LINK-80 OPERATOR'S GUIDE

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APPENDIXES

I . LINK LINKAGE EDITOR.

LINK is a utility used to combine relocatable object modules into an absolute file ready for execution under CP/M or MP/M. The relocatable object modules may be of two types. The first has a filetype of REL, and is produced by PL/I-80, RMAC, or any other language translator that produces relocatable object modules in the Microsoft format. The second has a filetype of IRL, and is generated by the CP/M librarian LIB. An IRL file contains the same information as a REL file, but includes an index which allows faster linking of large libraries.

Upon completion, LINK lists the symbol table, any unresolved symbols, a memory map qnd the use factor at the console. The memory map shows the size and locations of the different segments, and the use factor indicates the amount of available memory used by LINK as a hexadecimal percentage. LINK writes the symbol table to a SYM file suitable for use with the CP/M Symbolic Instruction Debugger (SID), and creates a COM or PRL file for direct execution under CP/M or MP/M.

1.1. LINK Operation

LINK is invoked by typing

```
LINK filenamel{,filename2,...,filenameN}
```

where filenamel,...,filenameN are the names of the object modules to be linked. If no filetype is specified, REL is assumed. LINK will produce two files: filenamel.COM and filenamel.SYM. If some other filename is desired for the COM and SYM files, it may be specified in the command line as follows:

```
LINK newfilenaine=filenamel{,filename2,...,filenameN}
```

When linking PL/I programs, LINK will automatically search the r un- t im e library file PLILIB.IRL on the default disk and include any subroutines used by the PL/I programs.

A number of optional switches, provided for additional control of the link operation, are described in the following section.

During the link process, LINK may create up to eight temporary files on the default disk. The files are named:

```
XXABS.$$$    XXPROG.$$$    XXDATA.$$$    XXCOMM.$$$
YYABS.$$$    YYPROG.$$$    YYDATA.$$$    YYCOMM.$$$
```

These files are deleted if LINK terminates normally, but may remain on the disk if LINK aborts due to an error condition.

1.2. LINK Switches

LINK switches are used to control the execution parameters of LINK. They are enclosed in square brackets immediately following one or more of the filenames in the command line, and are separated by commas.

Example:

```
LINK TEST[L40001,IOMOD,TESTLIB[S,NL,GSTARTI
```

All switches except the S switch may appear after any filename in the command line. The S switch must follow the filename to which it refers.

1.2.1. The Additional Memory (A) Switch. The A switch is used to provide LINK with additional space for symbol table storage by decreasing the size of LINK's internal buffers. This switch should be used only when necessary, as indicated by a MEMORY OVERFLOW error, since using it causes the internal buffers to be stored on the disk, thus slowing down the linking process considerably.

1.2.2. The Data origin (D) Switch. The D switch is used to specify the origin of the data and common segments. If not used, LINK will put the data and common segments immediately after the program segment. The form of the D switch is Dnnnn, where nnnn is the desired data origin in hex.

1.2.3. The Go (G) Switch. The G switch is used to specify the label where program execution is to begin, if it does not begin with t'he first byte of the program segment. LINK will put a jump to the label at the load address. The form of the G switch is G<label>.

1.2.4. The Load Address (L) Switch. The load address defines the base address of the COM file generated by LINK. Normally, the load address is 100H, which is the base of the Transient Program Area in a standard CP/M system. The form of the L switch is Lnnnn, where nnnn is the desired load address in hex. The L switch also sets the program origin to nnnn, unless otherwise defined by the P switch.

Note that COM files created with a load address other than 100H will not execute properly under a standard CP/M system.

1.2.5. The Memory Size (M) Switch. The M switch may be used when creating PRL files for execution under MP/M to indicate that additional data space is required by the PRE, program for proper execution. The form of the M switch is Mnnnn, where nnnn is the amount of additional data space needed in hex.

1.2.6. The No List (NL) Switch. The NL switch is used to suppress the listing of the symbol table at the console.

1.2.7. The No Recording of Symbols (NR) Switch. The NR switch is used to suppress the recording of the symbol table file.

1.2.8. The Output COM File (OC) Switch. The OC switch directs LINK to produce a COM file. This is the default condition for LINK.

1.2.9. The Output PRL File (OP) Switch. The OP switch directs LINK to produce a page relocatable PRL file for execution under MP/M, rather than a COM file. See section 1.3 for more information on creating PRL files.

1.2.10. The Program Origin (P) Switch. The P switch is used to specify the origin of the program segment. If not used, LINK will put the program segment at the load address, which is 100H unless otherwise specified by the L switch. The form of the P switch is Pnnnn, where nnnn is the desired program origin in hex.

1.2.11. The '?' Symbol (Q) Switch. Symbols in the PL/I run-time library begin with a question mark to avoid conflict with user symbols. Normally LINK suppresses listing and recording of these symbols. The Q switch causes these symbols to be included in the symbol table listed at the console and recorded on the disk.

1.2.12. The Search (S) Switch. The S switch is used to indicate that the preceding file should be treated as a library. LINK will search the file and include only those modules containing symbols which are referenced but not defined in the modules already linked.

1.3. Creating MP/M PRL Files

Assembly language programs often contain references to symbols in the base page such as BOOT, BDOS, DFCB, and DBUFF. To run properly under CP/M (or as a COM file under MP/M) these symbols are simply defined in equates as follows:

```
BOOT    EQU     0       ;JUMP TO WARM BOOT
BDOS    EQU     5       ;JUMP TO BDOS ENTRY POINT
DFCB    EQU     5CH     ;DEFAULT FILE CONTROL BLOCK
DBUFF   EQU     80H     ;DEFAULT 1/0 BUFFER
```

With PRL files, however, the base page itself may be relocated at load time, so LINK must know that these symbols, while at fixed location s within the base page, are relocatable. To do this, simply declare these symbols as externals in the modules in which they are referenced:

```
EXTRN   BOOT, BDOS, DFCB, DBUFF
```

and link in another module in which they are declared as publics and defined in equates:

```
        PUBLIC  BOOT, BDOS, DFCB, DBUFF
BOOT    EQU     0       ;JUMP TO WARM BOOT
BDOS    EQU     5       ;JUMP TO BDOS ENTRY POINT
DFCB    EQU     5CH     ;DEFAULT FILE CONTROL BLOCK
DBUFF   EQU     80H     ;DEFAULT 1/0 BUFFER
        END
```

1.4. Sample Link

A sample link is shown on the following pages. First the sample program GRADE.PLI is compiled, and then a COM file is created by LINK. LINK automatically searches the PL/I run-time library PLILIB.IRL for the subroutines used by GRADE. The Q switch causes the symbols taken from PLILIB.IRL to be included in the symbol table listing (and the SYM file). The memory map following the symbol table indicates the length and location assigned to each of the segments. A use factor of 49 indicates that 49H%, or a little more than a quarter of the memory available to LINK was used.

PL/I-80 V1.0, COMPILATION OF: GRADE

D: Disk Print
L: List Source Program

NO ERROR(S) IN PASS 1
NO ERROR(S) IN PASS 2

PL/I-80 V1.0, COMPILATION OF: GRADE

```
 1  a  0000 average:
 2  a  0006         proc options (main);
 3  a  0006         /* grade averaging program
 4  a  0006
 5  c  0006         dcl
 6  c  000D                 sysin file,
 7  c  000D                 (grade,total,n) fixed;
 8  c  000D
 9  c  000D         on error (1)
10  c  0014                 /* conversion
11  d  0014                 begin;
12  e  0017                 put skip list('  Bad Value, TryAqain.'  );
13  e  0033                 get skip;
14  e  0044                 go to retry;
15  d  0047                 end;
16  d  0047
17  c  0047         on endfile (sysin)
18  d  004F                 begin;
19  e  0052                 if n -= 0 then
20  e  005B                         put skip list
21  e  008A                                 (Averaqe is'  ,total/n);
22  e  008A                 stop;
23  d  008D                 end;
24  d  008D
25  c  008D         put     skip list
26  c  00A9                 ('  Type a List of Grades, End with Ctl-Z'  );
27  c  00A9         total = 0;
28  c  00AF         n =     0;
29  c  00B9
30  c  0OB9         retry:
31  c  0069         put     skip;
32  c  00CA                 do while('l'  b);
33  c  00CA                 get list (grade);
34  c  00E2                 total = total + grade;
35  c  00ED                 n = n +
36  c  00F7                 end;
37  a  00F7         end     average;
```

CODE SIZE = 00F7
DATA AREA = 004C

```
B>link grade[q)
LINK VO.4

AVERAG    0100    /SYSIN/   1B77    ?START    1A08    ?ONCOP    18AE
?SYSPR    02C5    ?SKPOP    0430    ?SLCTS    1367    ?PNCOP    01FD
?QIOOP    1987    ?SYSIN    02C1    ?ID22N    13B3    ?QICOP    127E
?PNVOP    0221    ?STOPX    1B19    ?RECOV    1468    ?GNVOP    07D5
?QCIOP    11FB    /?FILAT/  1B9C    /?FPB/    1BA5    ?PNBOP    01F7
?PNCPR    04CF    ?IS22N    13F9    ?SIOOP    02CA    ?SIOPR    02E8
/?FPBST/ 1BD3     /SYSPRI/ 1BE6     ?OIOOP    05A7    ?FPBIO    0758
?OIOPR    05C6    ?BSL16    131C    ?SIGNA    1626    ?SKPPR    0439
?GNCPR    094F    ?WRBYT    OE36    ?PAGOP    07C7    ?NSTOP    1322
?SMVCM    1390    ?SJSVM    132D    ?SSCFS    137A    ?QB081    11E7
?OPNFI    0013    /?FMTS/   1COE    ?FPBOU    19DB    ?FPBIN    1993
?GNVPR    0812    ?RDBYT    OE23    ?RDBUF    OE5C    ?WRBUF    OE7F
?CLOSE    OF68    ?GETKY    OF99    ?SETKY    OFBF    ?PATH     OF4C
?BDOS     0005    ?DFCBO    005C    ?DFCB1    006C    ?DBUFF    0080
?ALLOP    14D2    ?FREOP    1568    ?ADDIO    1A64    ?SUBIO    1A7B
?WRCHR    19F1    ?RFSIZ    1OC4    ?RRFCB    1136    ?RWFCB    113B
?QB161    11EA    ?IN20     13F1    ?CNVER    1400    ?BSL08    1316
?SJSCM    132F    ?SJSTS    1341    ?SLVTS    1365    ?SMCCM    1394
?ID22     13CB    ?IN20N    13F1    ?ZEROD    1420    ?IS22     13F9
/?CONSP/ 1C16     ?OFCOP    14B2    ?RSBLK    1437    ?RECLS    1E79
?ERMSG    1B34    ?BEGIN    1E77    /?ONCOD/  1C37    ?SIGOP    1616
?STACK    1E71    ?ONCPC    194B    ?REVOP    1903    /?CNCOL/ 1C3A
?BOOT     0000    ?CMEM     1B77    ?DMEM     1E7B

ABSOLUTE      0000
CODE SIZE 1A77 (0100-lB76)
DATA SIZE 023F (lC3C-lE7A)
COMMON SIZE 0OC5 (lB77-lC3B)
USE FACTOR 49
```

```
A>b:qrade

Type a List of Grades, End with Ctl-Z
50,_75, 25
^Z

Average is          50
End of Execution

A>b:grade

Type a List of Grades, End with Ctl-Z
50
75
zot,66

Bad Value, Try Again.
25
^Z

Average is          50
End of Execution

A>b:grade

Type a List of Grades, End with Ctl-Z
^Z

End of Execution
```

1.5. Error Messages

CANNOT CLOSE: An output file cannot be closed. The diskette may be write protected.

COMMON ERROR: An undefined common block has been selected.

DIRECTORY FULL: There is no directory space for the output files or intermediate files.

DISK READ ERROR: A file cannot be read properly.

DISK WRITE ERROR: A file cannot be written properly, probably due to a full diskette.

FILE NAME ERROR: The form of a source file name is invalid.

FIRST COMMON NOT LARGEST: A subsequent COMMON declaration is larger than the first COMMON declaration for the indicated block. Check that the files being linked are in the proper order, or that the modules in a library are in the proper order.

INDEX ERROR: The index of an IRL file contains invalid information.

INSUFFICIENT MEMORY: There is not enough memory for LINK to allocate its buffers. Try using the A switch.

INVALID REL FILE: The file indicated contains an invalid bit pattern. Make sure that a REL or IRL file has been specified.

INVALID SYNTAX: The command line used to invoke LINK was not properly formed.

MAIN MODULE ERROR: A second main module was encountered.

MEMORY OVERFLOW: There is not enough memory to complete the link operation. Try using the A switch.

MULTIPLE DEFINITION: The specified symbol is defined in more than one of the modules being linked.

NO FILE: The indicated file cannot be found.

OVERLAPPING SEGMENTS: LINK attempted to write a segment into memory already used by another segment. Probably caused by incorrect use of P and/or D switches.

UNDEFINED START SYMBOL: The symbol specified with the G switch is not defined in any of the modules being linked.

UNDEFINED SYMBOLS: The symbols following this message are referenced but not defined in any of the modules being linked.

UNRECOGNIZED ITEM: An unfamiliar bit pattern has been scanned (and ignored) by LINK.

1.6. Format of REL Files

The information in a REL file is encoded in a bit stream, which is interpreted as follows:

1) If the first bit is a 0, then the next 8 bits are loaded according to the value of the location counter.

2) If the first bit is a 1, then the next 2 bits are interpreted as follows:

00 - special link item (see 3)

01 - program relative. The next 16 bits are loaded after being offset by the program segment origin.

10 - data relative. The next 16 bits are loaded after being offset by the data segment origin.

11 - common relative. The next 16 bits are loaded after being offset by the origin of the currently selected common block.

3) A special item consists of:

- A 4 bit control field which selects one of 16 special link items described below.
- An optional value field which consists of a 2 bit address type field and a 16 bit address field. The address type field is interpreted as follows:

  00 - absolute
  01 - program relative
  10 - data relative
  11 - common relative

- An optional name field which consists of a 3 bit name count followed by the name in 8 bit ASCII characters.

The following items are followed by a name field only.

0000 - entry symbol. The symbol indicated in the name field is defined in this module, so the module should be linked if the current file is being searched (as indicated by the S switch).

0001 - select common block. Instructs LINK to use the location counter associated with the common block indicated in the name field for subsequent common relative items.

0010 - program name. The name of the relocatable module. LINK checks that the first item in each module if a program name, and issues an error if it is not.

0011 - unused.

0100 - unused.

The following items are followed by a value field and a name field.

0101 - define common size. The value field determines the amount of memory to be reserved for the common block described in the name field. The first size allocated to a given block must be larger than or equal to any subsequent definitions for that block in other modules being linked.

0110 - chain external. The value field contains the head of a chain which ends with an absolute 0. Each element of the chain is to be replaced with the value of the external symbol described in the name field.

0111 - define entry point. The value of the symbol in the name field is defined by the value field.

1000 - unused.

The following items are followed by a value field only.

1001 - external plus offset. The following two bytes in the current segment must be offset by the value of the value field after all chains have been processed.

1010 - define data size. The value field contains number of bytes in the data segment of the current module.

1011 - set location counter. Set the location counter to the value determined by the value field.

1100 - chain address. The value field contains the head of a chain which ends with an absolute 0. Each element of the chain is to be replaced with the current value of the location counter.

1101 - define program size. The value field contains the number of bytes in the program segment of the current module.

1110 - end module. Defines the end of the current module. if the value field contains a value other than absolute 0, it is to be used as the start address for the program being linked. The next item in the file will start at the next byte boundary.

The following item has no value field or name field.

1111 - end file. Follows the end module item of the last module in the file.

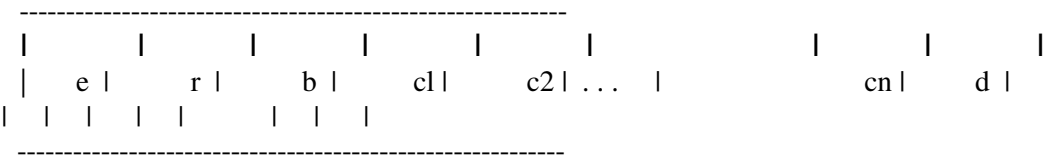
1.7. Format of IRL Files

An IRL file consists of three parts: a header, an index and a REL section.

The header contains 128 bytes defined as follows:

byte 0 - extent number of first record of REL section. byte I - record number of first record of REL section. bytes 2-127 - currently unused.

