": /* Hex */
    case "X": /* Print */
        _prntx(x); /* Call conversion routine */
        break; /* Go do output */
/*******/
    case 'S': /* String */
    case 's': /* Output? */
        s=x; /* Yes, (easy) */
        break; /* Go finish up */
/*******/
    case 'C': /* Character */
    case 'c ': /* Output? */
        *_ptrbf++ = x&0377; /* Just load buffer */
        break; /* Go output */
/*******/
    case 'E': /* Floating point? */
    case 'e "': /* */

```

```

    case 'F':          /*                               */
    case "f" :        /*                               */
        dblptr = adx-1; /* Assumes 64 bit float! */
        zz = *dblptr; /* Load value */
        adx += 1; /* Bump past second word */
        ftoa (zz,buf,prec,c); /* Call floating conversion */
        prec = 0; /* Fake out padding routine */
        a = buf; /* just like string print */
        break; /* Go Output */
        /*******/
    default:          /* None of the above? */
        (*f) (fd,c) ; /* Just Output */
        ccount++; /* Count it, */
        adx--1 ; /* Fix arg address */
    } /* End switch */
    /*******/
if (s == 0) /* If a = 0, string is in */
{ /* "buf", */
    *_ptrbf = '0'; /* Insure termination */
    s = buf; /* Load address */
} /*******/
/*                               */
n = strlen(s) ; /* Compute converted length */
n = (prec<n && prec != 0) ? prec : n; /* Take min(Prec ,n) */
m = width-n; /* m is # of pad haracters */
/*******/
if (adj == 'r') /* For right adjust , */
    while (m-- > 0) /* Pad in front */
    { /*                               */
        (*f) (fd ,padchar) ; /* Thusly */
        ccount++; /* Count it */
    } /*                               */
    /*******/
while (n-- ) /* Output Converted */
{ /*                               */
    (*f) (fd ,*s++) ; /* Data */
    ccount++; /* Count it */
} /*                               */
/*******/
while (m-- > 0) /* If left adjust, */
{ /*                               */
    (*f) (fd ,padchar) ; /* Pad */
    ccount++; /* Count padded characters */
} /*******/
_ptrbf = buf; /* Reset buffer pointer */

```

```
        }
    }
    if (*f) == _putstr
        (*f) (fd, '0');

    return(ccount) ;
}

/* End else */
/* End while */
/* If string output , */
/* Drop in terminator char */
/*******/
/* Return appropriate value */
/* End _printf */
/*******/
```

```

/*****
/*          - P R N T 8   P R O C E D U R E          */
/*          -----          */
/*
/*  Routine "_prnt8" converts a binary LONG value to octal ascii.  */
/*  The area at "_ptrbf" is used,          */
/*          */
/*  Calling Sequence:          */
/*          */
/*      _prnt8(n) ;          */
/*          */
/*  n  is the number to be converted,          */
/*          */
/*  Returns:          */
/*          */
/*      (none)          */
/*          */
*****/
VOID _prnt8 (n)          /*          */
    LONG n;          /* Number to convert          */
{          /*          */
    REG WORD  p;          /* Counts bits          */
    REG WORD  k;          /* Temporary 3-bit value          */
    REG WORD  sw;          /* Switch 1  > output          */
    /*          */
    if (n==0)          /* Handle 0 as special case          */
    {          /*          */
        *_ptrbf++ = '0';          /* Put  in one zero          */
        return;          /*      And quit          */
    }          /*          */
    /*          */
    sw = 0;          /* Indicate no output Yet          */
    /*          */
    for (p=HIBIT; p >= 0; p == 3)          /* Use 3 bits at a time          */
    /*          */
    if ((k = (n>>p)&07) : | sw)          /* Need to output yet?          */
    {          /*          */
        if (p==HIBIT)          /* 1st  digit has only 2 bits          */
            k = k & 02;          /* Mask appropriately          */
        *_ptrbf++ = '0' + k;          /* ASCIIfy digit          */
        sw = 1 ;          /* Set  output flag          */
    }          /* End if          */
}          /* End _prnt8          */
/*****

```

```

/*****
/*
/*          _P r n t x   F u n c t i o n
/*
/*
/*  The "_prntx'" function converts a binary LONG quantity to hex ASCII */
/*  and stores the result in "*_ptrbf". Leading zeros are suppressed. */
/*
/*  Calling sequence:
/*
/*      _prntx(n);
/*
/*  where "n" is the value to be converted.
/*
/*  Returns:
/*
/*      (none)
/*
/*****
VOID _prntx (n)          /*
    LONG n;             /* 32 bits
{
    REG LONG  d;        /* A digit
    REG LONG  a;        /* Temporary value
                        /*
    if (a = n>>4)      /* Peel off low 4 bits
        _prntx(a & 0xfffff); /* If <> 0, print first
    d = n&017;         /* Take low four bits
    *_ptrbf++ = d > 9 ? 'A'+d-10 : '0' + d; /* ASCIIfy into buffer
}
                        /*

```

```

/*****
/*
/*          -- C o n v   F u n c t i o n
/*          -----
/*
/*  Function "__conv" is used to convert a decimal ASCII string in
/*  the format to binary.
/*
/*  Calling Sequence:
/*
/*      val = __conv( ) ;
/*
/*  Returns:
/*
/*      "val" is the converted value
/*      Zero is returned if no value
/*
/*          */
/*****
LONG __conv( )
{
    REG BYTE    c;
    REG LONG    n;

    n = 0;
    while(((c= *__fmt++) >= '0')
           && (c <= '9'))
        n = n*10+c- '0' ;
    __fmt-- ;

    return(n) ;
}
/*****

```

```

/*****
/*
/*          - P u t s t r   F u n c t i o n
/*          -----
/*
/*
/*
/*      Function '_putstr' is used by 'sprintf' as the outPut function
/*      argument to "_printf". A single character is copied to the buffer
/*      at "=ptrst".
/*
/*      Calling Sequence:
/*
/*          =putstr(str,chr);
/*
/*      where "str" is a dummy argument necessary because the other output
/*      functions have two arguments.
/*
/*      Returns:
/*
/*          (none)
/*
*****/
VOID _putstr(str,chr)          /*
    REG BYTE   chr;          /* The output character
    BYTE       *str;         /* Dummy argument
{
    *_ptrst++ = chr;        /* Output the character
    return(0);              /* Go back
}
*****/

```