The index consists of a number of entries corresponding to the entry symbol items in the REL section. The entries are of the form:



where:

e = extent offset from start of REL section to start of module r = record offset from start of extent to start of module b = byte offset from start of record to start of module
cl-cn = name of symbol
d = end of symbol delimiter (OFEH)

The index is terminated by an entry in which cl = OFFH. The remainder of the record containing the terminating entry is unused.

The REL section contains the relocatable object code as described in the previous section.

2. RMAC RELOCATING MACRO ASSEMBLER.

The CP/M Relocating macro Assembler, called RMAC, is a modified version of the CP/M Macro Assembler (MAC). RMAC produces a relocatable object file (REL), rather than an absolute object file (HEX), which may be linked with other modules produced by RMAC, or other language translators such as PL/I-80, to produce an absolute file ready for execution.

The differences between RMAC and MAC are described in the following sections. For a complete description of the assembly language and macro facilities, see CP/M MAC Macro Assembler: Language Manual and Application Guide.

2.1. RMAC Operation

RMAC is invoked by typing

RMAC filename. fi1etype

followed by optional assembly parameters. If the filetype is not specified, ASM is assumed. RMAC produces three files: a list file (PRN), a symbol file (SYM), and a relocatable object file (REL). Characters entered in the source file in lower case appear in lower case in the list file, except for macro expansions.

The assembly parameter "H" in MAC, used to control the destination of the HEX file, has been replaced by "R", which controls the destination of the REL file. Directing the REL file to the console or printer (RX or RP) is not allowed, since the REL file does not contain ASCII characters.

Example:

RMAC TEST $PX SB RB

directs RMAC to assemble the file TEST.ASM, send the PRN file to the console, and put the symbol file (SYM) and the relocatable object file (REL) on drive B.

2.2. Expressions

The operand field of a statement may consist of a complex arithmetic expression (as described in the MAC manual, section 3) with the following restrictions:

1) In the expression A+B, if A evaluates to a relocatable value or

an external, then B must be a constant.

2) In the expression A-B, if A is an external, then B must be a constant.

3) In the expression A-B, if A evaluates to a relocatable value, then:

   a) B must be a constant, or

   b) B must be a relocatable value of the same relocation type as A (both must appear in a CSEG, DSEG, or in the same COMMON block).

4) In all other arithmetic and logical operations, both operands must be absolute.

An expression error (' E') will be generated if an expression does not follow the above restrictions.

2.3. Assembler Directives

The following assembler directives have been added to support relocation and linking of modules:

ASEG	use absolute location counter
CSEG	use code location counter
DSEG	use data location counter
COMMON	use common location counter
PUBLIC	symbol may be referenced in another module
EXTRN	symbol is defined in another module
NAME	name of module

The directives ASEG, CSEG, DSEG and COMMON allow program modules to be split into absolute, code, data and common segments, which may be rearranged in memory as needed at link time. The PUBLIC and EXTRN directives provide for symbolic references between program modules.

NOTE: While symbol names may be up to 16 characters, the first six characters of all symbols in PUBLIC, EXTRN and COMMON statements must be unique, since symbols are truncated to six characters in the object module.

2.3.1. The ASEG Directive. The ASEG statement takes the form

```
label    ASEG
```

and instructs the assembler to use the absolute location counter until otherwise directed. The physical memory locations of statements following an ASEG are determined at assembly time by the absolute location counter, which defaults to 0 and may be reset to another value by an ORG statement following the ASEG statement.

2.3.2. The CSEG' Directive. The CSEG statement takes the form

```
label    CSEG
```

and instructs the assembler to use the code location counter until otherwise directed. This is the default condition when RMAC begins an assembly. The physical memory locations of statements following a CSEG are determined at link time.

2.3.3. The DSEG Directive. The DSEG statement takes the form

```
label    DSEG
```

and instructs the assembler to use the data location counter until otherwise directed. The physical memory locations of statements following a DSEG are determined at link time.

2.3.4. The COMMON Directive. The COMMON statement takes the form

```
COMMON   /identifier/
```

and instructs the assembler to use the COMMON location counter until otherwise directed. The physical memory locations of statements following a COMMON statement are determined at link time.

2.3.5. The PUBLIC Directive. The PUBLIC statement takes the

form

PUBLIC label{,label, ...,label}

where each label is defined in the program. Labels appearing in a PUBLIC statement may be referred to by other programs which are linked using LINK-80.

2.3.6. The EXTRN Directive. The form of the EXTRN statement is

EXTRN label{,label, ...,label}

The labels appearing in an EXTRN statement may be referenced but must not be defined in the program being assembled. They refer to labels in other programs which have been declared PUBLIC.

2.3.7. The NAME Directive. The form of the NAME statement is

NAME ' text string'

The NAME statement is optional. It is used to specify the name of the relocatable object module produced by RMAC. If no NAME statement appears, the filename of the source file is used as the name of the object module.

3. LIB PROGRAM LIBRARIAN.

The function of LIB is to handle libraries, which are files consisting of any number of relocatable object modules. LIB can concatenate a group of REL files into a library, create an indexed library (IRL), select modules from a library, and print module names and PUBLICS from a library.

3.1. LIB Operation

LIB is invoked by typing

```
LIB filename=filenamel,...,filenameN
```

This command will create a library called filename.REL from the files filenamel.REL,...,filenameN.REL. If filetypes are omitted, REL is assumed .

A flename may be followed by a group of module names enclosed in parentheses. Only the modules indicated will be included in the LIB function being performed. If omitted, all modules in the file are included.

Example:

```
LIB TEST=A(Al,A2),B,C(Cl-C4,C6)
```

This command will create a file TEST.REL consisting of modules Al and A2 from A.REL, all the modules from B.REL, and the modules between Cl and C4, and C6 from C.REL.

Any of several optional switches may be included in the command line for LIB. These switches are enclosed in square brackets and appear after the first filename in the LIB command. The switches are:

I - create an indexed library (IRL)

M - print module names

P - print module names and PUBLICS

Examples:

```
LIB TEST=A,B,C
```

creates a file TEST.REL consisting of A.REL, B.REL and C.REL.

```
LIB TEST=TEST,D
```

appends D.REL to the end of TEST.REL.

LIB TEST(I]

creates an indexed library TEST.IRL from TEST.REL.

LIB TEST[I]=A,B,C,D

performs the same function as the preceding LIB examples, except no TEST.REL file is created.

LIB TEST(P]

lists all the module names and PUBLICS in TEST.REL.

3.2. Error Messages

CANNOT CLOSE: The output file cannot be closed. The diskette may be write protected.

DIRECTORY FULL: There is no directory space for the output file.

DISK READ ERROR: A file cannot be read properly.

DISK WRITE ERROR: A file cannot be written properly, probably due to a full diskette.

FILE NAME ERROR: The form of a source file name is invalid.

NO FILE: The indicated file cannot be found.

NO MODULE: The indicated module cannot be found.

SYNTAX ERROR: The command line used to invoke LIB was not properly formed.

4. DATA REPRESENTATION AND INTERFACE CONVENTIONS.

This section describes the layout of memory used by various Digital Research language processors so that the programmer can properly interface assembly language routines with high level language programs and the PL/I-80 runtime subroutine library. A set of standard subroutine interface conventions is also given so that programs produced by various programmers and language processors can be conveniently interfaced.

4.1. Representation of Data Elements.

The internal memory representation of data items is presented below.

4.1.1. Pointers, and Entry and Label Variables. Variables which provide access to memory addresses are stored as two contiguous bytes, with the low order byte stored first in memory. Pointer, Entry, and Label data items appear graphically as shown below:

where "LS" denotes the least significant half of the address, and "MS" denotes the most significant portion. Note that MS is the "page address," where each memory page is 256 bytes, and LS is the address within the page.

4.1.2. Fixed Binary Data Format. Simple single and double byte signed integer values are stored in Fixed Binary format. Two modes are used, depending upon the precision of the data item. Fixed Binary values with precision 1-7 are stored as single byte values, while data items with precision 8-15 are stored in a word (double byte) location. As with other 8080, 8085, and Z-80 items, the least significant byte of multi-byte storage appears first in memory. All Fixed Binary data is represented in two' s complement form, allowing single byte values in the range -128 to +127, and word values in the range -32768 to +32767. The values 0, 1, and -1 are shown graphically below, where each boxed value represents a byte of memory, with the low order byte appearing before the high order byte:

Fixed Binary(7)	Fixed Binary(15)
|01|	|01|00|

Fixed Binary(7)	Fixed Binary(15)
|FE|	|FE|FF|

4.1.3. Bit Data Representation. Bit String data, like the Fixed Binary items shown above, are represented in two forms, depending upon the declared precision. Bit Strings of length 1-8 are stored in a single byte, while Bit Strings of length 9-16 occupy a word (double byte) value. Bit values are left justified in the word, with "don' t care" bits to the right when the precision is not exactly 8 or 16 bits. The least significant byte of a word value is stored first in memory. The Bit String constant values ' 1' b, ' AO' b4, and ' 1234' b4 are stored shown below

Bit(8)	Bit(16)
|80|	|00|80|

Bit (8)	Bit (16)
|AO|	|00|AO|

Bit (8)	Bit (16)
N/A	|34|12|

4.1.4. Character Data Representation. Two forms of character data are stored in memory, depending upon the declaration. Fixed character strings, declared as CHAR(n) without the VARYING attribute, occupy n contiguous bytes of storage with the first string character stored lowest in memory. Character strings declared with the VARYING attribute are prefixed by the character string length, ranging from 0 to 254. The length of the area reserved for a CHAR(n) VARYING is n+l. Note that in either case, n cannot exceed 254. The string constant

'Walla Walla Wash'

is stored in a CHAR(20) fixed character strinq as

This same string is stored in a CHAR(20) VARYING data area as

where "10" is the (hexadecimal) string length, and "?" represents undefined character positions.

4.1.5.Fixed Decimal Data Representation. Decimal data items are stored in packedBCD form, using nine' s complement data representation. The leastsignificant BCD pair is stored first in memory, with one BCD digit position reserved for the sign. Positive numbers have a 0 sign, while negative numbers have a 9 in the high order sign digit position. The number of bytes occupied by adecimal number depends upon its declared precision. Given a decimal number with precision p, the number of bytes reserved is the integer part of

$$(P + 2) / 2$$

where p varies between 1 and 15, resulting in a minimum of 1 byte and a maximum of 8 bytes to hold a decimal data item. Given a decimal number field ofprecision 5, the numbers 12345 and -2 are represented as shown below

4.1.6. Floating Point Binary Representation. Floating Point Binary numbers are stored in four consecutive byte locations, no matter what the declared precision. The number is stored with a 24 bit mantissa, which appears first in memory, followed by an 3-bit exponent. Following data storage conventions, the least significant byte of the mantissa is stored first in memory. The floating point number is normalized so that the most significant bit of the mantissa is "l" for non-zero numbers. A zero mantissa is represented by an exponent byte of 00. Since the most significant bit ofthe mantissa must be "l" for non-zero values, this bit position is replaced by the mantissa sign. The binary exponent byte is biased by 80 (hexadecimal) so that 81 represents an exponent of 1 while 7F represents an exponent of -1. The Floating Point Binary value 1.5 has the representation shown below

Note that in this case, the mantissa takes the bit stream form

0100 0000 0000 0000 0000 0000

which indicates that the mantissa sign is positive. Setting the (assumed) high order bit to "l" produces the mantissa bit stream

1100 0000 0000 0000 0000 0000

Since the exponent 81 has a bias of 80, the binary exponent is 1, resulting in the binary value

1.100 0000 0000 0000 0000 0000

or, equivalently, 1.5 in a decimal base.

4.1.7. File Constant Representation. Each file constant in a PL/I-80 program occupies 32 contiguous bytes, followed by a variable length field of 0 to 14 additional bytes. The fields of a file constant are all implementation dependent and subject to change without notice.

4.2. Layout of Aggregate Storage.

PL/I-80 data items are contiguous in memory with no filler bytes. Bit data is always stored unaligned. Arrays are stored in row-major order, with the first subscript running slowest and the last subscript running fastest. The RMAC COMMON statement is used to share data with PL/I-80 programs which declare data using the EXTERNAL attribute. The following PL/I-80 program is used as an example:

```
declare
   a (10) bit(8) external,
   1 b external,
      2 c bit(8) ,
      2 d fixed binary(15),
      2 e (0:2,0:1) fixed;
```

The following RMAC COMMON areas share data areas with the program containing the declaration given above.

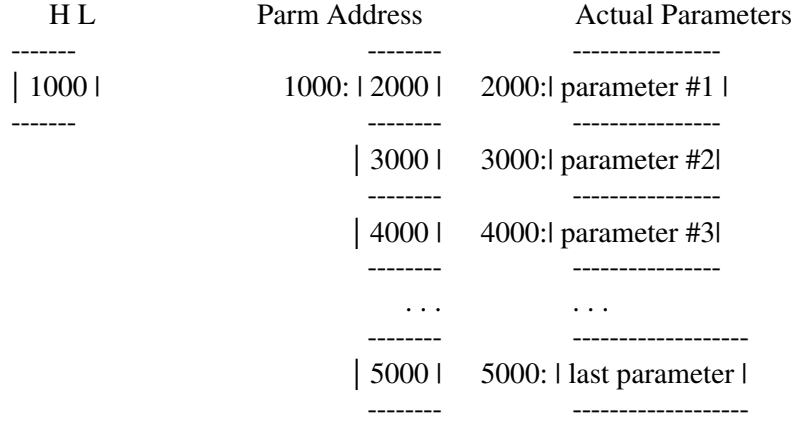
```
            common /a/
x:          ds          1

            common /b/
c:          ds          1
d:          ds          2
e00:        ds          2
eOl:        ds          2
elO:        ds          2
ell:        ds          2
e20:        ds          2
e2l:        ds          2
```

where the labels eOO, eOl, e2l correspond to the PL/I-80 subscripted variable locations e (0, 0), e(0, 1), . . . , e (2, 1) .

4.3. General Parameter Passing Conventions.

Communication between high-level and assembly language routines can be performed using the PL/I-80 general-purpose parameter passing mechanism described below. Specifically, upon entry to a PL/I-80 or assembly language routine, the HL register pair gives the address of a vector of pointer values which, in turn, lead the the actual parameter values. This situation is illustrated in the diagram below, where the address fields are assumed as shown for this example:



The number of parameters, and the parameter length and type is determined implicitly by agreement between the calling program and called subroutine.

Consider the following situation, for example. Suppose a PL/I-80 prog ram uses a considerable number of floating point divide operations, where each division is by a power of two. Suppose also that the loop where the divisions occur is speed-critical, and thus an assembly language subroutine will be used to perform the division. The assembly language routine will simply decrement the binary exponent for the floating point number for each power of two in the division, effectively performing the divide operations without the

overhead of unpacking, performing the general division operation, and repacking the result. During the division, however, the assembly language routine could produce underflow. Thus, the assembly language routine will have to signal the UNDERFLOW condition if this occurs.

The programs which perform this function are given on the following pages. The DTEST program, listed first, tests the division operation. The external entry DIV2 is the assembly language subroutine that performs the division, and is defined on line 4 with two parameters: a fixed(7) and a floating point binary value. The test value 100 is stored into "f" on each loop at line 9, and is passed to the DIV2 subroutine on line 10. Each time DIV2 is called, the value of f is changed to f/(2**i) and printed using a PUT statement. At the point of call, DIV2 receives a list of two addresses, corresponding to the two parameters i and f, used in the computation.

The assembly language subroutine, called DIV2, is listed next. Upon entry, the value of i is loaded to the accumulator, and the HL pair is set to point to the exponent field of the input floating point number. If the exponent is zero, DIV2 returns immediately since the resulting value is zero. Otherwise, the subroutine loops at the labe1 "dby2" while counting down the exponent as the power of two diminishes to zero. If the exponent reaches zero during this counting process, an UNDERFLOW signal is raised.

The call to "?signal" within DIV2 demonstrates the assembly language set-up for parameters which use the general-purpose interface. The ?signal subroutine is a part of the PL/I-80 subroutine library (PLILIB.IRL) . Th e HL register pair is set to the signal parameter list, denoted by "siqlst. " The signal parameter list, in turn, is a vector of four addresses which lead to the signal code "siqcode," the signal subcode "siqsub," the file name indicator "sigfil" (not used here), and the auxiliary message "siqaux" which is the last parameter. The auxiliary message is used to provide additional information to the operator when the error takes place . The signal subroutine prints the message until either the string length is exhausted (32, in this case) or a binary 00 is encountered in the string.

The (abbreviated) output from this test program is shown following the assembly language listing. Note that the loop counter i becomes negative when it reaches 128, but the processing within the DIV2 subroutine treats this value as an unsigned magnitude value, thus the underflow occurs when i reaches -123.

4.4. Returning Values from Functions.

As an alternative to returning values through the parameter list, as described in the previous section, subroutines can produce function values which are returned directly in the registers or on the

```
PL/I-80 V1.0, COMPILATION OF: DTEST

L: List Source Program

      NO ERROR(S) IN PASS I

      NO ERROR(S) IN PASS 2

PL/I-80 V1.0, COMPILATION of: DTEST

    1   a   0000 dtest:
    2   a   0006          proc options(main);
    3   c   0006          dcl
    4   c   0006                div2 entry(fixed(7),float),
    5   c   0006                i fixed(7),
    6   c   0006                f float;
    7   c   0006
    8   c   0006                do i = 0 by 1;
    9   c   000A                f = 100;
   10   c   0015                call div2(i,f);
   11   c   001B                put skip list('  100                2
   12   c   0063                end;
   13   a   0063          end   dtest;

CODE SIZE = 0063
DATA AREA = 0018
```

```
                                public  div2
                                extrn   ?signal
                        ;       entry:
                        ;               pl -> fixed(7) power of two
                        ;               p2 -> floating point number
                        ;       exit:
                        ;               pl -> (unchanged)
                        ;               p2 -> p2 / (2**pl)
                        div2:                           ;HL =.low(.pl)
0000 5E                         mov     e,m             ;low(.Pl)
0001 23                         inx     h               ;HL = hiqh(.pl)
0002 56                         mov     d,m             ;DE = pl
0003 23                         inx     h               ;HL = low(p2)
0004 1A                         ldax    d               ;a = pl (power of two)
0005 5E                         mov     e,m             ;low(.p2)
0006 23                         inx     h               ;HL =   high(.p2)
0007 56                         mov     d,m             ;DE =   p2
0008 EB                         xchg                    ;HL =   p2
                        ;
                       ;        A = power of 2, HL = low byte of fp num
0009    23                      inx     h               ;to middle of mantissa
000A    23                      inx     h               ;to high byte of mantissa
000B    23                      inx     h               ;to exponent byte
000C    34                      inr     m
000D    35                      dcr     m               ;p2 already zero?
000E    C8                      rz                      ;return if so
                        dby2:   ;divide by two
000F    B7                      ora     a               ;counted power of 2 to zero?
0010    C8                      rz                      ;return if so
0011    3D                      dcr     a               ;count power of two down
0012    35                      dcr     m               ;count exponent down
0013    C20F00                  jnz     dby2            ;loop again if no underflow

                        ;underflow occurred, signal underflow condition
0016 210000                     lxi     h,siqlst        ;signal parameter list
0019 CD0000                     call    ?signal         ;signal underflow
001C C9                         ret                     ;normally, no return

                                dseq
0000    0800            siglst: dw      siqcod          ;address    of  signal code
0002    0900                    dw      siqsub          ;address    of  subcode
0004    0A00                    dw      siqfil          ;address    of  file code
0006    0C00                    dw      sigaux          ;address    of  aux messaqe
                       ;    end of parameter vector, start of params
0008 03                 siqcod: db      3               ;03 = underflow
0009 80                 sigsub: db      128             ;arbitrary subcode for id
000A 0000               sigfil: dw      0000            ;no associated file name
000C 0E00               sigaux: dw      undmsq          ;0000 if no aux messaqe
000E 20556E6465undmsq: db               32,'Underflow in Divide by Two'  ,0
002A                            end
```

```
A> b:dtest

100   /   2                0  =    1.OOOOOOE+02
100   /   2                1  =    5.OOOOOOE+01
100   /   2                2  =    2.500000E+01
100   /   2                3  =    1.250000E+01
100   /   2                4  =    0.625000E+01
100   /   2                5  =    3. 125000E+00
100   /   2                6  =    1. 562500E+00
100   /   2                7  =    0.781250E+00
100   /   2                8  =    3.906250E-01
100   /   2                9  =    1.953125E-01
100   /   2               10  =    0.976562E-01
100   /   2               11  =    4 . 88281 2E-02
100   /   2               12  =    2.441406E-02
100   /   2               13  =    1.220703E-02
100   /   2               14  =    0.610351E-02
100   /   2               15  =    3.051757E-03
100   /   2               16  =    1.525878E-03
100   /   2               17  =    0.762939E-03
100   /   2               18  =    3. 814697E-04
100   /   2               19  =    1.907348E-04
100   /   2               20  =    0 .953674E-04
100   /   2               21  =    4.768371E-O'
100   /   2               22  =    2. 38 4185"          J
100   /   2               23  =    1.192" .,-~-30
100   /   2               24  =    0 ' -487E-31
100   /   2               25  =       0.540743E-31
100   /   2              26 =  0.770372E-31
100   /   2             111 =  3.851859E-32
100   /   2             112 =  1.925929E-32
100   /   2             113 =  0.962964E-32
100   /   2             114 =  4.814824E-33
100   /   2             115 =  2 . 407412E-33
100   /   2             116 =  1.203706E-33
100   /   2             117 =  0.601853E-33
100   /   2             118 =  3 . 009265E-34
100   /   2             119 =  1.504632E-34
100   /   2             120 =  0.752316E-34
100   /   2             121 =  3 . 761581 E-35
100   /   2             122 =  1.880790E-35
100   /   2             123 =  0.940395E-35
100   /   2             124 =  4.701977E-36
100   /   2             125 =  2.350988E-36
100   /   2             126 =  1.175494E-36
100   /   2             127 =  0.587747E-36
100   /   2            -128 =  2.938735E-37
100   /   2            -127 =  1.469367E-37
100   /   2            -126 =  0.734683E-37
100   /   2            -125 =  3.673419E-38
100   /   2            -124 =  1.836709E-38
100   /   2            -123 =  0.918354E-38
100   /   2            -122 =  4.591774E-39
UNDERFLOW (128), Underflow in Divide by Two
 Traceback: 017F 011B
 End of Execution
```

stack. This section shows the general-purpose conventions for returning data as functional values.

4.4.1. Returning Pointer, Entry, and Label Variables. Variables which provide access to memory addresses occupy a word value, as described in the previous section. In the case of Pointer, Entry, and Label Variables, the values are returned in the HL register pair. If a label variable is returned which can be the target of a GO TO operation, it is the responsibility of the subroutine containing the label -to restore the stack to the proper level when control reaches the label.

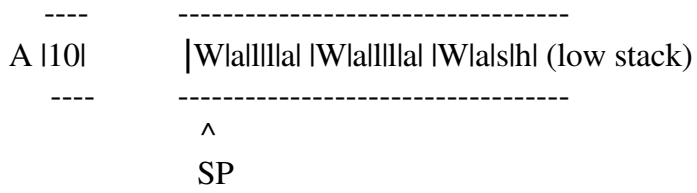
4.4.2. Returning Fixed Binary Data. Functions which return Fixed Binary data items do so by leaving the result in the A register " or HL register pair, depending upon the precision of the data item . Fixed Binary data with precision 1-7 are returned in A, while precision 8-15 items are returned in HL. It is always safe to return the value in HL, with the low order byte copied to the A register, so that register A is equal to register L upon return.

4.4.3. Returning Bit String Data. Similar to Fixed Binary data items, Bit String data is returned in the A register, or the HL register pair, depending upon the precision of the data item. Bit Strings of length 1-8 are returned in A, while precision 9-16 items are returned in the HL pair. Note that Bit Strings are left justified in their fields, so the BIT(l) value "true" is returned in the A register as 80 (hexadecimal). Again, it is safe to return a bit value in the HL register pair, with a copy of the high order byte in A, so that register A is equal to register H upon return.

4.4.4. Returning Character Data. Character data items are returned on the stack, with the length of the string in register A, regardless of whether the function has the VARYING attribute. The string

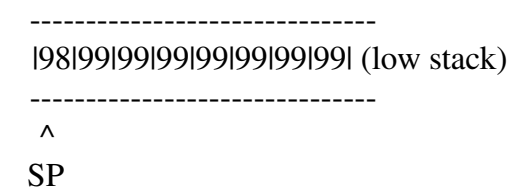
'Walla Walla Wash'

for example, is returned as shown in the diagram below:

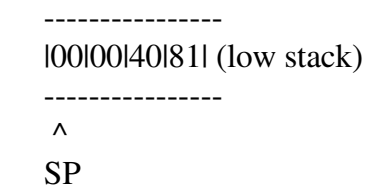


where register A contains the string length 10 (hexadecimal), and the Stack Pointer (SP) addresses the first character in the string.

4.4.5. Returning Fixed Decimal Data. Fixed Decimal data is always returned as a sixteen decimal digit value (8 contiguous bytes) in the stack. The low order decimal pair is stored lowest in memory (at the "top" of the stack), with the high order digit pair highest in memory. The number is represented in nine' s complement form, and sign-extended through the high order digit position, with a positive sign denoted by 0, and a negative sign denoted by 9. The decimal number -2, for example, is returned as shown below:



4.4.6. Returning Floating Point Numbers. Floating Point numbers are returned as a four-byte sequence at the top of the stack, regardless of the declared precision. The low order byte of the mantissa is at the top of the stack, followed by the middle byte, then the high byte. The fourth byte is the exponent of the number. The value 1.5 is returned as shown in the following diagram:



The sequence

```
POP D
POP B
```

loads the Floating Point value from the stack for manipulation, leaving the exponent in B, and the 24-bit mantissa in C, D, and E. The result can be placed back into the stack using

```
PUSH B
PUSH D
```

An example of returning a functional value is shown in the two program listings which follow. The first program, called FDTEST, is similar to the previous floating point divide test, but instead includes an entry definition for FDIV2 which is an assembly language subroutine that returns the result in the stack. The FDIV2 subroutine is then listed, which resembles the previous DIV2 program with some minor changes. First note that the input floating point value is loaded into the BCDE registers so that a temporary copy can be manipulated which does not affect the input value. The exponent field in register B is decremented by the input count, and returned on the stack before the PCHL is executed.

```
PL/I-80 V1.0, COMPILATION OF: FDTEST

L: List Source Program

     NO ERROR(S) IN PASS 1

     NO ERROR(S) IN PASS 2

PL/I-80 V1.0, COMPILATION OF: FDTEST

  1  a  0000 dtest:
  2  a  0006          proc options(main);
  3  c  0006          dcl
  4  c  0006                  fdiv2 entry(fixed(7)              ,float)
  5  c  0006                        returns (float),
  6  c  0006                  i fixed(7),
  7  c  0006                  f float;
  8  c  0006
  9  c  0006                  do i = 0 by 1;
 10  c  000A                  put skip list('  100 /            2 **',I,'=',
 11  c  0055                        fdiv2(i,100))
 12  c  0055                  end;
 13  a  0055          end     dtest;

CODE SIZE = 0055
DATA AREA = 0018
```

```
                                public      fdiv2
                                extrn       ?signal
                                entry:
                        ;                   pl -> fixed(7)    power of two
                        ;                   p2 -> floating point number
                        ;           exit:
                        ;                   pl -> (unchanged)
                        ;                   p2 -> (unchanged)
                        ;           stack:  p2 / (2 ** pl)
                        fdiv2:                                  ;HL = .low(.pl)
0000 5E                             mov     e,m                 ;low(.Pl)
0001 23                             inx     h                   ;HL = .high(.pl)
0002 56                             mov     d,m                 ;DE = .pl
0003 23                             inx     h                   ;HL = .low(p2)
0004 1A                             ldax    d                   ;a = pi (power of two)
0005 5E                             mov     e,m                 ;low(.p2)
0006 23                             inx     h                   ;HL = .hiqh(.p2)
0007 56                             mov     d,m                 ;DE = .P2
0008 EB                             xchg                        ;HL =  .p2

                        ;           A = power of 2, HL = low byte of fp num
0009    5E                          mov     e,m                 ;E = low mantissa
OOOA    23                          inx     h                   ;to middle of mantissa
OOOB    56                          mov     d,m                 ;D = middle mantissa
OOOC    23                          inx     h                   ;to high byte of mantissa
OOOD    4E                          mov     c,m                 ;C = high mantissa
OOOF    23                          inx     h                   ;to exponent byte
OOOF    46                          mov     b,m                 ;B = exponent
0010    04                          inr     b                   ;B = 00?
0011    05                          dcr     b                   ;becomes 00 if so
0012    CA2AOO                      jz      fdret               ;to return from float div
                        dby2:       ;divide by two
0015    B7                          ora     a                   ;counted power of 2 to zero?
0016    CA2AOO                      jz      fdret               ;return if so
0019    3D                          dcr     a                   ;count power of two down
001A    05                          dcr     b                   ;count exponent down
001B    C21500                      jnz     dby2                ;loop again if no underflow

                        ;underflow occurred, signal underflow condition
001E 210000                         lxi     h,siglst    ;signal parameter list
0021 CDOOOO                         call    ?signal     ;signal underflow
0024 010000                         lxi     b,0             ;clear to zero
0027 110000                         lxi     d,0             ;for default return
                        ;
002A El                 fdret:      POP     h               ;recall return address
002B C5                             push    b               ;save high order fp num
002C D5                             push    d               ;save low order fp num
002D E9                             pchl                    ;return to calling routine
                        ;
                                    dseg
0000 0800               siglst:     dw      sigcod          ;address of signal code
0002 0900                           dw      siqsub          ;address of subcode
0004 OAOO                           dw      sigfil          ;address of file code
0006 0C00                           dw      sigaux          ;address of aux message
                    ;           end of parameter vector, start of params
0008 03             siqcod: db              3               ;03 = underflow
0009 90             siqsub: db              128             ;arbitrary subcode for id
000A 0000           siqfil: dw              0000            ;no associated file name
000C 0E00           sigaux: dw              undmsg          ;0000 if no aux message
000E 20556E6465undmsg: db                   32,'  Underflow in Divide by Two'  ,O
002A                                end
```

5. PL/I-80 RUNTIME SUBROUTINES.

The PL/I-80 Runtime Subroutine Library (PLILIB.IRL) is discussed in this section, along with the optional subroutines for direct CP/M Input Output. The information given here is useful when PL/I-80 is used as a "systems language," rather than an application language, since direct access to implementation dependent CP/M functions is allowed. Note that the use of these features makes your program very machine and operating system dependent.

5.1. Stack and Dynamic Storage Subroutines.

A number of implementation-dependent functions are included in the PL/I-80 Runtime Library which provide access to stack and dynamic storage structures. The functions are discussed below, with sample programs which illustrate their use. The stack is placed above the code and data area, and below the dynamic storage area. The default value of the stack size is 512 bytes, but can be changed using the STACK(n) option in the OPTIONS portion of the main program procedure heading. In general, the PL/I-80 dynamic storage mechanism maintains a list of all unallocated storage. Upon each request for storage, a search is made to find the first memory segment which satisfies the request size. If no storage is found, the ERROR(7) condition is signaled (Free Space Exhausted) otherwise, the requested segment is taken from the free area, and the remaining portion goes back to the free ' space list. In version 1.0 of PL/I-80, storage is dynamically allocated only upon entry to RECURSIVE procedures, upon explicit or implicit OPENS for files which access the disk, or upon executing an ALLOCATE statement. In any case, an even number of bytes, or whole words, is always allocated, no matter what the request size.

5.1.1. The T0TWDS and MAXWDS Functions. It is often useful to find the amount of storage available at any given point in the execution of a particular program. The TOTWDS (Total Words) and MAXWDS (Max Words) functions can be used to obtain this information. The functions must be declared in the calling program as

```
dcl totwds returns(fixed(15));
dcl maxwds returns(fixed(15));
```

When invoked, the TOTWDS subroutine scans the free storage list and returns the total number of words (double bytes) available in the free list. The MAXWDS subroutine performs a similar function, but returns the size of the largest segment in the free list, again in words. A subsequent ALLOCATE statement which specifies a segment size not

exceeding MAXWDS will not cause the ERROR(7) signal to be raised, since at least that much storage is available. Note that since both TOTWDS and MAXWDS count in word units, the values can be held by FIXED BINARY(15) counters. If, during the scan of free memory, invalid link words are encountered (usually due to a out-of-bounds subscript or pointer store operation), both TOTWDS and MAXWDS return the value -1. Otherwise, the returned value will be a non-negative integer value.