```

/*****
/*
/*          - P r t l   F u n c t i o n
/*          -----
/*
/*  Function "_prtl" converts a LONG binary quantity to decimal ASCII
/*  at the buffer pointed to by "_ptrbf"
/*
/*  Calling Sequence:
/*
/*      =prtl(n) ;
/*
/*  where "n" is the value to be converted.
/*
/*  Returns:
/*
/*      (none)
/*
*****/
VOID _prtl(n)
    REG LONG  n;
{
    REG LONG  digs[15];
    REG LONG  *dpt;

    dpt = digs;

    if (n >= 0)
        n = -n;
    else
        *_ptrbf++ = '-';

    for (; n != 0; n = n/10)
        *dpt++ = n%10;

    if (dpt == digs)
        *dpt++ = 0;

    while (dpt != digs)
    {
        --dpt;
        *_ptrbf++ = '0' - *dpt;
    }
}

```

End of Appendix C

Appendix D

Error Messages

This appendix lists the error messages returned by the components of the CP/M-68K C compiler, the C Parser, C068, the C Co-generator, C168, the C Preprocessor, CP68, and by the CP/M-68K C Run-time Library. The sections are arranged alphabetically. Error messages are listed within each section in alphabetical order with explanations and suggested user responses.

D. I C068 Error Messages

The CP/M-68K C Parser, C068, returns two types of error messages: diagnostic error messages and messages indicating errors in the internal logic of C068. Both types of error messages take the general form:

*line no. error message text

The asterisk (*) indicates that the error message comes from C068. The "error message text" describes the error. You must correct any errors you receive from C068 before invoking C168. Uncorrected errors from C068 cause erroneous error messages to occur when you run C168.

D.1.1 Diagnostic Error Messages

These error messages occur mostly in response to syntax errors in the source code. Refer to your C language manual for a complete discussion of the C language syntax.

The error messages are listed in Table D-1 in alphabetical order with short explanations and suggested user responses.

Table D-1. C068 Diagnostic Error Messages

Message	Meaning
*line no. address of register	<p>You have attempted to take the address of a register. Correct the source code before you recompile it.</p>
*line no. assignable operand required	<p>On the line indicated, the operand to the left of the equals sign in the assignment statement is not a valid operand. Supply a valid operand. This error might occur because the operand is a constant instead of a variable.</p>
*line no. bad character constant	<p>A character constant on the line indicated is invalid. The character must be a single character between quotes. A control character, more than one character, or a symbol that is not a character will cause this error to occur.</p>
*line no. bad direction	<p>You attempted to reference by address instead of by value, but the expression you used is not an address. Supply a value or a valid address before you recompile the source code.</p>
*line no. can't open filename	<p>Either the filename or the drive code is incorrect. Specify the correct drive code and filename before you recompile the source code.</p>
*line no. case not inside a switch block	<p>The case on the line indicated is not inside a switch block. Correct the source code before you recompile it.</p>
*line no. character constant too long	<p>The character constant on the line indicated is too long. A character constant must be a single character between quotes. Correct the source code before you recompile it.</p>

Table D-1. (continued)

Message	Meaning
*line no. constant required	<p>The operation on the line indicated requires a constant. Correct the error before you recompile the source code.</p>
*line no. declaration syntax	<p>The syntax of the declaration on the line indicated is Incorrect. Refer to your C language manual. Correct the syntax before you recompile the source code.</p>
*line no. default not inside a switch block	<p>The default on the line indicated is not inside a switch block. Correct the Source code before you recompile it.</p>
*line no. dimension table overflow	<p>There are too many dimensions, at or prior to the line indicated, for the dimension table. The dimension table does not have space for more than 8 or 9 dimensions. Structures count as dimensions. Rewrite the source code to use fewer dimensions and structures before you recompile it.</p>
*line no. duplicate case value	<p>Two cases for the same switch are identical. Eliminate one of the cases before you recompile the source code.</p>
*line no. expected label	<p>A go to statement on the line indicated does not have a label. Supply the missing label before you recompile the source code.</p>
*line no. expression too complex	<p>Due to internal limitations in C068, the expression on the line indicated is too complex to be evaluated. Simplify the expression before recompiling the source code.</p>

Table D-1. (continued)

Message	Meaning
*line no. external definition syntax	<p>The syntax of the external definition on the line indicated is incorrect. Correct the syntax before you recompile the source code. Refer to your C language manual for the correct syntax.</p>
*line no. field overflows byte	<p>The bit field asks for more bits than fit in an 8-bit byte. Reduce the number of bits in the bit field before you recompile the source code.</p>
*line no. field overflows word	<p>The word field asks for more bytes than fit in a word. Reduce the number of bytes in the byte field before you recompile the source code.</p>
*line no. floating point not supported	<p>CP/M-68K does not support floating point. Rewrite the source code before you recompile it.</p>
*line no. function body syntax	<p>There is no bracket at the beginning of the function on the line indicated. Supply the missing bracket before you recompile the source code.</p>
*line no, illegal call	<p>You attempted to call something that is not a function. Correct the source code before you recompile it.</p>
*line no. illegal function declaration	<p>The storage class of the function declared in the line indicated is illegal. The only two storage classes allowed for functions are static and external. Correct the declaration before you recompile the source code.</p>
*line no. illegal register specification	<p>The register specification in the line indicated is illegal. Structures and arrays cannot be put into a register. Correct the source code before you recompile it.</p>

Table D-1. (continued)

Message	Meaning
*line no. illegal type conversion	<p>You made an incompatible assignment. This error commonly occurs when attempting to convert a pointer, 32 bits, to an int, 16 bits. Correct the source code before you recompile it.</p>
line no. indirection on function invalid source	<p>You attempted to use the indirection operator () on a function. Correct the code before you recompile it.</p>
*line no, initializer alignment	<p>This message usually indicates a missing initializer value, or values out of order. Check the initializer list and correct it before you re compile the source code.</p>
*line no. initializer list too long	<p>The initializer list is too long for C068. Shorten the list before you recompile the source code.</p>
*line no. invalid break statement	<p>The break statement on the line indicated is not inside a loop or a switch. Correct the source code before you recompile it.</p>
*line no. invalid character	<p>There is an invalid character in the collating sequence in the line indicated. Control characters or members of the extended character set are not valid characters. Correct the source code before you recompile it.</p>
*line no. invalid continue statement	<p>The continue statement on the line indicated is not inside a loop. This error might occur when you have used a continue statement in a switch. A continue statement is only valid in a loop. Correct the source code before reinvoking C068.</p>

Table D-1. (continued)

Message	Meaning
*line no. invalid conversion	<p>You attempted an incompatible assignment, for example, a pointer, 32 bits, and an int, 16 bits. Correct the source code before you recompile it.</p>
*line no. invalid data type	<p>The line indicated contains an expression that attempts to equate two incompatible quantities, for example, an int, 16 bits, and a pointer,</p>
*line no. invalid declarator	<p>The declarator in the line indicated is not a recognizable language element. Supply a valid declarator before you recompile the source code.</p>
*line no. invalid expression	<p>The expression in the line indicated contains a syntax error. Correct the syntax of the expression before you recompile the source code.</p>
*line no. invalid field size	<p>The field in the line indicated is less than or equal to zero. Correct the field size before you recompile the source code.</p>
*line no. invalid field type description	<p>You attempted to put a pointer or a long into a bit field. Correct the source code before you recompile it.</p>
*line no. invalid for statement	<p>The for statement in the line indicated contains a syntax error. Refer to your C language manual for the correct syntax of a for statement. Correct the statement before you recompile the source code.</p>
*line no. invalid initializer	<p>The initializer you specified in the line indicated is not a constant. You can only initialize to a constant. Correct the source code before you recompile it.</p>

Table D-1. (continued)

Message	Meaning
*line no. invalid label	<p>You used a variable name as a label in the line indicated. Correct the source code before you recompile it.</p>
*line no. invalid long declaration	<p>You attempted to declare something long that cannot be long, for example, a character. Correct the source code before you recompile it.</p>
*line no. invalid operand type	<p>The expression in the line indicated contains an invalid operand. Correct the source code before you recompile it.</p>
*line no. invalid register specification	<p>You attempted to put something larger than allowed into a register, for example, a structure or a function. Correct the source code before you recompile it.</p>
*line no. invalid short declaration	<p>You attempted to declare something short that cannot be short. Correct the source code before you recompile it.</p>
*line no. invalid storage class	<p>You specified an invalid storage class in a declaration. Refer to your C language manual for the allowed storage classes. Correct the source code before you recompile it.</p>
*line no. invalid structure declaration: name	<p>The size of the structure indicated by the variable name has a size less than or equal to zero. Correct the source code before you recompile it.</p>
*line no. invalid structure member name	<p>The structure reference in the line indicated is not a member of any structure. Correct the source code before you recompile it.</p>

Table D-1. (continued)

Message	Meaning
*line no.	invalid structure prototype: name
	In the line indicated you reference a structure name that is not a prototype. Correct the source code before you recompile it.
*line no.	invalid type declaration
	The type declared in the line indicated is invalid. Refer to your C language manual for a discussion of valid types. Correct the source code before you recompile it.
*line no.	invalid typedef statement
recompile	The line indicated contains a statement with more than one typedef keyword. Only one typedef is allowed per statement. Correct the source code before you recompile it.
*line no.	invalid unsigned declaration
	The quantity you declared unsigned in the line indicated might not be unsigned. Only an int can be unsigned. Correct the declaration before you recompile the source code.
*line no.	invalid?: operator syntax
	This message indicates an error in the use of the ?: conditional operator in the line indicated. Refer to your C language manual for the correct syntax. Correct the source code before you recompile it.
*line no.	label redeclaration: label
	You used the same label for two separate items. Correct the source code before you recompile it.
*line no.	missing colon
	You left out a colon. Supply a colon in the correct location before you recompile the source code.
*line no.	missing{in initialization
	You neglected to put in the left curly brace in the initialization of an array or structure. Supply the missing brace before you recompile the source code.

Table D-1. (continued)

Message	Meaning
*line no. missing }	<p>You left the right curly brace out of the initialization of an array or structure. Supply the missing brace before you recompile the source code.</p>
*line no. missing while	<p>The do statement at the line indicated is missing a while at the end. Supply the missing while before you recompile the source code.</p>
*line no. missing semicolon	<p>A semicolon is missing from the line indicated. Supply the missing semicolon before you recompile the source code.</p>
*line no. no structure name	<p>You referred to a structure in the line indicated without giving the structure name. Correct the source code before you recompile it.</p>
*line no. no */ before EOF	<p>The last comment in the source code is missing its final delimiter. Supply the missing delimiter before you recompile the source code.</p>
*line no. not a structure: name	<p>The structure referenced in the line indicated is not a structure. Correct the source code before you recompile it.</p>
*line no, not in parameter list: x	<p>In the line indicated, you declared the something indicated by the variable x to be an argument to a function, but x is not in the function parameter list. Correct the source code before you recompile it.</p>