5.1.2. The ALLWDS Subroutine. The PL/I-80 Runtime Library contains a subroutine, called ALLWDS, which is useful in controlling the dynamic allocation size. The subroutine must be declared in the calling program as

```
dcl allwds entry(fixed(15)) returns(ptr);
```

The ALLWDS subroutine allocates a segment of memory of the size given by the input parameter, in words (double bytes). if no segment is available, the ERROR(7) condition is raised. Further, the input value must be a non-negative integer value. The ALLWDS function returns a pointer to the allocated segment.

An example of the use of TOTWDS, MAXWDS, and ALLWDS functions is given in the ALLTST program on the next page. A sample program interaction is given following the program listing.

5.1.3. The STKSIZ Function. The function STKSIZ (Stack Size) returns the current stack size in bytes whenever it is called. This function is particularly useful for checking possible stack overflow conditions, or in determining the maximum stack depth during program testing. The STKSIZ function is declared in the calling program as

```
dcl stksiz returns(fixed(15));
```

A Sample use of the STKSIZ function appears in the listing of the recursive Ackermann test. In this case, it is used to check the maximum stack depth during the recursive function processing. An interaction with this program is given following the program listing.

PL/I-80 V1.0, COMPILATION OF: ALLTST

L: List Source Program

NO ERROR(S) IN PASS 1

NO ERROR(S) IN PASS 2

PL/I-80 V1.0, COMPILATION OF: ALLTST

```
 1  a  0000 alltst:
 2  a  0006          proc options(main);
 3  a  0006          /* assembly language interface to
 4  a  0006          dynamic storage allocation module
 5  c  0006          dcl
 6  c  0006                totwds returns(fixed(15)),
 7  c  0006                maxwds returns(fixed(15)) '
 8  c  0006                allwds entry(fixed(15)) returns(ptr);
 9  c  0006
10  c  0006          dcl
11  c  0006                allreq fixed(15),
12  c  0006                memptr ptr,
13  c  0006                meminx fixed(15),
14  c  0006                memory (0:0) bit(16) based(memptr);
15  c  0006
16  c  0006                do while('l'  b);
17  c  0006                put    edit (totwds(),'   Total Words Available'  ,
18  c  004F                       maxwds(),'   Maximum Segment Size'  ,
19  c  004F                       '  Allocation Size? ')
20  c  004F                       (2(skip,f (6) ,a), skip, a)
21  c  004F                get 1ist (a1 req) ;
22  c  0067                memptr = allwds(allreq);
23  c  0070                put edit('  Allocated'all,req,
24  c  00B2                      '   Words at un,spec(memptr))
25  c  00B2                       (skip,a,f(6),a,b4);
26  c  00B2
27  c  00B2                       /* clear memory as example
28  c  00B2                       do meminx = 0 to allreq-1 ;'
29  c  00CC                       memory(meminx) = 10000lb4;
30  c  00E7                       end;
31  c  00E7                end;
32  a  00E7          end alltst;
```

CODE SIZE = 00E7
DATA AREA = 0078

```
A>B:ALLTST

25596 Total Words Available 25596
Maximum Segment Size
Allocation Size? 0

Allocated          0 Words at 250A
  25594 Total Words Available
  25594 maximum Segment Size
Allocation Size? 100

Allocated        100 Words at 250E
  25492 Total Words Available
  25492 maximum Segment Size
Allocation Size? 25000

Allocated 25000 Words at 25DA
490 Total Words Available 490
Maximum Segment Size
Allocation Size? 490

Allocated        490 Words at E92E
        0 Total Words Available
        0 Maximum Segment Size
Allocation Size? 1

ERROR (7) , Free Space Exhausted
Traceback: 016D
End of Execution
```

PL/I-80 V1.0, COMPILATION OF: ACKTST

L: List Source Program

NO ERROR(S) IN PASS 1

NO ERROR(S) IN PASS 2

PL/I-80 V1.0, COMPILATION OF: ACKTST

```
 1  a  0000 ack:
 2  a  0006          procedure options(main,stack(2000));
 3  c  0006          dcl
 4  c  0006                  (m, n) fixed ,
 5  c  0006                  (maxm,maxn) fixed,
 6  c  0006                  ncalls decimal(6),
 7  c  0006                  (curstack, stacksize) fixed,
 8  c  0006                  stksiz entry returns(fixed);
 9  c  0006
10  c  0006          put skip list('Type max m,n: ');
11  c  0022          get list(maxm,maxn);
12  c  0046                  do m = 0 to maxm;
13  c  005F                          do n = 0 to maxn;
14  c  0078                          ncalls = 0;
15  c  0088                          curstack        = 0;
16  c  008E                          stacksize = 0;
17  c  0091                          put     edit
18  c  012F                                  ('Ack(',m,','  ,n,') =',ackermann(m,n),
19  c  012F                                  ncalls,' Calls,'  ,stacksize,'   Stack Bytes'  )
20  c  012F                                  (skip,a,2(f(2) ,a) ,f (6) ,f(7) ,a,f(4) ,a);
21  c  012F                          end;
22  c  012F                  end;
23  c  012F          stop;
24  c  0132
25  c  0132          ackermann:
26  c  0132                  procedure(m,n)          returns(fixed) recursive;
27  e  0132                  dcl
28  e  015C                          (m,n) fixed;
29  e  015C                  ncalls = ncalls + 1;
30  e  0177                  curstack = stksiz();
31  e  017D                  if curstack > stacksize then
32  e  018A                          stacksize       =   curstack;
33  e  0190                  if m = 0 then
34  e  0199                        return (n+l
35  e  OlAl                  if n = 0 then
36  e  01AA                          return(ackermann(m-1,1));
37  e  01BB                  return (ackermann(m-1 ,ackermann(m,n-1)
38  c  01DC                  end ackermann;
39  a  01DC          end ack;
```

CODE SIZE = 01DC
DATA AREA = 0082

```
A>B:ACKTST

Type max m,n: 6,6

Ack(  0,  0)=          1          1 Calls,          4 Stack Bytes
Ack(  0,  1)=          2          1 Calls,          4 Stack Bytes
Ack(  0,  2)=          3          1 Calls,          4 Stack Bytes
Ack(  0,  3)=          4          1 Calls,          4 Stack Bytes
Ack(  0,  4)=          5          1 Calls,          4 Stack Bytes
Ack(  0,  5)=          6          1 Calls,          4 Stack Bytes
Ack(  0,  6)=          7          1 Calls,          4 Stack Bytes
Ack(  1,  0)=          2          2 Calls,          6 Stack Bytes
Ack(  1,  1)=          3          4 Calls,          8 Stack Bytes
Ack(  1,  2)=          4          6 Calls,         10 Stack Bytes
Ack(  1,  3)=          5          8 Calls,         12 Stack Bytes
Ack(  1,  4)=          6         10 Calls,         14 Stack Bytes
Ack(  1,  5)=          7         12 Calls,         16 Stack Bytes
Ack(  1,  6)=          8         14 Calls,         18 Stack Bytes
Ack(  2,  0)=          3          5 Calls,         10 Stack Bytes
Ack(  2,  1)=          5         14 Calls,         14 Stack Bytes
Ack(  2,  2)=          7         27 Calls,         18 Stack Bytes
Ack(  2,  3)=          9         44 Calls,         22 Stack Bytes
Ack(  2,  4)=         11         65 Calls,         26 Stack Bytes
Ack(  2,  5)=         13         90 Calls,         30 Stack Bytes
Ack(  2,  6)=         15        119 Calls,         34 Stack Bytes
Ack(  3,  0)=          5         15 Calls,         16 Stack Bytes
Ack(  3,  1)=         13        106 Calls,         32 Stack Bytes
Ack(  3,  2)=         29        541 Calls,         64 Stack Bytes
Ack( 3, 3)=           61       2432 Calls,    128 Stack Bytes
Ack( 3, 4)=          125      10307 Calls,    256 Stack Bytes
Ack(  3, 5)=
```

5.2. PL/I-80 Runtime Subroutine Entry Points.

The standard PL/I-80 Runtime Library entry points are listed below. The entry point name is shown to the left, followed by the input value registers and the result registers. A short explanation is given on the right. Note that this list does not include the environmental or 1/0 operators since these entry points may vary from version to version. Further, the definitions shown below are for general information purposes only, and are subject to change without notice. The register names are given in capital letters, M(r) denotes memory addressed by the register pair r, and ST represents a stacked value.

name	parameters		result	comment or definition
im22n	DE	HL	HL	word*word integer multiply
id22n	DE	HL	HL	word/word integer divide
is22n	DE	HL	HL	word-word integer subtract
in20n	HL		HL	-word
f140m	HL		ST	fp load from M(HL) to stack
fx44s	ST	HL	M(HL)	fp xfer from stack to M(HL)
fx44m	DE	HL	M(HL)	fp xfer from M(HL) to M(DE)
fa44s	ST	ST	ST	fp add stack+stack to stack
fa44m	DE	HL	ST	fp add M(DE)+M(HL) to stack
fa441	ST	HL	ST	fp add stack+M(HL) to stack
fa44r	HL	ST	ST	fp add M(HL)+stack to stack
fs44s	ST	ST	ST	fp sub stack-stack to stack
fs44m	DE	HL	ST	fp sub M(DE)-M(HL) to stack
fs441	ST	HL	ST	fp sub stack-M(HL) to stack
fs44r	HL	ST	ST	fp sub M(HL)-stack to stack
fm44s	ST	ST	ST	fp mul stack*stack to stack
fm44m	DE	HL	ST	fp mul M(DE)*M(HL) to stack
fm441	ST	HL	ST	fp mul stack*M(HL) to stack
fm44r	HL	ST	ST	fp mul M(HL)*stack to stack
fd44s	ST	ST	ST	fp div stack/STack to stack
fd44m	DE	HL	ST	fp div M(DE)/M(HL) to stack
fd441	ST	HL	ST	fp div stack/M(HL) to stack
fd44r	HL	ST	ST	fp div M(HL)/STack to stack
fc44s	ST	ST	ST	fp comp stack:stack to stack
fc44m	DE	HL	ST	fp comp M(DE):M(HL) to stack
fc441	ST	HL	ST	fp comp stack:M(HL) to stack
fc44r	HL	ST	ST	fp comp M(HL):stack to stack
fn40s	ST		ST	fp negate stack
fn40m	HL		ST	fp load from M(HL) and negate
fe40s	ST		A	float p extract sign from stack
fe40m	HL		A	float p extract sign from memory
				1 => positive sign (non zero set)
				0 => zero result (zero flag set)
				-1 => negative sign (minus set)
fmodf	ST	ST	ST	floating point mod(x,y)
fabsf	ST		ST	floating point abs(x)
fmaxf	ST	ST	ST	floating point max(x,y)
fminf	ST	ST	ST	floating point min(x,y)

froun	ST	A	ST	floating point round(x,k)
ftrnc	ST		ST	floating point trunc(x)
fflor	ST		ST	floating point floor(x)
fceil	ST		ST	floating point ceil(x)
fexop	ST	A	ST	fp ** k (k pos constant)
ffxop	ST	ST	ST	x ** y (exp(y*log(x))
bcl2n	D	HL	HL	8/16 bit concatenate, where B=length of d, C=mask
bc22n	DE	HL	HL	16/16 bit concatenate, where B=length of d, C=mask
bs116	B	HL	HL	bit shift left 16, size in b
bsl08	A	B	A	bit shift left 8, size in b
bst08	A B C	HL	M(HL)	bit substring store bit(8) in A to bit(8) in memory at HL, B = index, C = length
bst16	B C DE HL		M(HL)	bit substring store bit(16) in DE to bit(16) in memory at HL
bix08	A B D H		A/HL	bit index, A=source, B=search D=len(source), E=len(search)
bix16	B C DE HL		A/HL	bit index, B=len(source), C=Ien(search), DE=source, HL=search
boolf	B DE HL		HL	bool(x,y,b), B = 4-bit mask x,y operands in DE and HL
iel2n	A		HL	sign extend A to HL
ielOn	A		A	inteqer extract sign (8-bit)
ie20n	HL		A	integer extract sign (16-bit)
imdop	DE	HL	HL	integer mod(x,y)
iab07	A		A	integer 7 abs(i)
iabl5	HL		HL	integer 15 abs(i)
imaxf	DE	HL	HL	integer max(x,y)
iminf	DE	HL	HL	integer min(x,y)
iroun	HL	A	HL	integer round(i,k)
iexop	HL	A	HL	integer ** k (k pos constant)
slvts	HL		A	string load varying to stack A=length of string on return
slcts	A	HL		string load char to stack A=Iength of char string
ssvfs	A	B	HL	string store varying from stack A=current len, B=max length
sscfs	A	B	HL	string store char from stack
smvvm	A	DE	HL	string move vary to vary in memory A=max target len, DE=source, HL=tarqet
smvcm	A	DE	HL	string move vary to char in memory A=target length
smcvm	A B	DE	HL	strinq move char to vary in memory A=max target len, B=source len
smccm	A B	DE	HL	A=target len, B=source len
sjsts	A	ST	ST'	string juxtapose (catenate) stack A=Iength of left, ST=chars of left ST' = pushed psw with length of right followed by chars of right
sjscm	A	B	HL	string juxtapose stack with char memory A=stacked len, B=char len, HL=.char

sjsvm	A			HL	string juxtapose stack with vary memory
savvm	A		B	HL	string append vary to vary in memory A=char len, B=max target length
sasvm	A		B	HL	string append stack to vary in memory A=stacked length, B=max target length
sacvm	A		B	HL	string append char to vary in memory A=char len, B=max target length
scccM	A	B	DE	HL	string compare char to char in memory A=len right, B=len left, DE = char left, HL = char right
sccvm		B	DE	HL	string compare char to vary in memory B=len left, DE=.char, HL=.vary
scvcm	A		DE	HL	string compare vary to char in memory A=len right char, DE=.vary, HL=.char
scvvm			DE	HL	string compare vary to vary in memory DE=.vary left, HL=.vary right
scscm	A	B		HL	string compare stack to char in memory A=len stk, B=len char, HL=.char
scsvm	A			HL	string compare stack to vary in memory A=len stk, HL=.vary
sccms	A	B		HL	string compare char in mem to stack A=len stk, B=len char, HL=.char
scvms	A			HL	string compare vary in mem to stack A=Ien stk, HL=.vary
scsts	A				string compare stack to stack A=len right element on stack, ST is stack right string, next is pushed psw with len left string, followed by left string, result: sign value & cond if 1 < r, zero value & cond if I = r, pos value & cond if 1 >= r, nzer value & cond if 1 > r.
cs2ad	A		E	HL	char substr(ex,ei) address A=lenqth, E=ei, HL=ex A=result length on return
cs3ad	A	C	E	HL	char substr(ex,ei,el) address C=el A=result length on return
vs2ad			E	HL	vary substr(ex,ei) address E=ei, HL=ex A=result length on return
vs3ad		C	E	HL	vary substr(ex,ei,el) address C=el A=result length on return
cxccm	A	B	DE	A/HL	str index char to char in memory A=len right, B=Ien left, DE = char left, HL = char right
cxcvm		B	DE	A/HL	str index char to vary in memory B=len left, DE=.char, HL=.vary
cxvcm	A		DE	A/HL	str index vary to char in memory A=.len right char, DE=.vary, HL=.char
cxvvm			DE	A/I~L	str index vary to vary in memory DE=.vary left, HL=.vary right