*line no. parenthesized expression syntax	<p>The line indicated contains a syntax error in the parenthesized expression. Correct the source code before you recompile it.</p>

Table D-1. (continued)

Message	Meaning
*line no. redeclaration: symbol	
	A symbol has been declared twice. Remove one of the declarations before recompiling the source code.
*line no. string cannot cross line	
	The character string at the line indicated continues beyond one line. The closing quote to a character string must be on the same line as the opening quote, unless you use a backslash (\) at the end of the first line to indicate that the line continues. Correct the source code before you recompile it.
*line no. string too long	
	The string at the line indicated is longer than 255 characters. A string cannot be longer than 255 characters on a single line. Break the string and use a continuation, indicated by a backslash (\) at the end of the line to be continued.
*line no. structure declaration syntax	
	The syntax of the structure declaration on the line indicated is incorrect. Correct the Syntax before reinvoking C068.
*line no. structure operation not yet implemented	
	On the line indicated, you assigned a structure to another structure. Assigning a structure to another structure is not yet supported by the CP/M-68K C compiler. Correct the source code before reinvoking C068.
*line no. structure table overflow	
	There are too many structures in your program for the structure tables. Eliminate some structures before reinvoking the C compiler.
*line no. symbol table overflow	
	Your program uses too many symbols for the space available on the symbol table. Eliminate some symbols before reinvoking the C compiler.

Table D-1. (continued)

Message	Meaning
*line no. temp creation error	<p>The drive code or filename of the temporary file referenced in the line indicated is incorrect. Specify the correct drive code and filename before you recompile the source code.</p>
*line no. too many cases in switch	<p>The switch at the line indicated has too many cases. Eliminate some cases before you recompile the source code.</p>
*line no. too many initializers	<p>The initializer list in the line indicated contains more initializers than there are members of the array being initialized. Correct the list before you recompile the source code.</p>
*line no. too many params	<p>The function declaration at the line indicated contains too many parameters. Rewrite the source code before you recompile the source code.</p>
*line no. undefined label: label	<p>The label indicated by the variable <code>label</code> has not been defined. Correct the source code before you recompile it.</p>
*line no. undefined symbol: symbol	<p>The symbol indicated by the variable "symbol" is undefined. Correct the source code before you recompile it.</p>
*line no. unexpected EOF	<p>This error usually occurs when there is no right curly brace (<code>}</code>) after a function, or when there are mismatched comment delimiters. Locate and correct the error before you recompile the source code.</p>

Table D-1. (continued)

Message	Meaning
*line no, usage:c068 source asm str	The syntax of the C compiler command line is incorrect. The correct syntax is given in the error message. Reenter the command line using a valid syntax.
*line no. { not matched by }	A left curly brace ({) is not matched by a right curly brace. This error frequently occurs in an initialization sequence. Supply the missing brace before you recompile the source code.
*line no. ="char" assumed	You have used a = + type operation with an invalid character. When an invalid character occurs after the = sign, C068 puts in = = instead of = . Correct the source code before you recompile the source code.
*line no. &operand illegal	You attempted to take the address of something that is not a variable, for example, a register. Correct the source code and recompile it.

D.1.2 Internal Logic Errors

These messages indicate fatal errors in the internal logic of C068:

- *line no. can't copy filename
- *line no. invalid keyword
- *line no. too many chars pushed back
- *line no. too many tokens pushed back

Contact the place you purchased your system for assistance. Provide the following information:

- o Indicate the version of the operating system you are using.
- o Describe your system's hardware configuration.
- o Provide sufficient information to reproduce the error. Indicate which program was running at the time the error occurred. If possible, also provide a disk with a copy of the program.

D.2 C168 Error Messages

The CP/M-68K C Co-generator, C168, returns two types of fatal error messages: diagnostic error messages and messages indicating errors in the internal logic of C168. Both types of error messages take the general form:

****line no. error message text**

The asterisks (**) indicate that the error message comes from C168. The error message text describes the error. If you run C168 before correcting any errors you received from C068, you receive erroneous errors from C168.

D.2.1 Fatal Diagnostic Errors

The C168 fatal, diagnostic error messages are listed in Table D-2 in alphabetical order, with explanations and suggested user responses.

Table D-2. C168 Fatal Diagnostic Errors

Message	Meaning
**line no. can't create filename	Either the drive code or the filename for the file indicated by the variable "filename" is incorrect. Ensure that you are requesting the correct drive code and filename before you recompile the source code.
**line no. can't open filename	Either the drive code or the filename for the file indicated by the variable "filename" is incorrect. Ensure that you are requesting the correct drive code and filename before you recompile the source code:
**line no, divide by zero	You attempted to divide by zero in the line indicated. Correct the source code before you recompile it.
**line no, expression too complex	An expression on the line indicated is too complex for C168. Simplify the expression before you recompile the source code.

Table D-2. C168 Fatal Diagnostic Errors

Message	Meaning
**line no. modulus by zero	The second operand of the percent operator in the line indicated is zero. Correct the source code before you recompile it.
**line no. structure operation not implemented	The operation you attempted with a structure in the line indicated is illegal. Correct the source code before you recompile it.
**line no. usage: c188 icode asm [-DLmec]	The command line syntax is incorrect. The correct command line syntax is given in the error message. Correct the syntax before you reenter the command line.

D.2.2 Internal Logic Errors

The following messages indicate fatal errors in the internal logic of C168:

```

**line no. cdsiz: invalid type
**line no. code skeleton error: op
**line no. hard long to register
**line no. intermediate code error
**line no, invalid initialization
**line no. invalid operator op
**line no, invalid register expression
**line no. invalid storage class sc
**line no. no code table for op
**line no, skelmatch type: stype

```

If you receive one of these messages, contact the place where you purchased your system for assistance. Provide the following information:

- o Indicate the version of the operating system you are using.
- o Describe your system's hardware configuration.
- o Provide sufficient information to reproduce the error. Indicate which program was running at the time the error occurred. If possible, also provide a disk with a copy of the program.

D.3 CP68 Error Messages

The CP/M-68K C Preprocessor, CP68, returns two types of fatal error messages: diagnostic error messages and messages indicating errors in the internal logic of CP68. Both types of error messages take the general form:

```
# line no. error message text
```

The pound sign (#) indicates that the error message comes from CP68. The "error message text" describes the error.

D.3.1 Diagnostic Error Messages

A fatal diagnostic error message prevents CP68 from processing your file. The CP68 diagnostic error messages are listed in Table D-3 with explanations and suggested user responses.

Table D-3 . CP68 Diagnostic Error Messages

Message	Meaning
---------	---------

```
#line no. argument buffer overflow
```

An argument list in the line indicated contains too many characters for the space allocated to the argument buffer. Reduce the number of characters in the argument list before rerunning CP68.

```
#line no. bad argument: arg
```

In the line indicated, the argument represented by the variable "arg" contains an invalid character. Replace or eliminate the invalid character before rerunning CP68.

Table D-3 (continued)

Message	Meaning
#line no. bad character octal no.	<p>The line indicated contains an illegal character. The ASCII code of the invalid character is represented by the variable "octal no", Examine the line indicated to locate the error. Replace the character before rerunning CP68.</p>
#line no. bad define name: name	<p>The name indicated by the variable n a me contains one or more invalid characters. Examine the name to locate the error. Replace the invalid characters before rerunning CP68.</p>
#line no. bad include file	<p>The syntax of the "#include" statement is incorrect. The "#include" statement must follow one of the following two formats:</p> <pre>#include <filename> #include "filename"</pre> <p>Rewrite the statement before rerunning CP68.</p>
#line no. bad include file name	<p>In the line indicated, the filename in the "#include" statement contains either an invalid character or more than 8 characters, the maximum allowed. Supply a valid filename before rerunning CP68.</p>
#line no. can't open file	<p>The "#include" statement in the line indicated contains an invalid or nonexistent filename. Check the filename before rerunning CP68.</p>
#line no. can't open infile	<p>CP68 cannot open the input file indicated by the variable "infile". Either the drive code or the filename is incorrect. Check the drive code and the filename before rerunning CP68.</p>

Table D-3 (continued)

Message	Meaning
#line no. can't open outfile	<p>CP68 cannot open the output file indicated by the variable "outfile". Either the drive code is incorrect, or the disk to which CP68 is writing is full. Check the drive code. If it is correct, the file is full. Erase unnecessary files, if any, or insert a new</p>
#line no. condition stack overflow	<p>The source code contains too many nested #if's for the space allocated to the condition stack. The stack overflowed before the line indicated. Rewrite the source code before rerunning CP68.</p>
#line no. define recursion	<p>A name or variable on the line indicated has been defined in terms of itself. Redefine the name before rerunning CP68.</p>
#line no. define table overflow	<p>The source code contains one or a combination of the following: too many names, too many long names, too many expressions, or too many large expressions. The space allocated to the define table was filled before the line indicated. Simplify and rewrite the source code before rerunning CP68.</p>
#line no. expression operator stack overflow	<p>An expression in the line indicated contains too many terms for the space allocated to the expression operator stack. Eliminate or consolidate some operations before rerunning CP68.</p>
*line no. expression stack overflow	<p>An expression in the line indicated contains too many terms for the space allocated to the expression stack. Eliminate or consolidate some terms before rerunning CP68.</p>
*line no. expression syntax	<p>The syntax of an expression in the line indicated is incorrect. Examine the line to locate the error. Correct the syntax before rerunning CP68.</p>

Table D-3 (continued)

Message	Meaning
*line no. includes nested too deeply	<p>The "#include" statement in the line indicated contains more than 7 nested include files, the maximum allowed. Rewrite the source code so that no one "#include" statement contains more than 7 nested include files.</p>
#line no. invalid #else	<p>A "#else" statement occurs in the source code without a preceding "#if" statement. Supply the missing "#if" statement or eliminate the "#else" statement before rerunning CP68.</p>
#line no. invalid #endif	<p>A "#endif" statement occurs in the source code without a preceding "#if" statement. Supply the missing "#if" statement or eliminate the "#endif" statement before rerunning CP68.</p>
#line no. invalid preprocessor command	<p>The command in the line indicated is either not valid for CP68 or is incorrectly formatted. Correct the command before rerunning CP68.</p>
#line no. line overflow	<p>The line indicated contains more than 255 characters, the maximum allowed. Reduce the line to no more than 255 characters before rerunning CP68.</p>
#line no. macro argument too long	<p>An argument name in the line indicated contains more than 8 characters, the maximum allowed. Use no more than 8 characters for the argument name, and rerun CP68.</p>
#line no. no */ before EOF	<p>A comment in the source code is missing the closing */. Supply the missing */ before rerunning CP68.</p>

Table D-3 (continued)

Message	Meaning
#line no. string cannot cross line	<p>A string in the line indicated is missing a closing quotation mark. Supply the missing quotation mark before rerunning CP68.</p>
#line no. string too long	<p>The line indicated contains a string greater than 255 characters, the maximum allowed. Shorten the string to no more than 255 characters before rerunning CP68.</p>
#line no. symbol table overflow	<p>The source code uses too many symbols for the space allocated to the symbol table. The symbol table was filled prior to the line indicated. Eliminate some symbols before rerunning CP68.</p>
#line no. too many arguments	<p>One of the names in the line indicated contains more than 9 arguments, the maximum allowed. Reduce the number of arguments to no more than 9 per name before rerunning CP68.</p>
#line no. unexpected EOF	<p>This message indicates an incomplete program. Examine the source code to locate the error. Correct before rerunning CP68.</p>
#line no. unmatched conditional	<p>A "#if" statement occurs in the source code without a matching "#endif" statement. Supply the missing "#endif" statement before rerunning CP68.</p>
#line no. usage: c68 [-ix:] inputfile outputfile	<p>This message indicates incorrect syntax in the command line. The correct syntax is given. Correct the command line before rerunning CP68. Refer to your C manual for an explanation of the command line syntax.</p>

D.3.2 Internal Logic Errors

CP68 returns only one message indicating an error in the internal logic of CP68:

```
#line no. too many characters pushed back
```

If you receive this message, contact the place where you purchased your system for assistance. Provide the following information:

- o Indicate the version of the operating system you are using.
- o Describe your system's hardware configuration.
- o Provide sufficient information to reproduce the error. Indicate which program was running at the time the error occurred. If possible, also provide a disk with a copy of the program.

D.4 C-Run-time Library Error Messages

The C-Run-time Library returns only one fatal error message, stack overflow. The stack overflow message means the program you are trying to include in the C-Run-time Library is too big. Reduce the size of the program.

End of Appendix D

Index

^, 2-42
%, 2-34, 2-42
*, 2-34, 2-41
, 2-34

A

A.68K, 1-1
abort function, 2-3
abs function, 2-4
absolute load module, B-4
access function, 2-5
addition, 3-5
address variables, B-2
addressing error trap, 2-44
alignment, 2-22
AND, 3-5
alphanumeric characters, 2-22
argc /argv interface, 1-5
argument,
 absolute value of, 2-4
 pointer, 2-42
 same length, 1-4
 with side effects, 2-4,2-13,2-22,5-35
arithmetic comparison, 3-5
arithmetic trap, 2-44
AS68, B-i, B-2
ASCII character, 2-34, 2-41
ASCII files, 1-6, 2-18
 in CP/M-68K, 1-6
ASCII string,
 converting to integer or binary, 2-6
 null-terminated, 2-34

assembler,
 initialization file, B-3
 temp files, B-3
assembly-language source file, B-2
atoi function, 2-6
atol function, 2-6
automatic variables, 1-1

B

binary and ASCII files,
 distinguishing, 1-6
binary,
 files, 1-6, 2-18
 I/O, 3-2
binary numbers, converting to decimal
 ASCII, 2-34
bit flags, 3-6
black boxes, 3-1
blank padding, 2-34, 2-41
block size, changing, 2-8
blocks, releasing, 2-8
bogus address, freeing, 2-8
BOOLEAN condition, 3-3
boundaries, 128-byte, 2-40, 2-54
brackets, 2-42, 3-8
break location, 2-14
brk function, 1-2, 2-7
BSS, 1-1, 2-14, 3-6
buffer flushing, 2-15
BUSERR, 2-44
BYTE, 3-4
byte order, 2-22, 2-35
byte stream, transferring, 2-20

C

- c character, 2-42
- C Co-generator, D-1
- C language,
 - functions implemented in, 2-2
 - portability, 3-1
 - program memory layout, 1-1
 - program compiling, 1-1
- c operator, 2-34, 2-42
- C Parser, D-1
- C Preprocessor, D-1
- c.sub, 1-1, B-3
- C1 68, B-i, D-1
- calling conventions, 1-2
- calloc function, 2-8
- carriage return, 2-12
- carriage return line-feed, 1-6
- character, 8-bit, 2-35
- character class, 2-12
- character string, 2-42
- characters, locating in strings, 2-27
- CHK instruction, 2-44
- chmod function, 2-9
- chown function, 2-9
- clib, B-2
- clink.sub, 1-1, B-3
- close function, 2-10
- closing streamfiles, 2-16
- C068, B-i, D-1
- coding conventions,
 - mandatory, 3-2
 - suggested, 3-8
- code generator, B-i, B-2
- command line interface, 1-5
- commas, 3-5
- comments in a module, 3-7
- comparing two elements, 2-38
- compilation, speeding, B-4
- compiler, B-i, B-2, B-3, B-4
- compiler-generated code, 1-5
- compiling a C program, 1-1
- completion code, 2-15
- compound statement, 3-8
- CON:, 1-5, 2-28, 2-51
- concatenating strings, 2-46
- console device, 2-21, 2-28
- contiguous digits, 2-6
- control characters, 2-12
- control string format, 2-41
- controlling statement, 3-8
- conversion character, 2-41
- conversion code, capitalized, 2-34
- conversion operators, 2-33
 - optional instructions in, 2-34
- conversion specifications, 2-41
- copying strings, 2-48
- CP68, B-i
- CP/M-68K C compiler, D-1
- CP/M-68K C Run-time Library, D-1
- creat function, 2-10, 2-11, 2-18, 2-40
- creata function, 2-11
- creatb function, 2-11
- CTRL-Z, 1-6
- ctype function, 2-12
- <ctype.h> file, 2-12

D

- D flag, B-2
- d character, 2-42
- d operator, 2-34
- data,
 - conversion, 2-2
 - region, 2-14
 - structures, 3-1
- DDT-68K, 2-3
- decimal ASCII, 2-34
 - integer conversion, 2-42
- DEFAULT, 3-4
- default drive, B-3
- # define statement, 3-3, B-I
 - module-specific, 3-7
- deleting a file, 2-53
- destination string, 2-48
- /dev/lp, 1-5
- device access, terminating, 2-10
- device I/O, 1-5
- digit string, 2-34
- disk space, conserving, B-i, B-3
- disks, swapping, B-3
- do, 3-8
- documenting code, 3-8
- drive changing, B-3
- dynamic memory allocation, 2-1
- dynamic memory areas,
 - heap, 1-2
 - stack, 1-2

E

- EACCES, A-1
- EBADF, A-1

- edata location, 1-2, 2-14