cxscm	A B	A/HL	str index stack to char in memory

				A=len stk, B=Ien char, HL=.char
cxsvm	A		A/HL	str index stack to vary in memory A=len stk, HL=.vary
cxcms	A B		A/HL	str index char in mem to stack A=len stk, B=len char, HL=.char
cxvms	A		A/HL	str index vary in mem to stack A=len stk, HL=.vary
cxsts	A			str index stack to stack A=len right element on stack, ST is stack right string, next is pushed psw with len left string, followed by left string, result: A/HL = 0 if right not found in left, otherwise index returned
verop	A	ST ST	A/A/HL	verify(s,c), A=len(c), st has chars(c) len(s) chars(s)
colop			A/ST	collateo, A=128, stack has
xl2op	A	ST ST	A/ST	translate(s,t), A=len(t), stack has chars(t) , s
xl3op	A	ST ST ST	A/ST	translate(s,t,x) A=len(x), stack has chars(x), t, s 0,1, ..., 127 (ascii chars)
d1dop	A	HL	ST	decimal load to stack, A = prec
dasop	A	ST	HL	decimal assign, stack to memory
dadop	ST	ST	ST	decimal add to stack
dsuop	ST	ST	ST	decimal subtract to stack
dngop	ST		ST	decimal negate to stack
dcmop	ST		A	decimal compare operator
dexop	ST	ST	ST	decimal exponentiate to stack
dmuop	ST	ST	ST	decimal multiply to stack
ddvop	ST	ST	ST	decimal divide to stack
dsiop	ST		A	decimal sign extract
dmodf	ST	ST	ST	decimal mod(x,y)
dabsf	ST		ST	decimal abs(x)
dmaxf	s,r	ST	ST	decimal max(x,y)
dminf	ST	ST	ST	decimal min(x,y)
droun	ST	A	ST	decimal round(x,k)
dtrnc	ST		ST	decimal trunc(x)
dflor	ST		ST	decimal floor(x)
dceil	ST		ST	decimal ceil(x)
dexop	ST	A	ST	decimal ** k (k pos constant)
qcdop	A B	ST	ST	convert character to decimal A string length, B = scale ST character string, returns ST decimal number
qddsl	A	ST	ST	decimal/decimal left shift A = shift count
qddsr	A	ST	ST	decimal/decimal right shift A = shift count
qicop	A		HL	convert integer to char in stack A=string size, HL=integer value
qvcop	A/ST		A/ST	convert varying to char

qi07d	A	ST	convert	fix(7) to decimal
qil5d	HL	ST	convert	fix(15) to decimal
qi07f	A	ST	convert	fix(7) to float

qil5f	HL		ST	convert fix(15) to float
qfi07	ST		A	convert float to fix(7)
qfil5	ST		HL	convert float to fix(15)
qfcss	A	ST	A/ST	convert float-char stack to stack A=target length, ST=fp number
qfcms	A	M(HL)	A/ST	convert float-char memory to stack
qb08c	A	B	ST	convert bit(8) in a, to string in stack, with precision b
qbl6c	HL	B	ST	convert bit(16) in HL to string
qb08i	A	B	HL	convert bit(8) in A to fixed with precision B in HL
qbl6i	HL	B	HL	convert bit(16) to fixed
qi07b	A	B	A	convert fix(<8) to bit(8) fixed precision in b
qil5b	HL	B	HL	convert fix(<16) to bit(16)
qdi07	ST		A	convert dec in stack to fix(7)
qdil5	ST		HL	convert dec in stack to fix(15)
qciop	A/ST		HL	convert char in stack to integer
qcfop	A/ST		ST	convert char in stack to float
qccop	A B	ST	A/ST	convert char to char on stack A=len(s), B=converted length return A=b, ST trunc or extend
nstop	BC DE	HL	M(HL)	non-computational store, move M(DE) to M(HL) for BC bytes
nc22n	DE	HL	A	double byte non-computational compare: zero flag set if DE = HL, non-zero otherwise
ncomp	BC DE	HL	M(HL)	non-computational compare, M(DE) - M(HL;) , set flags

5.3. Direct CP/M Function Calls.

Access to all CP/M version 1 and 2 functions, and equivalent MP/M calls, is accomplished through the optional subroutines included in PLIDIO.ASM, given in the listing of Appendix A, and included in source form on the PL/I-80 diskette.

The PLIDIO.ASM subroutines are not included as a part of the standard PLILIB.IRL file because specific applications may require various changes to the direct CP/M functions which either remove operations to decrease space, or alter the manner in which the interface to a specific function takes place. Note that if the interface to a function is changed, it is imperative that the name of the entry point is also changed to avoid confusion when the program is read by another programmer.

The relocatable file, PLIDIO.REL, is created by assembling the source program using RMAC:

```
rmac plidio $pz+s
```

(the $pz+s option avoids production of the listing and symbol files) . Given that a PL/I-80 program, such as DIOCOPY.PLI, is present on the disk, the DIOCOPY.REL file is produced by typing: pli diocopy

(a listing of the DIOCOPY program is given in Appendix C). These two programs are then linked with the PLILIB.IRL file by typing:

link diocopy,plidio

resulting in the file DIOCOPY.COM which is a program that directly executes under CP/M.

The file DIOMOD.DCL is a source file containing the standard PLIDIO entry point declarations so that they can be conveniently copied into the source program during compilation using the "include" statement

%include ‘x:diomod.dcl’;

where the optional "x:" drive prefix indicates the drive name (A: through P:) containing the DIOMOD.DCL file. The drive prefix need not be present if the DIOMOD.DCL file is on the same drive as the PLI source file. The contents of the DIOMOD.DCL file is shown below, and
in the listing of Appendix C.

```
dcl

        memptr          entry           returns (ptr),
        memsiz          entry       returns (fixed(15)),
        memwds          entry       returns (fixed(15)),
        dfcb0           entry           returns (ptr),
        dfcbl           entry           returns (ptr),
        dbuff           entry           returns (ptr),
        reboot          entry,
        rdcon           entry         returns (char(l)),
        wrcon           entry                 (char(l)),
        rdrdr           entry         returns (char(l)),
        wrpun           entry                 (char(l)),
        wrlst           entry                (char(l) ),
        coninp          entry         returns (char(l)),
        conout          entry                 (char(l)),
        rdstat          entry          returns (bit(l)),
        getio           entry          returns (bit(8)),
        setio           entry                (bit(8)),
        wrstr           entry                  (ptr),
        rdbuf           entry                  (ptr),
        break           entry          returns (bit(l)),
        vers            entry         returns (bit(16)),
        reset           entry,
        select          entry                (fixed(7)),
        open entry (ptr) returns (fixed(7)),
        close entry (ptr) returns (fixed(7)),
        sear entry (ptr) returns (fixed(7)),
```

```
searn     e n try                 returns (fixed(7)),
delete    entry       (ptr),
rdseq     entry       (ptr)       returns (fixed(7)),
wrseq     entry       (ptr)       returns (fixed(7)),
make      entry       (ptr)       returns (fixed(7)),
rename    entry       (ptr),
logvec    entry                   returns (bit(16)),
curdsk    entry                   returns (fixed(7)),
setdma    entry                   (ptr) ,
allvec    entry                   returns (ptr),
wpd is k  en try,
rovec     entry                   returns (bit(16)),
filatt    e ntry                  (ptr),
getdpb    entry                   returns (ptr),
getusr    entry                   returns (fixed(7)),
setusr    entry       (fixed(7)) ,
rdran     entry       (ptr)       returns (fixed(7)),
wrran     entry       (ptr)       returns (fixed(7)),
filsiz    entry       (ptr),
setrec    entry       (ptr),
resdrv    entry                   (bit (16)
wrranz    entry       (ptr)       returns (fixed(7));
```

Three programs are included which illustrate the use of the PLIDIO calls. Appendix B lists the DIOCALLS program that gives examples of all the basic functions, while Appendix C shows how the fundamental disk 1/0 operations take place, in a program called DIOCOPY which performs a fast file-to-file copy function. The last program, given in Appendix D, illustrates the operation of the random access primitives. These programs are designed to demonstrate all of the PLIDIO entry points, and show various additional PL/I-80 programming facilities in the process.

The file FCB.DCL is used throughout DIOCOPY and DIORAND to define the body of each File Control Block declaration. This file is copied into the source program during compilation using the statement:

```
%include 'x:fcb.dcl'  ;
```

where, again, "x:" denotes the optional drive prefix for the drive containing the FCB.DCL file.

Note that the use of these entry points generally precludes the use of some PL/I-80 facilities. In particular, the dynamic storage area is used by the PL/I-80 system for recursive procedures and file 1/0 buffering. (Be aware that there are no guarantees that the dynamic storage area will not be used for other purposes as additional facilities are added to PL/I-80.) Thus, the use of the MEMPTR function as shown in Appendix B disallows the use of dynamic storage allocation functions. Further, you must ensure that the various file maintenance functions, such as delete and rename do not access a file which is currently open in the PL/I-80 file system. Simple peripheral access, as shown in these examples, is generally safe since no buffering takes place in this case.

APPENDIX A:

LISTING OF "PLIDIO"
DIRECT CP/M CALL ENTRY POINTS

```
CP/M RMAC ASSEM 0.4     #001        DIRECT CP/M CALLS FROM PL/I-80
                        name        ' DIOMOD'
                        title       ' Direct CP/M Calls From PL/I-80'

                        cp/m calls from pl/i for direct i/o

                        public      memptr      ;return pointer to base of free mem
                        public      memsiz      ;return size of memory in bytes
                        public      memwds      ;return size of memory in words
                        public      dfcb0       ;return address of default fcb 0
                        public      dfcbl       ;return address of default fcb 1
                        public      dbuff       ;return address of default buffer
                        public      reboot      ;system reboot (#0)
                        public      rdcon       ;read console character (#l)
                        public      wrcon       ;write console character(#2)
                        public      rdrdr       ;read reader character (#3)
                        public      wrpun       ;write punch character (#4)
                        public      wrlst       ;write 1 ' ist character (#5)
                        public      coninp      ;direct console input (#6a)
                        public      conout      ;direct console output (#6b)
                        public      rdstat      ;read console status (#6c)
                        public      qetio       ;get io byte (#8)
                        public      setio       ;set i/o byte (#9)
                        public      wrstr       ;write string (#10)
                        public      rdbuf       ;read console buffer (#10)
                        public      break       ;get console status (#11)
                        public      vers        ;get version number (#12)
                        public      reset       ;reset disk system (#13)
                        public      select      ;select disk (#14)
                        public      open        ;open file (#15)
                        public      close       ;close file (#16)
                        public      sear        ;search for file (#17)
                        public      searn       ;search for next (#18)
                        public      delete      ;delete file (#l 9)
                        public      rdseq       ;read file sequential mode (#20)
                        public      wrseq       ;write file sequential mode (#21)
                        public      make        ;create file (#22)
                        public      rename      ;rename file (#23)
                        public      logvec      ;return login vector (#24)
                        public      curdsk      ;return current disk number (#25)
                        public      setdma      ;set DMA address (#26)
                        public      allvec      ;return address of alloc vector (#27)
                        public      wpdisk      ;write protect disk (#28)
                        public      rovec       ;return read/only vector (#29)
                        public      filatt      ;set file attributes (#30)
                        public      getdpb      ;get base of disk parm block (#31)
                        public      qetusr      ;get user code (#32a)
                        public      setusr      ;set user code (#32b)
                        public      rdran       ;read random (#33)
                        public      wrran       ;write random (#34)
                        public      filsiz      ;random file size (#35)
                        public      setrec      ;set random record pos (#36)
```

```
public    resdrv    ;reset drive (#37)
public    wrranz    ;write random, zero fill (#40)
```

```
                        extrn   ?begin   ;beginning of free list
                        extrn   ?boot    ;system reboot entry point
                        extrn   ?bdos    ;bdos entry point
                        extrn   ?dfcb0   ;default fcb 0
                        extrn   ?dfcbl   ;default fcb 1
                        extrn   ?dbuff   ;default buffer

                    equates for interface to cp/m bdos

OOOD =          cr      equ     Odh     ;carriage return
OOOA =          lf      equ     Oah     ;line feed
001A =          eof     equ     lah     ;end of file
0001 =          readc   equ     1       ;read character from console
0002 =          writc   equ     2       ;write console character
0003 =          rdrf    equ     3       ;reader input
0004 =          punf    equ     4       ;punch output
0005 =          listf   equ     5       ;list output function
0006 =          diof    equ     6       ;direct i/o, version 2.0
0007 =          getiof  equ     7       ;get i/o byte
0008 =          setiof  equ     8       ;set i/o byte
0009 =          printf  equ     9       ;print string function
OOOA =          rdconf  equ     10      ;read console buffer
OOOB =          statf   equ     11      ;return console status
OOOC =          versf   equ     12      ;get version number
OOOD =          resetf  equ     13      ;system reset
OOOE =          seldf   equ     14      ;select disk function
OOOF =          openf   equ     15      ;open file function
0010 =          closef  equ     16      ;close file
0011 =          serchf  equ     17      ;search for file
0012 =          serchn  equ     18      ;search next
0013 =          deletf  equ     19      ;delete file
0014 =          readf   equ     20      ;read next record
0015 =          writf   equ     21      ;write next record
0016 =          makef   equ     22      ;make file
0017 =          renamf  equ     23      ;rename file
0018 =          loginf  equ     24      ;get login vector
0019 =          cdiskf  equ     25      ;get current disk number
001A =          setdmf  equ     26      ;set dma function
001B =          getalf  equ     27      ;get allocation base
001C =          wrprof  equ     28      ;write protect disk
001D =          getrof  equ     29      ;get r/o vector
001E =          setatf  equ     30      ;set file attributes
001F =          getdpf  equ     31      ;get disk parameter block
0020 =          userf   equ     32      ;set/get user code
0021 =          rdranf  equ     33      ;read random
0022 =          wrranf  equ     34      ;write random
0023 =          filszf  equ     35      ;compute file size
0024 =          setrcf  equ     36      ;set random record position
0025 =          rsdrvf  equ     37      ;reset drive function
0028 =          wrrnzf  equ     40      ;write random zero fill
```

```
                                utility functions

                                  general purpose routines used upon entry

                        getpl:    ;get single byte parameter to register e
0000    5E                        mov     e,m                     ;low (addr)
0001    23                        inx     h
0002    56                        mov     d,m                     ;high(addr)
0003    EB                        xchg                            ;hl = char
0004    5E                        mov     e,m                     ;to register e
0005    C9                        ret

                        getp2:    ;get single word value to DE
                        getp2i:   ; (equivalent to qetp2)
0006    CDOOOO                    call    getpl
0009    23                        inx     h
OOOA 56                           mov     d,m                     ;get high byte as well
OOOB C9                           ret
                      ;
                        getver:   ;get cp/m or mp/m version number
OOOC E5                           push    h                       ;save possible data adr
OOOD OEOC                         mvi     c,versf
OOOF CDOOOO                       call    ?bdos
0012    El                        pop     h                       ;recall data addr
0013    C9                        ret
                      ;
                        chkv20: ; check for version 2.0 or greater
0014 CDOCOO                       call    getver
0017 FE14                         cpi     20
0019 DO                           rnc                             ;return if > 2.0
                                  error message and stop
001A C32300                       jmp     vererr                  ;version error
                      ;
                        chkv22:   ;check for version 2.2 or greater
001D CDOCOO                       call    getver
0020 FE22                         cpi     22h
0022 DO                           rnc                             ;return if >= 2.2
                        vererr:
                                  ;version error, report and terminate
0023    112EOO                    lxi     d,vermsg
0026    OE09                      mvi     c,printf
0028    CDOOOO                    call    ?bdos                   ;write message
002B    C30000                    jmp     ?boot                   ;and reboot
002E    ODOA4C6174vermsg:         db      cr,lf,'  Later CP/M or MP/M Version Required$'
                      ;
                        memptr:   ;return pointer to base of free storage
0054 2AOOOO                       lhld    ?begin
0057 C9                           ret
```

```
CP/M RMAC ASSEM 0.4             #004        DIRECT CP/M CALLS FROM PL/I-80
                        ;
                        memsiz:  ;return    size of free memory in bytes
0058 2AO100                      lhld       ?bdos+l                ;base of bdos
005B EB                          xchg                              ;de = bdos
005C 2AOOOO                      lhld       ?begin                 ;beginning of free storage
005F 7B                          mov        a,e                    ;low(.bdos)
0060 95                          sub        l                      ;-low(begin)
0061 6F                          mov        l,a                    ;back to 1
0062 7A                          mov        a,d                    ;high(.bdos)
0063 9C                          sbb        h
0064 67                          mov        h,a                    ;hl = mem size remaining
0065 C9                          ret
                        ;
                        memwds:  ;return    size of free memory in words
0066    CD5800                   call       memsiz                 ;hl = size in bytes
0069    7C                       mov        a,h                    ;high(size)
006A    B7                       ora        a                      ;cy = 0
0 06B   1F                       rar                               ;cy = ls bit
006C    67                       mov        h,a                    ;back to h
006D    7D                       mov        a,l                      low(size)
006E 1F                          rar                               include ls bit
006F 6F                          mov        l,a                    ;back to 1
0070 C9                          ret                               ;with wds in hl
                        ;
                        dfcbO:   ;return address of default fcb 0
0071 210000                      lxi        h,?dfcbO
0074 C9                          ret
                        ;
                        dfcbl:   ;return address of default fcb 1
0075 210000                      lxi        h,?dfcbl
0078 C9                          ret
                        ;
                        dbuff:   ;return address of default buffer
0079 210000                      lxi        h,?dbuff
007C C9                          ret
                        ;
                        reboot:  ;system reboot (#0)
007D C30000                      jmp        ?boot
```

```
CP/M RMAC ASSEM 0.4     #005     DIRECT CP/M CALLS FROM PL/I-80
                        ;
                rdcon:  ;read console character (#l)
                        ;return  character value to stack
0080 OE01               mvi     c,readc
0082 C38COO             jmp     chrin           ;common code to read char
                        ;
                wrcon:  ;write console character(#2)
                        ;1->char(l)
0085 OE02               mvi     c,writc         ;console write function
0087 C39COO             jmp     chrout          ;to write the character
                        ;
                rdrdr:  ;read reader character (#3)
008A OE03               mvi     c,rdrf          ;reader function
                chrin:
                        ;common  code for character input
008C  CDOOOO            call    ?bdos           ;value returned to A
008F  El                POP     h               ;return address
0090  F5                push    psw             ;character to stack
0091  33                inx     sp              ;delete flags
0092  3EO1              mvi     a,l             ;character length is 1
0094 E9                 pchl                    ;back to calling routine
                        ;
                wrpun:  ;write punch character (#4)
                        ;1->char(l)
0095 OE04               mvi     c,punf          ;punch output function
0097 C39COO             jmp     chrout          ;common code to write chr
                        ;
                wrlst:  ;write list character (#5)
                        ;1->char(l)
009A OE05               mvi     cflistf         ;list output function
                chrout:
                        ;common  code to write character
                        ;1-> character to write
009C CDOOOO             call    getpl           ;output Char to register e
009F C30000             jmp     ?bdos           ;to write and return
                        ;
                coninp: ;perform console input,  char returned in stack
0OA2 21AEOO             lxi     h,chrstr        ;return address
0OA5 E5                 push    h               ;to stack for return
```

```
0OA6 2AO100          lhld    ?boot+l         ;base of bios imp vector
0OA9 110600          lxi     d,2*3           ;offset to imp conin
OOAC 19              dad     d
OOAD E9              pchl                    ;return to chrstr
                ;
                chrstr:  ;create charaQter string, length 1
OOAE El              POP     h               ;recall return address
OOAF F5              push    psw             ;save character
OOBO 33              inx     sp              ;delete psw
00B1  E9             pchl                    ;return to caller
                ;
                conout:  ;direct console output
                         ;1->char(l)
0OB2  CDOOOO         call    getpl           ;get parameter
0OB5  4B             mov     c,e             ;character to c
0OB6  2AO100         lhld    ?boot+l         ;base of bios imp
0OB9  110900         lxi     d,3*3           ;console output offset
OOBC 19              dad     d               ;hl = jmp conout
OOBD E9              pchl                    ;return through handler
                ;
                rdstat:  ;direct console status read
OOBE 21ECOO          1xi     h,rdsret        ;read status return
0OC1  E5             push    h               ;return to rdsret
0OC2  2AO100         lhld    ?boot+l         ;base of imp vector
0OC5  110300         lxi     d,1*3           ;offset to jmp const
0OC8  19             dad     d               ;hl = jmp const
0OC9  E9             pchl
                ;
                getio:   ;qet io byte (#8)
OOCA OE07            mvi     c,qetiof
OOCC C30000          jmp     ?bdos           ;value returned to A
                ;
                setio:   ;set i/o byte (#9)
                         ;1->i/o byte
OOCF CDOOOO          call    getpl           ;new i/o byte to E
OOD2 OE08            mvi     c,setiof
OOD4 C30000          jmp     ?bdos           ;return through bdos
                ;
                wrstr:   ;write string (#10)
                         ;1->addr(string)
OOD7 CD0600          call    qetp2           ;get parameter value to DE
```

```
OODA OE09               mvi     c,printf        ;print string function
OODC C30000             imp     ?bdos           ;return through bdos
                rdbuf:  ;read console buffer (#10)
                        ; 1->addr(buf f)
OODF CD0600             call    getp2i          ;DE = buff
OOE2 OEOA               mvi     c,rdconf        ;read console function
OOE4 C30000             jmp     ?bdos           ;return through bdos
                ;
                break:  ;get console status (#11)
OOE7 OEOB               mvi     c,statf
OOE9 CDOOOO             call    ?bdos           ;return through bdos
                ;
                rdsret: ;return clean true value
OOEC B7                 ora     a               ;zero?
OOED C8                 rz                      ;return if so
OOEE 3EFF               mvi     a,Offh          ;clean true value
OOFO C9                 ret
                ;
                vers:   ;get version number (#12)
00K OEOC                mvi     c,versf
0OF3 C30000             jmp     ?bdos           ;return through bdos
                ;
                reset:  ;reset disk system (#13)
0OF6 OEOD               mvi     c,resetf
0OF8 C30000             jmp     ?bdos

                select: ;select disk (#14)
                        ;1->fixed(7) drive number
OOFB CDOOOO             call    getpl           ;disk number to E
OOFE OEOE               mvi     c,seldf
0100 C30000             jmp     ?bdos           ;return through bdos
                open:   ;open file (#15)
                        ;1-> addr(fcb)
0103 CD0600             call    getp2i          ;fcb address to de
0106 OEOF               mvi     c,openf
0108 C30000             jmp     ?bdos           ;return through bdos
```

```
                        close:  ;close file (#16)
                                ;1-> addr(fcb)
010B CD0600                     call    getp2i          ;.fcb to DE
010e OE10                       mvi     c,closef
0110 C30000                     jmp     ?bdos           ;return through bdos
                        ;
                        sear:   ;search for file (#17)
                                ;1-> addr(fcb)
0113 CD0600                     call    getp2i          ;.fcb to DE
0116 OEll                       mvi     c,serchf
0118 C30000                     jmp     ?bdos

                        searn:  ;search for next (#18)
011B OE12                       mvi     c,serchn        ;search next function
011D C30000                     jmp     ?bdos           ;return through bdos
                        ;
                        delete: ;delete file (#19)
                                ;1-> addr(fcb)
0120 CD0600                     call    qetp2i          ;.fcb to DE
0123 OE13                       mvi     c,deletf
0125 C30000                     jmp     ?bdos           ;return through bdos
                        ;
                        rdseq:  ;read file sequential mode (#20)
                                ;1-> addr(fcb)
0128 CD0600                     call    getp2i          ;.fcb to DE
012B OE14                       mvi     c,readf
012D C30000                     jmp     ?bdos           ;return through bdos
                        ;
                        wrseq:  ;write file sequential mode (#21)
                                ;1-> addr(fcb)
0130 CD0600                     call    getp2i          ;.fcb to DE
0133 OE15                       mvi     c,writf
0135 C30000                     jmp     ?bdos           ;return through bdos
                        ;
                        make:   ;create file (#22)
```

```
                        ;1-> addr(fcb)
0138 CD0600             call    getp2i          ;.fcb to DE
013B OE16               mvi     c,makef
013D C30000             jmp     ?bdos           ;return through bdos
                ;
                rename: ;rename file (#23)
                        ; 1-> add r(fcb)
0140  CD0600            call    getp2i          ;.fcb to DE
0143  OE17              mvi     c,renamf
0145  C30000            jmp     ?bdos           ;returnthrough bdos
                ;
                loqvec: ;return login vector (#24)
0148 OE18               mvi     c,loginf
014A C30000             jmp     ?bdos           ;returnthrough BDOS
               ;
                curdsk: ;return current disk number (#25)
014D OE19               mvi     c,cdiskf
014F C30000             jmp     ?bdos           ;return value in A
               ;
                setdma: ;set DMA address (#26)
                        ;1-> pointer (dma address)
0152  CD0600            call    getp2           ;dma address to DE
0155  OElA              mvi     c,setdmf
0157  C30000            jmp     ?bdos           ;return through bdos
                ;
                allvec: ;return address of allocation vector (#27)
015A OElB               mvi     c,getalf
015C C30000             jmp     ?bdos           ;return through bdos
                ;
                wpdisk: ;write protect disk (#28)
015F CD1400             call    chkv20          ;must be 2.0 or greater
0162 OElC               mvi     c,wrprof
0164 C30000             jmp     ?bdos
                ;
                rovec:  ;return read/only vector (#29)
```

```
0167 CD1400                 call    chkv20          ;must be 2.0 or greater
016A OElD                   mvi     c,getrof
016C C30000                 jmp     ?bdos           ;value returned in HL
                    ;
                    filatt: ;set file attributes (#30)
                            ;1-> addr(fcb)
016F CD1400                 call    chkv20          ;must be 2.0 or greater
0172 CD0600                 call    qetp2i          ;.fcbto DE
0175 OElE                   mvi     c,setatf
0177 C30000                 imp     ?bdos
                    ;
                    getdpb: ;get base of current disk parm block (#31)
017A CD1400                 call    chkv20          ;check for 2.0 or greater
017D OElF                   mvi     c,getdpf
017F C30000                 jmp     ?bdos           ;addr returned in HL
                    ;
                    getusr: ;get user code to register A
0182 CD1400                 call    chkv20          ;check for 2.0 or greater
0185 1EFF                   mvi     e,Offh          ;to get user code
0187 OE20                   mvi     c,userf
0189 C30000                 jmp     ?bdos
                    ;
                    setusr: ;set user code
018C    CD1400              call    chkv20          ;check for 2.0 or greater
018F    CDOOOO              call    getpl           ;code to E
0192    OE20                mvi     c,userf
0194 C30000                 jmp     ?bdos
                    ;
                    rdran:  ;read random (#33)
                            ;1-> addr(fcb)
0197 CD1400                 call    chkv20          ;checkfor 2.0 or greater
019A CD0600                 call    getp2i          ;.fcb to DE
019D OE21                   mvi     c,rdranf
019F C30000                 jmp     ?bdos           ;return through bdos
                    ;
                    wrran:  ;write random (#34)
                            ;1-> addr(fcb)
01A2 CD1400                 call    chkv20          ;check for 2.0 or greater
```

```
01A5 CD0600                 call    qetp2i              ;.fcb to DE
01A8 OE22                   mvi     c,wrranf
01AA C30000                 jmp     ?bdos               ;return through bdos
                    ;
                    filsiz: ;compute file size (#35)
01AD CD1400                 call    chkv20              ;must be 2.0 or greater
01BO CD0600                 call    getp2               ;.fcb to DE
01B3 OE23                   mvi     c,filszf
01B5 C30000                 jmp     ?bdos               ;return through bdos
                    ;
                    setrec: ;set random record position (#36)
01B8 CD1400                 call    chkv20              ;must be 2.0 or greater
01BB CD0600                 call    getp2               ;.fcb to DE
01BE OE24                   mvi     c,setrcf
01CO C30000                 jmp     ?bdos               ;return through bdos
                   ;
                    resdrv: ;reset drive function (#37)
                            ;1->drive vector - bit(16)
01C3 CDlDOO                 call    chkv22              ;must be 2.2 or greater
01C6 CDO600                 call    getp2               ;drive reset vector to DE
01C9 OE25                   mvi     c,rsdrvf
01CB C30000                 imp     ?bdos               ;return through bdos

                    wrranz: ;write random, zero fill function
                            ;1-> addr(fcb)
01CE CDlDOO                 call    chkv22      ;must be 2.2 or greater
OID1 CD0600                 call    getp2i              ;.fcb to DE
01D4 OE28                   mvi     c,wrrnzf
01D6 C30000                 imp     ?bdos
OID9                        end
```

015A	ALLVEC	OOE7	BREAK	0019	CDISKF	0014	CHKV20	001D	CHKV22
008C	CHRIN	009C	CHROUT	OOAE	CHRSTR	010B	CLOSE	0010	CLOSEF
0OA2	CONINP	0OB2	CONOUT	OOOD	CR	014D	CURDSK	0079	DBUFF
0120	DELETE	0013	DELETF	0071	DFCBO	0075	DFCB1	0006	DIOF
001A	EOF	016F	FILATT	01AD	FILSIZ	0023	FILSZF	001B	GETALF
017A	GETDPB	001F	GETDPF	OOCA	GETIO	0007	GETIOF	0000	GETP1
0006	GETP2	0006	GETP21	001D	GETROF	0182	GETUSR	OOOC	GETVER
OOOA	LF	0005	LISTF	0018	LOGINF	0148	LOGVEC	0138	MAKE
0016	MAKEF	0054	MEMPTR	0058	MEMSIZ	0066	MEMWDS	0103	OPEN
OOOF	OPENF	0009	PRINTF	0004	PUNF	OOOF	RDBUF	0080	RDCON
OOOA	RDCONF	0197	RDRAN	0021	RDRANF	008A	RDRDR	0003	RDRF
0128	RDSEQ	OOEC	RDSRET	OOBE	RDSTAT	0001	READC	0014	READF
007D	REBOOT	0140	RENAME	0017	RENAMF	01C3	RESDRV	OOFI;	RESET
OOOD	RESETF	0167	ROVEC	0025	RSDRVF	0113	SEAR	011B	SEARN
OOOE	SELDF	OOFB	SELECT	0011	SERCHF	0012	SERCHN	001E	SETATF
0152	S ETT)MA	001A	SETOMF	OOCF	SETIO	0008	SETIOF	0024	SETRCF
01B8	SETREC	018C	SETUSR	OOOB	STATF	0020	USERF	0023	VERERR
002E	VERMSG	0OF1	VERS	OOOC	VERSF	015F	WPDISK	0085	WRCON
0002	WRITC	0015	WRITF	009A	WRLST	001C	WRPROF	0095	WRPU
01A2	WRRAN	0022	WRRANF	01CE	WRRANZ	0028	WRRNZF	0130	WRSEQ
OOD7	WRSTR	0000	?BDOS	0000	?BEGIN	0000	?BOOT	0000	?DBUFF
0000	?DFCBO	0000	?DFCB1						

APPENDIX B:

LISTING OF "DIOCALLS"
SHOWING THE BASIC CP/M DIRECT INTERFACE

PL/I-80 V1.0, COMPILATION OF: DIOCALLS

L: List Source Program

```
%include 'diomod.dcl'  ;
      NO ERROR(S) IN PASS 1

      NO ERROR(S) IN PASS 2
```

PL/I-80 V1.0, COMPILATION OF: DIOCALLS

```
 1 a 0000 diotst:
 2 a 0006              proc options(main);
 3 a 0006              /* external CP/M 1/0 entry points
 4 a 0006              /* (note: each source line begins with tab chars)
 5+c 0006              dcl
 6+c 0006                    memptr entry                        returns (ptr),
 7+ c 0006                   memsiz     entry                    returns      ( f ixed (15)
 8+ c 0006                   memwds     entry                    returns      (fixed(15)),
 9+ c0006                    dfcbO      entry                    returns      (ptr),
10+c0006                    dfcbl      entry                    returns      (ptr),
ll+  c0006                  dbuff      entry                    returns      (ptr),
12+ c 0006                  reboot entry,
13+c  0006                  rdcon      entry                    returns (char(l)),
14+c  0006                  wrcon      entry                    (char(l)),
15+c  0006                  rdrdr      entry                    returns (char(l)),
16+c  0006                  wrpun      entry                    (char(l)),
17+c  0006                  wrlst      entry                    (char(l)),
18+c  0006                  coninp entry                        returns (char(l)),
19+c  0006                  conout entry                        (char(l)),
20+c  0006                  rdstat entry                        returns (bit(l)),
21+c  0006                  getio      entry                    returns (bit(8)),
22+c  0006                  setio      entry                    (bit(8)),
23+c  0006                  wrstr      entry                    (ptr),
24+c  0006                  rdbuf      entry                    (ptr),
25+c  0006                  break      entry                    returns (bit(l)),
26+c  0006                  vers       entry                    returns (bit(16)),
27+c  0006                  reset      entry,
28+c 0006                   select entry                         (fixed(7)),
29+c  0006                  open       entry      (ptr)         returns      (fixed(7)),
30+c  0006                  close      entry      (ptr)         returns      (fixed(7)),
31+c  0006                  sear       entry      (ptr)         returns      (fixed(7)),
32+c  0006                  searn      entry                    returns      (fixed(7)),
33+c  0006                  delete     entry      (ptr),
34+c  0006                  rdseq      entry      (ptr)         returns (fixed(7)),
35+c  0006                  wrseq      entry      (ptr)         returns (fixed(7)),
36+c  0006                  make       entry      (ptr)         returns (fixed(7)),
37+c  0006                  rename     entry      (ptr),
38+c  0006                  loqvec     entry                    returns (bit(16)),
39+c  0006                  curdsk     entry                    returns (fixed(7)),
40+c  0006                  setdma     entry                    (ptr),
41+c  0006                  allvec     entry                    returns (ptr),
42+c  0006                  wpdisk     entry,
43+c      0006              rovec      entry                    returns (bit(16)),
44+c      0006              filatt     entry                    (ptr),
45+c      0006              getdpb     entry                    returns (ptr),
46+c      0006            getusr       entry                  returns (fixed(7)),
```

```
47+c    0006                setusr      entry          (fixed(7)),
48+c    0006                rdran       entry          (ptr)       returns (fixed(7)),
49+c    0006                wrran       entry          (ptr)       returns (fixed(7)),
50+c    0006                filsiz      entry          (ptr),
51+c    0006                setrec      entry          (ptr),
52+c    0006                resdrv entry                           (bit(16)),
53+c    0006                wrranz entry               (ptr) returns (fixed(7));
 54 c   0006          dcl
 55 c   0006                c char(l),
 56 c   0006                v char(254) var,
 57 c   0006                i fixed;
 58 c   0006
 59 c   0006          /*
 60 c   0006
 61 c   0006
 62 c   0006              Fixed Location Tests:
 63 c   0006                   MEMPTR, MEMSIZ, MEMWDS,
 64   c 0006                   DFCBO, DFCB1, DBUFF
 65   c 0006          */
 66   c 0006
 67   c 0006          dcl
 68   c 0006                memptrv ptr,
 69   c 0006                memsizv fixed,
 70   c 0006                (dfcb0v, dfcblv, dbuf fv) ptr,
 71   c 0006                command char(127) var based (dbuffv),
 72   c 0006                1fcbO based(dfcb0v),
 73   c 0006                    2   drive      fixed(7),
 74   c 0006                    2   name       char(8),
 75   c 0006                    2   type       char(3),
 76   c 0006                    2   extnt      fixed(7),
 77   c 0006                    2   space      (19) bit(8),
 78   c 0006                    2   cr         fixed(7),
 79   c 0006                memory (13:0) based(memptrv)bit(8);
 80   c 0006          memptrv       = memptro;
 81   c 000C          memsizv       = memsizo;
 82   c 0012          dfcbOv        = dfcb0();
 83   c 0018          dfcblv        = dfcbl();
 84   c 001E          dbuffv        = dbuffo;
 85   c 0024          put edit ('  Command Tail: '  ,command) (a);
 86   c 004A          put edit ('  First Default File: ‘,
 87   c 008D                fcbO.name,'  .'  ,fcbO.type) (skip,4a);
 88   c 008D          put edit ('dfcbO ' unspec(dfcb0v),
 89   c 0137                'dfcbl ' unspec(dfcblv),
 90   c 0137                'dbuff ' unspec(dbuffv),
 91   c 0137                amemptr'  ,unspec(memptrv),
 92   c 0137                Imemsizl,unspec(memsizv),
 93   c 0137                'memwds' memwds() )
 94   c 0137               (5 (skip,a (7) b4) skip,a (7)f (6)
 95   c 0137          put   skip list('Clearinq Memory'  );
 96   c 0153                /* sample loop to clear mem */
 97   c 0153                do i = 0 repeat(i+l) while (i-=memsizv-1);
 98   c 016A                memory (i) = '  001b4;
 99   c 017F                end;
100   c 017F
101   c 017F
102   c 017F                /*
103   c 017F
104   c 017F                        REBOOT Test
105   c 017F
```

```
106   c   017F
107   c   017F          put skip list ('  Reboot? (Y/N)'  );
108   c   019B          get list (c);
109   c   01B5          if translate(c,1Y1,1y'  ) = '  Y'   then
110   c   01DD                  call rebooto;
111   c   01E0
112   c   01E0
113   c   OlEO
114   c   01E0
115   c   01E0                        RDCON, WRCON Test
116   c   01E0
117   c   01E0
118   c   01E0          put list(Type Input, End with
119   c   01F7          v             - M-j'  ;
120   c   0204                  do while (substr(v,length(v))
121   c   0220                  v = v 11                        rdcono;
122   c   022E                  end;
123   c   022E          put skip list('  You Typed:'  );
124   c   024A                  do i = 1 to lenqth(v);
125   c   0266                  call wrcon(substr(v,i,l));
126   c   028E                  end;
127   c   028E
128   c   028E
129   c   028E
130   c   028E
131   c   02SE                        RDRDR and WRPUN Test
132   c   028E
133   c   02SE
134   c   028E          put skip list('  Reader to Punch Test?(Y/N)'  );
135   c   02AA          get list (c) ;
136   c   02C4          if translate(c,'  Y'  ,'  y'  ) = '  Y'   then
137   c   02EC                  do;
138   c   02EC                  put skip list('Copyinq RDR to PUN until ctl-z'  );
139   c   0308                  C = I I ;
140   c   0314                        do while (c -= '-z'  );
141   c   0323                        c = rdrdro;
142   c   032E                        if c -= '-z'   then
143   c   033D                              call wrpun(c)
144   c   0346                        end;
145   c   0346                  end;
146   c   0346
147   c   0346
148   c   0346
149   c   0346
150   c   0346                              WRLST Test
151   c   0346
152   c   0346
153   c   0346          put list('  List Output Test?(Y/N)'  );
154   c   035D          qet list(c);
155   c   0377          if translate(c,'  Y'  ,'  y'  ) = '  Y'   then
156   c   039F                  do i = 1 to lenqth(v);
157   c   03BB                  call wrlst(substr(v,i,l));
158   c   03E3                  end;
159   c   03E3
160   c   03E3
161   c   03E"
162   c   03E3
163   c   03E3                  Direct 1/0, CONOUT, CONINP
164   c   03E3
165   c   03E3
```

```
166  c  03E3          put list
167  c  03FA                  ('  Direct 1/0, Type Line, End with Line Feed'  );
168  c  03FA                  c = ' ';
169  c  0406                          do while (c ^= '^j');
170  c  0415                          call conout(c);
171  c  041B                          c = coninp();
172  c  0429                          end;
173  c  0429
174  c  0429
175  c  0429          /*
176  c  0429
177  c  0429                 Direct 1/0,                  Console Status
178  c  0429                                        RDSTAT
179  c  0429          */
180  c  0429
181  c  0429          put skip list('Status Test, Type Character'  );
182  c  0445                  do while (^rdstat());
183  c  044F                  end;
184  c  044F          /* clear the character */
185  c  044F          c = coninp();
186  c  045A
187  c  045A
188  c  045A          /*
189  c  045A
190  c  045A                          GETIO,          SETIO Iobyte
191  c  045A
192  c  045A          */
193  c  045A          dcl
194  c  045A                  iobyte bit,(8);
195  c  045A          iobyte = getio();
196  c  0460          put edit ('IObyte is ' iobyte,
197  c  0493                   '  , New Value: '  ) (skip,a,b4,a);
198  c  0493          qet edit (iobyte) (b4(2));
199  c  04AF          call setio(iobyte);
200  c  04B5
201  c  04B5
202  c  04B5          /*
203  c  04B5
204  c  04B5                  Buffered Write, WRSTR Test
205  c  0435          */
206  c  04B5
207  c  04B5          put list('  Buffered Output Test:'  );
208  c  04CC          /* "v" was previously filled by RDCON */
209  c  04CC          call wrstr(addr(v));
210  c  04D8
211  c  04D8
212  c  04D8          /*
213  c  04D8
214  c  04D8                      Buffered Read RDBUF Test
215  c  04D8          */
216  c  04D8
217  c  04D8          dcl
218  c  04D8                  1 inbuff static,
219  c  04D8                    2 maxsize bit(8) init('  80'  b4),
220  c  04D8                    2 inchars char(127) var;
221  c  04D8          put skip list('Line Input, Type Line, End With Return'  );
222  c  04F4          put skip;
223  c  0505          call rdbuf(addr(inbuff));
224  c  0511          put skip list('  You Typed: 'inchars);
225  c  0536
```

```
226   c  0536              /*
227   c  0536
228   c   0536                        Console BREAK Test
229   c   0536            */
230   c   0536
231   c   0536
232   c   0536            put skip     list('Console Break Test, Type Character');
233   c   0552                    do while(^break());
234   c   055C                    end;
235   c   055C            c = rdcon();
236   c   0567
237   c   0567
238   c   0567            /*
239   c   0567
240   c   0567                        Version Number VERS Test
241   c   0567            */
242   c   0567
243   c   0567            dcl
244   c   0567                    version bit(16);
245   c   0567            version = vers();
246   c   056D            if substr(version,1,8) = '00'b4 then
247   c   0576                    put skip list('Cp/M'); else
248   c   0595                    put skip list('  MP/M');
249   c   05B1            put edit('   Version ',substr(version,9,4),
250   c   05F5                    '.' ,substr(version,13,4)) (a,b4,a,b4);
251   c   05F5
252   c   05F5
253   c   05F5            /*
254   c   05F5
255   c   05F5                        Disk System RESET Test
256   c   0 5F5           */
257   c   05F5
258   c   05F5            put skip list('  Resetting Disk System'  );
259   c   0611            call reset();
260   c   0614
261   c   0614            /*
262   c   0614
263   c   0614
264   c   0614                        Disk          SELECT Test
265   c   06l 4           */
266   c   0614
267   c   0614            put skip list('  Select Disk # ');
268   c   0630            get list(i);
269   c   0648            call select(i);
270   c   0654
271   c   0654            /*
272   c   0654
273   c  0654                 Note:          The OPEN, CLOSE, SEAR,
274   c  0654                                SEARN, DELETE, RDSEQ,
275   c  0654                                WRSEQ, MAKE, and RENAME
276   c   0654                functions are tested in the
277   c   0654                               DIOCOPY program
278   c   0654
279   c   0654                */
280   c   0654
281   c   0654                /*
282   c   0654
283   c   0654                                 LOGVFC and CURDSK
284   c   0654
285   c   0654                */
```

```
286   c   0654          put skip list ('Login Vector'  ,
287   c   0695                loqvec(),'  Current Disk'  ,
288   c   0695                curdsk());
289   c   0695
290   c   0695          /*
291   c   0695
292   c   0695              See DIOCOPY for SETDMA Function
293   c   0695
294   c   0695          */
295   c   0695
296   c   0695
297   c   0695          /*
298   c   0695                Allocate Vector ALLVEC Test
299   c   0695
300   c   0695          */
301   c   0695          dcl
302   c   0695                alloc (0:30) bit(8)
303   c   0695                      based (allvec()),
304   c   0695                allvecp ptr;
305   c   0695          allvecp = allvec();
306   c   069B          put edit('Alloc Vector at ‘,
307   c   0700                unspec(allvecp),'  :’,
308   c   0700                (alloc(i) do i=O to 30))
309   c   0700                (skip,a,b4,a,254(skip,4(b,x(l))));
310   c   0700
311   c   0700          /*
312   c   0700
313   c   0700                Note: the followinq functions
314   c   0700                apply to version 2.0 or newer.
315   c   0700
316   c   0700          */
317   c   0700
318   c   0700          /*
319   c   0700
320   c   0700                                    WPDISK Test
321   c   0700          */
322   c   0700
323   c   0700          put skip list('  Write Protect Disk?(Y/N)'  );
324   c   071C          get list(c);
325   c   0736          if translate(c,'  Y'  ,'  y'  ) = '  Y'   then
326   c   075E                call wpdisk();
327   c   0761
328   c   0761
329   c   0761          /*
330   c   0761                                    ROVEC Test
331   c   0761          */
332   c   0761
333   c   0761          put skip list('  Read/Only Vectors'  ,rovec());
334   c   0788
335   c   0788
336   c   0788          /*
337   c   0788                Disk Parameter Block Decoding
338   c   0788                                    Using GETDPB
339   c   0788          */
340   c   0788
341   c   0788          dcl
342   c   0788                dpbp ptr,
343   c   0788                1 dpb based (dpbp),
344   c   0788                    2 spt fixed(15),
345   c   0788                    2 bsh fixed(7),
```

```
346   c   0788                    2 blm bit(8) ,
347   c   0788                    2 exm hit(8) ,
348   c   0788                    2 dsm bit(16),
349   c   0788                    2 drm bit(16),
350   c   0788                    2 al0 bit(8),
351   c   0788                    2 all bit(B),
352   c   0788                    2 cks bit(16),
353   c   0788                    2 off fixed(7);
354   c   0788          dpbp = qetdpbo;
355   c   078E          put edit('  Disk Parameter Block:'  ,
356   c   08C6                'spt'  ,spt,'  bsh'  ,bsh,'  blm'  ,blm,
357   c   08C6                'exm',exm,'  dsm',dsm,'  drm',drm,
358   c   08C6                1al0'  ,al0,'all'  ,all,'cks',cks,
359   c   08C6                'off"off)
360   c   08C6                (skip,a,2(skip,a(4) f (6)
361   c   08C6                      4(skip,a(4),b4),
362   c   08C6                      skip,2(a(4),b,x(l)),
363   c   08C6                      skip,a(4),b4,
364   c   08C6                      skip,a(4),f(6));
365   c   08C6
366   c   08C6          /*
367   c   08C6
368   c   08C6                   Test          Get/Set user Code
369   c   08C6                      GETUSR, SETUSR
370   c   08C6          */
371   c   08C6
372   c   08C6          put skip list
373   c   08FC                ('  User is'  ,qetusr(),'  , New User:'  );
374   c   08FC          get list(i);
375   c   0914          call setusr(i);
376   c   0920
377   c   0920          /*
378   c   0920
379   c   0920                      FILSIZ, SETREC,
380   c   0920                   RDRAN, 14RRA.N, WRRANZ are
381   c   0920                      tested in DIORAND
382   c   0920
383   c   0920          */
384   c   0920
385   c   0920          /*
386   c   0920
387   c   0920                   Test Drive Reset RESDRV
388   c   0920                      (version      2.2 or newer)
389   c   0920
390   c   0920          */
391   c   0920          dcl
392   c   0920                drvect bit(16);
393   c   0920          put list('  Drive Reset Vector:'  );
394   c   0937          qet list(drvect);
395   c   094F          call resdrv(drvect);
396   c   0955
397   c   0955
398   c   0955
399   c   0955
400   c   0955
401   a   0955          end diotst;

CODE SIZE = 0958
DATA AREA = 04BA
```

APPENDIX C:

LISTING OF "DIOCOPY"
SHOWING DIRECT CP/M FILE 1/0 OPERATIONS

PL/I-80 V1.0, COMPILATION OF: DIOCOPY

L: List Source Program

```
%include 'diomod.dcl'  ;
%include ‘fcb.dcl'  ;
%include ‘fcb.dcl'  ;
%include 'fcb.dcl'  ;
%include 'fcb.dcl'  ;
```