- editor, B-3
- EFBIG, A-2
- EINVAL, A-2
- EIO, A-1
- else, 3-8
- end, 1-2
- end location, 2-14
- end-of-file, 2-17
- errors, 2-23
- ENFILE, A-2
- ENODSPC, A-2
- ENOENT, A-1
- ENOMEN, A-1
- ENOSPC, A-2
- NOTTY, A-2
- entry points, 2-2
- EROFS, A-2
- errno external variable, 2-32, A-i
- error,
 - in specified stream, 2-17
 - system-dependent, 2-3
- error file, 2-32
- error messages, numbers, 2-32, A-i
- error return, from getchar, 2-22
- etext location, 1-2, 2-14
- exception condition, 68000, 2-44
- executable file, B-2
- exit function, 2-15
- extended character sets, 3-6
- EXTERN, 3-4
- external,
 - names, 1-4
 - reference, B-2
 - variable, 2-32

F

- F option, B-2
- fcgetc function, 2-22
- fclose function, 2-10, 2-16
- feof function, 2-17
- ferror function, 2-17, 2-36
- fflush function, 2-16
- fgets function, 2-20
- field width, 2-34
- file access,
 - terminating, 2-10
 - legal, 2-5
- file data, reading, 2-40
- file descriptor, 2-51
- file I/O, 1-5
- file pointer, 2-40
- file size, reducing, B-3
- file statements, 3-7
- file streams, manipulating, 2-17
- file.0, B-2
- file.C, B-i
- file.I, B-I
- file.IC, B-i
- file.S, B-2
- file.ST, B-1.
- filename, temporary, 2-30
- files, changing protection and ID, 2-9
- floating-point,
 - conversion, 2-34
 - routines, 2-2
- flushing stream files, 2-16
- fopen function, 2-18
- fopena function, 2-18
- fopenb function, 2-18
- for, 3-8
- form feed, 2-12
- formatting data, 2-33
- fprintf function, 2-33
- fputc function, 2-35

- fputs function, 2-37
- frame pointer, 1-2
- fread function, 2-20
- free function, 1-2, 2-8
- freopa function, 2-18
- freopb function, 2-18
- freopen function, 2-18
- fscanf function, 2-41
- fseek function, 2-21, 2-52
- ftell function, 2-21
- fwrite functions, 2-20

G

- getc function, 2-22, 2-52
- getchar function, 2-22
- getl function, 2-22
- getpass function, 2-24
- getpid function, 2-25
- gets function, 2-26
- getw function, 2-22
- GLOBAL, 3-4
- global data areas, 3-1
- global variable, 3-3

H

- header file, 3-2
- heap management, 1-2
- heap space, allocating, 2-8
- heap extending, 2-7
- hex constant, 3-2
- hexadecimal ASCII, 2-34
 - integer conversion, 2-42
- high bytes, reversing with low bytes,
 - 2-50

I

- I flag, B-i
- #include, B-1
- #include "file.h", 3-2
- I/O,
 - redirection, 1-7
 - stream, 2-18
 - device, 1-5
 - file, 1-5
 - single-byte, 1-5
- if, 3-8
- illegal instruction trap, 2-44
- include files, nesting, 3-2
- indentation technique, 3-8
- index function, 2-27
- initialization file, B-2
- initialized data, 1-1, 3-6
- input, 1-6
 - format, 2-41
 - stream, 2-52
- instruction trap, 2-3
- int,
 - random number seed, 2-39
 - variable length, 3-2
- intermediate code file, B-1
- intermodule communication,
 - using procedure calls, 3-1
- isalnum(c), 2-12
- isalpha(c), 2-12
- isascii(c), 2-12
- isatty function, 2-28
- isctrll(c), 2-12
- isdigit(c), 2-12
- islower(c), 2-12
- isprint(c), 2-12
- ispunct(c), 2-12
- isspace(c), 2-12
- isupper(c), 2-12

J

- JSR instruction, 1-2

L

- L character, 2-34
- L flag, B-2
- L option, B-2
- language library, compatibility with
 - UNIX V7, 2-1
- leading sign, 2-6
- leading spaces, 2-6
- line A trap, 2-44
- line F trap, 2-44
- line-feed, 1-6, 2-12, 2-41
- linkage editor, 1-2, B-2
- linker, B-i, B-2, B-3, B-4
- linker, invoking, 1-1
- listing device, 2-21
- literal matches, 2-42
- L068, B-1, B-2
- load modules, B-3
- load time, reducing, B-3
- LOCAL, 3-4, 3-7
- local variable names, 3-3
- logical, 3-5
- LONG, 3-4
- long, 32-bit, 2-22, 2-34
- long masking constant, 3-5
- longimp function, 2-43
- low bytes, reversing with high bytes,
 - 2-50
- lower-case, 2-2, 3-2, 3-3
- lseek function, 2-29
- LST:, 1-5

M

- macro, 2-4, 2-13, 2-22, 2-35
- macro definitions, 3-2
- maintenance costs, 3-1
- maintenance documentation, 3-8
- malloc function, 1-2, 2-8
- mandatory coding conventions, 3-2
- margin, 3-8
- masking, 3-5
- memory allocation, 2-15
- memory layouts of C programs, 1-1
- minus sign, 2-34
- mktemp function, 2-30
- MLOCAL, 3-4
- modular programs, 3-1
- module,
 - layout, 3-7
 - size, 3-1
- module-specific #define statements, 3-7
- movem. 1 instruction, 1-4
- multibyte binary variables, 3-2
- multicharacter constants, 3-5

N

- nesting level, 3-8
- newline, 2-41
 - character, 2-26, 2-37
 - incompatibility, 2-37
- NO-OPS, 2-9
- nonlocal GOTO, 2-43
- null statement, 3-8
- null-terminated string, 2-34, 2-37
- concatenating, 2-46

O

- 0 character, 2-42
- 0 operator, 2-34
- O file.68K, B-2
- object code, reducing size, 2-22
- octal,
 - ASCII, 2-34, 2-42
 - constant, 3-2
- open function, 2-10, 2-18, 2-31, 2-40
- open stream, 2-17, 2-41
- opena function, 2-31
- openb function, 2-31
- opening files, 2-31
- operations, 3-5
- OR, 3-5
- output, 1-6
 - file, B-1
 - left-adjusted, 2-34
 - right-adjusted, 2-34
- overflow, detection and reporting, 2-6

P

- padding, blank or zero, 2-34
- parentheses, 3-2, 3-4
- parser, B-1
- password, 2-24
- PDP-11, 2-50
- percent sign, %, 2-33
- peripheral devices, 1-5
- perror function, 2-32, A-i
- pointer arithmetic, 3-5
- portability, 3-1 to 3-7
- precision field, 2-34

- precision string, 2-34
- preprocessor, B-1
- primary memory, 2-20
- printf function, 2-33, 3-2, 3-5
- privilege violation, 2-44
- procedure definitions, 3-7
- procedure header, 3-7
- process ID, false, 2-25
- punctuation characters, 2-12
- pushed-back characters, 2-52
- putc function, 2-35
- putchar function, 2-35
- putl function, 2-35
- puts function, 2-37
- putw function, 2-35

Q

- quick sort routine, 2-38

R

- R option, B-2
- rand function, 2-39
- random number generator, 2-39
- random numbers, retrieving, 2-39
- read errors, 2-23
- read function, 2-22, 2-40
- read pointer, 2-21
- readability, improving, 3-8
- realloc function, 2-8
- references, global, 3-7
- REG, 3-4
- registers, scratch, 1-4
- regular files, 1-6
- reloc utility, B-3
- relocatable files, B-2

- rewind function, 2-21
- rindex function, 2-27
- ROM, 3-6
- run-time start-up routine, B-2

S

- s character, 2-42
- s operator, 2-34
- S option, B-2
- S switch, B-4
- sample C module, C-i
- sbrk function, 1-2, 2-7, 2-14
- scanf function, 2-41
- screen editing, 3-8
- seed, 2-39
- setjmp function, 2-43
- sign-extending characters, 3-2
- signal function, 2-44
- single-byte I/O, 1-5
- single-density disk system, B-3
- source file, B-1
- space, 2-12
 - allocation for array, 2-8
- sprintf function, 2-33
- srand function, 2-39
- sscanf function, 2-41
- stack frame, 1-4
- stack use, 1-2
- stack-popping code, 1-4
- standard error file, 1-6
- standard type definitions, 3-3
- start-up file, B-2
- static data, 2-24
- static variables, 3-6
- stderr, 1-6
- stdin, 1-6
- <stdio.h> file, 1-6, 2-4, 2-22, 2-35
- stdout, 1-6

- storage class, 3-7
 - definitions, 3-3
- strcat function, 2-46
- strcmp function, 2-47
- strcpy function, 2-48
- stream,
 - address, 2-16
 - buffer, 2-29
 - file, 2-21, 2-26
 - output file, 2-15
- string,
 - comparison, 2-47
 - length, 2-47
 - null-terminated, 2-24
 - variables, 3-5
- strlen function, 2-49
- strncat function, 2-46
- strncpy function, 2-48
- strncmp function, 2-47
- stylistic rules in C programs, 3-1
- submit files, B-3
- subroutine calls, 1-4
- subtraction, 3-5
- suppressed assignments, 2-41
- swab function, 2-50
- swapping binary data, 2-50
- symbolic constants, 3-2
- symbolic names, A-i
- system,
 - calls, 2-1
 - error, 2-32
 - include files, B-1
 - traps, 2-1
- system-wide file, 3-2

T

- T switch, B-4
- tab, 2-12, 2-41, 3-8
- tell function, 2-29

- temporary file, B-1
- terminal device, 2-51
- terminating current program, 2-3
- text, 3-6
- tilde, 2-12
- trace trap, 2-42
- trailing null, 2-37, 2-42
- transferring data, 2-54
- TRAPV instruction, 2-42
- ttyname function, 2-51
- type, 3-2
- type definitions, 3-3
- typedef, 3-3

U

- u operator, 2-34
- U option, B-2
- UBYTE, 3-4
- underline character, 1-4
- ungetc function, 2-52
- uninitialized data, 1-1, 3-6
- UNIX,
 - compatibility, 2-9, 2-32, 2-37, 2-44
 - versions 1 through 6, 2-29
 - version 7, A-2
 - with fopen, 2-19
 - with getpid, 2-25
 - with getchar, 2-23
- UNIX programs, with binary files,
 - 2-31
- unlink function, 2-53
- unsigned characters, 2-47
- unsigned int, 3-2
- upper bound of program, setting, 2-7
- upper-case, 2-2, 3-2, 3-3
- user control block, 1-5
- UWORD, 3-4 .

V

- variable, 3-7
- variable names,
 - global, 3-3
 - local, 3-3
 - lower-case, 3-3
- variable type, 3-7
- VAX, 2-50
- vectors, sorting, 2-38
- VOID, 3-4

W

- while, 3-8
- white space characters, 2-12
- WORD, 3-4
 - 16-bit, 2-35
 - 32-bit longword, 2-3
- write function, 2-35, 2-54
- write pointer, 2-21

X

- X characters, 2-30, 2-35, 2-42
- X operator, 2-34

Z

- zero divide, 2-44
- zero padding, 2-34