NO ERROR(S) IN PASS 1

NO ERROR(S) IN PASS 2

PL/I-80 V1.0, COMPILATION OF: DIOCOPY

```
 1    a   0000 diocopy:
 2    a   0006          proc options(main);
 3    a   0006          /* file to file copy program */
 4    a   0006          /* (all source lines begin with tabs) */
 5    a   0006
 6    c   0006          %replace
 7    c   0006                bufwds      by 64,          /* words per buffer */
 8    c   0006                quest       by 63,          /* ASCII */
 9    c   0006                true        by '  1'  b,
10    c   0006                false       by '  0'  b;
11    c   0006
12+c  0006          dcl
13+c  0006                memptr entry                          returns (ptr),
14+c  0006                memsiz      entry                     returns       (fixed(15)),
15+c  0006                memwds      entry                     returns       (fixed(15)),
16+c  0006                dfcbo       entry                     returns       (ptr),
17+c  0006                dfcbl       entry                     returns       (ptr),
18+c  0006                dbuff       entry                     returns       (ptr),
19+c  0006                reboot      entry,
20+c  0006                rdcon       entry                     returns (char(l)),
21+c  0006                wrcon       entry                     (char(l)),
22+c  0006                rdrdr       entry                     returns (char(l)),
23+c  0006                wrpun       entry                     (char(l)),
24+c  0006                wrlst       entry                     (char(l)),
25+c  0006                coninp      entry                     returns (char(l)),
26+c  0006                conout      entry                     (char(l)),
27+c  0006                rdstat      entry                     returns (bit(l)),
28+c  0006                getio       entry                     returns (bit(8)),
29+c  0006                setio       entry                     (bit(8)),
30+c  0006                wrstr       entry                     (ptr),
31+c  0006                rdbuf       entry                     (ptr),
32+c  0006                break       entry                     returns (bit(l)),
33+c  0006                vers        entry                     returns (bit(16)),
34+c  0006                reset       entry,
35+c  0006                select      entry                      (fixed(7)),
36+c  0006                open        entry       (ptr)         returns       (fixed(7)),
37+c  0006                close       entry       (ptr)         returns       (fixed(7)),
38+c  0006                sear        entry       (ptr)         returns       (fixed(7)),
39+c  0006                searn       entry                     returns       (fixed(7)),
40+c  0006                delete      entry       (ptr),
41+c  0006                rdseq       entry       (ptr) returns (fixed(7)),
```

```
 42+c    0006                wrseq       entry          (ptr)        returns (fixed(7)),
 43+c    0006                make        entry          (ptr)        returns (fixed(7)),
 44+c    0006                rename      entry          (ptr) ,
 45+c    0006                loqvec      entry                       returns (bit(16)),
 46+c    0006                curdsk      entry                       returns (fixed(7)),
 47+c    0006                setdma      entry                       (ptr),
 48+c    0006                allvec      entry                       returns (ptr),
 49+c    0006                wpdisk      entry,
 50+c    0006                rovec       entry                       returns (bit(16)),
 51+c    0006                filatt      entry                       (ptr),
 52+c    0006                qetdpb      entry                       returns (ptr),
 53+c    0006                qetusr      entry                       returns (fixed(7)),
 54+c    0006                setusr      entry          (fixed(7)),
 55+C    0006                rdran       entry          (ptr)        returns (fixed(7)),
 56+c    0006                wrran       entry          (ptr)        returns (fixed(7)),
 57+c    0006                filsiz      entry          (ptr),
 58+c    0006                setrec      entry          (ptr),
 59+c    0006                resdrv      entry                       (bit(lr))
 60+c    0006                wrranz entry               (ptr) returns (fixed(7));
 61 c    0006
 62 c    0006          dcl
 63 c    0006              1   destfile,
 64+c    0006                  2namel,
 65+c    0006                      3 drive fixed(7),                  /*drive number */
 66+c    0006                      3 fname char(8),                   /* file name */
 67+c    0006                      3 ftype char(3),                   /* file type */
 68+c    0006                      3 fext fixed(7),                   /*file extent */
 69+c    0006                      3 space (3) bit(8),/* filler */
 70+c    0006                  2 name2,                               /*used in rename */
 71+c    0006                      3   drive2       fixed(7),
 72+c    0006                      3   fname2       char(B),
 73+c    0006                      3   ftype2       char(3),
 74+c    0006                      3   f ext2       fixed(7)
 75+c    0006                      3   space2       (3) bit(4)
 76+c    0006                  2 crec          f ixed (7 ) ,          /* current record */
 77+c    0006                  2 rrec          fixed(15),             /*random record */
 78+c    0006                  2 rovf          fixed(7);              /* random rec overflow */
 79 c    0006
 80 c    0006          dcl
 81 c    0006              dfcbop ptr,
 82 c    0006              1sourcefile based(dfcb0p),
 83+c    0006                  2namel,
 84+c    0006                      3 drive fixed(7),                  /*drive number */
 85+c    0006                      3   fname      char(8),            /*      file name */
 86+c    0006                      3   ftype      char(3),            /*      file type */
 87+c    0006                      3   fext       fixed(7),           /*      file extent */
 88+c    0006                      3   space      (3) bit(8)          /*      filler */
 89+c    0006                  2 name2,                               /*used in rename */
 90+c    0006                      3   drive2       fixed(7),
 91+c    0006                      3   fname2       char(8),
 92+ c   0006                      3   ftype2       char(3) ,
 93+c    0006                      3   fext2        fixed(7)
 94+c    0006                      3   space2       (3) bit(4),
 95+c    0006                  2 crec          fixed(7),              /* current record */
 96+c    0006                  2 rrec          fixed(15),             /*random record */
 97+c    0006                  2 rovf          fixed(7);              /* random rec overflow */
 98 c    0006
 99 c    0006          dcl
100 c    0006              1   dfcblfile based(dfcbl()),
101+c    0006                  2 namel,
```

```
102+c   0006                    3   drive       fixed (7)          /*    drive number */
103+c   0006                    3   fname       char(8),           /*    file name */
104+c   0006                    3   ftype       char(3),           /*    file type */
105+c   0006                    3   fext        fixed(7),          /*    file extent */
106+c   0006                    3   space       (3) bit(8),/*      /*    filler */
107+c   0006                2 name2,                               /*    used in rename */
108+c   0006                    3   drive2      fixed(7),
109+c   0006                    3   fname2      char(8),
110+c   0006                    3   ftype2      char(3),
111+c   0006                    3   fext2       fixed(7),
112+c   0006                    3   space2      (3) bit(8),
113+c   0006                2 crec          fixed(7),          /* current record */
114+c   0006                2 rrec          fixed(15),         /*random record */
115+c   0006                2 rovf          fixed(7);          /* random rec overflow */
116 c   0006
117 c   0006          dcl
118 c   0006                    1 renfile,
119+c   0006                    2 namel,
120+c   0006                    3 drive fixed(7),              /*drive number */
121+c   0006                    3 fname char(B),               /* file name */
122+c   0006                    3 ftype char(3),               /* file type */
123+c   0006                    3 fext fixed(7),               /*file extent */
124+c   0006                    3space (3) bit(8),/* filler */
125+c   0006                2 name2,                           /*used in rename */
126+c   0006                    3   drive2      fixed(7),
127+c   0006                    3   fname2      char(8),
128+c   0006                    3   ftype2      char(3),
129+c   0006                    3   fext2       fixed(7),
130+c   0006                    3   space2      (3) bit(8),
131+c   0006                2 crec          fixed(7),          /* current record */
132+c   0006                2 rrec          fixed(15),         /*random record */
133+c   0006                2 rovf          fixed(7);          /*random rec overflow */
134  c   0006
135  c   0006          dcl
136  c   0006                answer char(l),
137  c   0006                extcnt fixed(7);
138  c   0006
139  c   0006          dcl
140  c   0006                /* buffer management */
141  c   0006                eofile bit(8),
142  c   0006                i              fixed(15),
143  c   0006                m              fixed(15),
144  c   0006                nbuffs fixed(15),
145  c   0006                memory (0:0) bit(16) based(memptro);
146  c   0006
147 c   0006          /*compute number of buffs, 64 words each */
148 c   0006          nbuffs = divide (memwds (), bufwds, 15);
149 c   0017          if nbuffs = 0 then
150 c   0020                do;
151 c   0020                put skip list('  No Buffer Space'   );
152  c   003C                call rebooto;
153  c   003F                end;
154  c   003F
155  c   003F          /* initialize fcb'  s */
156  c   003F          dfcb0p = dfcb0();
157  c   0045          destfile = dfcblfile;
158  c   0054
159  c   0054          /* copy fcb to rename file, count extents */
160  c   0054          renfile = destfile;
161  c   0060          /* search all extents by inserting '?' */
```

```
162  c  0060          renfile.fext = quest;
163  c  0065          if sear(addr(renfile)) ^= -1 then
164  c  0076                  do;
165  c  0076                  extcnt = 1;
166  c  007B                          do while(searno ^= -1);
167  c  0083                          extcnt = extcnt + 1;
168  c  008A                          end;
169  c  008A                  put edit
170  c  00C1                          ('OK to Delete ',extcnt, ' Extent(s) ?(Y/N)');
171  c  00C1                          (skip,a,f (3), a);
172  c  00Cl                  get list(answer);
173  c  00DB                  if ^ (answer = '  Y'   | answer = 'y'  ) then
174  c  00FF                          call reboot();
175  c  0102                  end;
176  c  0102
177  c  0102          /* destination file will be deleted later */
178  c  0102          destfile.ftype = '  $$$'  ;
179  c  010E          /* delete any existing x.$$$ file */
180  c  010E          call delete(addr(destfile));
181  c  011A
182  c  011A          /* open the source file, if possible */
183  c  011A          if open(addr(sourcefile)) = -1 then
184  c  012B                  do;
185  c  012B                  put skip list('  No Source File'  );
186  c  0147                  call reboot();
187  c  014A                  end;
188  c  014A
189  c  014A          /* source file opened, create $$$ file */
190  c  014A          destfile.fext = 0;
191  c  014F          destfile.crec = 0 ;
192  c  0154          if make(addr(destfile)) = -1 then
193  c  0165                  do;
194  c  0165                  put skip list('  No Directory Space'  );
195  c  0181                  call reboot();
196  c  0184                  end;
197  c  0184
198  c  0184          /* $$$ temp file created, now copy from source */
199  c  0184          eofile = false;
200  c  0189                  do while (^eofile);
201  c  0190                  m = 0;
202  c  0196                          /* fill buffers */
203  c  0196                          do i = 0 relDeat (i+l) while (i<nbuffs);
204  c  0lA6                          call setdma(addr(memory(m)));
205  c  0189                          m = m + bufwds;
206  c  0lC3                          if rdseq(addr(sourcefile))  ^= 0 then
207  c  01D4                                  do;
208  c  01D4                                  eofile = true;
209  c  01D9                                  /* truncate buffer */
210  c  01D9                                  nbuffs = i;
211  c  01E9                                  end;
212  c  01E9                          end;
213  c  01E9                  M = 0;
214  c  01EF                          /* write buffers */
215  c  01EF                          do i = 0 to nbuffs-1;
216  c  0206                          call setdma(addr(memory(m)));
217  c  0219                          m = m + bufwds;
218  c  0223                           if wrseq(addr(destfile)) ^= 0 then
219  c  0234                                  do;
220  c  0234                                  put skip list('  Disk Full'  );
221  c  0250                                  call reboot();
```

```
222     c   0260                                    end;
223     c   0260                                end;
224     c   0260                            end;
225     c   0260
226     c   0260                    /*close destination file and rename */
227     c   0260                     if close(addr(destfile)) = -1 then
228     c   0271                            do;
229     c   0271                            put skip list('  Disk R/O'   );
230     c   028D                            call reboot();
231     c   0290                            end;
232     c   0290
233     c   0290                    /* destination file closed, erase old file */
234     c   0290                     call delete(addr(renfile));
235     c   029C
236     c   029C                    /* now rename $$$ file to old file name */
237     c   029C                    destfile.name2 = renfile.namel;
238     c   02AB                    call rename (add r(destfile)
239     c   02B7                    call reboot();
240     a   02BA                    end diocopy;

CODE SIZF   =  02BD
DATA AREA =  00EF
```

APPENDIX D:

LISTING OF "DIORAND"
SHOWING EXTENDED RANDOM ACCESS CALLS

PL/I-80 V1.0, COMPILATION OF: DIORAND

L: List Source Program

%include 'diomod.dcl' ; %includefcb.dcl' ; NO ERROR(S) IN PASS 1

NO ERROR(S) IN PASS 2

PL/I-80,Vl.O, COMPILATION OF: DIORAND

```
 1  a 0000 diorand:
 2  a 0006          proc options(main);
 3  a 0006          /* random access tests for 2.0 and 2.2 */
 4  a 0006
 5+c 0006         dcl
 6+c 0006                 memptr    entry                  returns (ptr),
 7+c 0006                 memsiz    entry                  returns       (fixed(15)),
 8+c 0006                 memwds    entry                  returns       (fixed(15)),
 9+c 0006                 dfcb0     entry                  returns       (ptr),
10+c 0006                 dfcbl     entry                  returns       (pt r) ,
11+c 0006                 dbuff     entry                  returns       (ptr),
12+c 0006                 reboot   entry,
13+c 0006                 rdcon     entry                  returns (char(l)),
14+c 0006                 wrcon     entry                  (char(l)),
15+c 0006                 rdrdr     entry                  returns (char(l)
16+c 0006                 wrpun     entry                  (char(l)),
17+c 0006                 wrlst     entry                  (char(l)),
18+c 0006                 coninp    entry                  returns (char(l)),
19+c 0006                 conout    entry                  (char(l) ),
20+c 0006                 rdstat    entry                  returns (bit(l)),
21+c 0006                 getio     entry                  returns (bit(8)),
22+c 0006                 setio     entry                  (bit(8)),
23+c 0006                 wrstr     entry                  (ptr),
24+c 0006                 rdbuf     entry                  (ptr),
25+c 0006                 break     entry                  returns (bit(l)),
26+c 0006                 vers      entry                  returns (bit(16)),
27+c 0006                 reset     entry,
28+c 0006                 select   entry                    (fixed(7)),
29+c 0006                 open      entry       (ptr)      returns       (fixed(7)),
30+c 0006                 close     entry       (ptr)      returns       (fixed(7)),
31+c 0006                 sear      entry       (ptr)      returns       (fixed(7)),
32+c 0006                 searn     entry                  returns       (fixed(7)),
33+c 0006                 delete    entry       (ptr),
34+c 0006                 rdseq     entry       (ptr)      returns (fixed(7)),
35+c 0006                 wrseq     entry       (ptr)      returns (fixed(7)),
36+c 0006                 make      entry       (ptr)      returns (fixed(7)),
37+c 0006                 rename    entry       (ptr),
38+c 0006                 logvec    entry                  returns (bit(16)),
39+c 0006                 curdsk    entry                  returns (fixed(7)),
40+c 0006                 setdma    entry                  (ptr),
41+c 0006                 allvec    entry                  returns (ptr),
42+c 0006                 wpdisk    entry,
43+c 0006                 rovec     entry                  returns (bit(16)),,
44+c 0006                 filatt    entry                  (ptr),
```

```
 45+c 0006                    getdpb      entry                       returns (ptr),
 46+c 0006                    qetusr      entry                       returns (fixed(7)),
 47+c 0006                    setusr      entry           (fixed(7)),
 48+c 0006                    rdran       entry           (ptr)       returns (fixed(7)),
 49+c 0006                    wrran       entry           (ptr)       returns (fixed(7)),
 50+c 0006                    filsiz      entry           (ptr),
 51+c 0006                    setrec      entry           (ptr),
 52+c 0006                    resdrv      entry                       (bit(16)
 53+c 0006                    wrranz      entry           (ptr)       returns (fixed(7));
 54  c 0006
 55  c 0006          dcl
 56  c 0006                   1   database,
 57+c 0006                       2 namel,
 58+c 0006                           3 drive fixed(7),                   /*drive number */
 59+c 0006                           3 fname char(8),                    /* file name */
 60+c 0006                           3 ftype char(3),                    /* file type */
 61+c 0006                           3 fext fixed(7),                    /*file extent */
 62+c 0006                           3 space (3) bit(8),                /* filler */
 63+c 0006                       2 name2,                                /*used in rename */
 64+c 0006                           3   drive2       fixed(7),
 65+c 0006                           3   fname2       char(8),
 66+c 0006                           3   ftype2       char(3),
 67+c 0006                           3   fext2        fixed(7),
 68+c 0006                           3   space2       (3) bit(B)
 69+c 0006                       2 crec          fixed(7),               /* current record */
 70+c 0006                       2 rrec          fixed(15),              /*random record */
 71+c 0006                       2 rovf          fixed(7);               /* random rec overflow */
 72 c 0006
 73 c 0006          dcl
 74 c 0006                   lower char(26) static initial
 75 c 0006                   ('abcdefghijklmnopqrstuvwxyz'),
 76 c 0006                   upper char(26) static initial
 77 c 0006                   ('  ABCDEFGHIJKLMNOPQRSTUVWXYZ');
 78 c 0006
 79 c 0006          dcl
 80 c 0006                   /* simple variables */
 81 c 0006                   i               fixed,
 82 c 0006                   fn              char(20),
 83 c  0006                  c               char(l),
 84 c  0006                  code            fixed(7),
 85 c  0006                  mode            fixed(2),
 86 c  0006                  zerofill        bit(l),
 87 c  0006                  version         bit(16);
 88 c  0006
 89 c  0006          dcl
 90 c  0006                  /* overlays on default buffer */
 91 c  0006                  bitbuf (128) bit(8) based(dbuffo),
 92 c  0006                  buffer char(127) var based(dbuffo);
 93 c  0006
 94 c  0006          put skip list('  Random Access Test'  );
 95 c  0022          /* check version number for 2.0 */
 96 c  0022          version = vers();
 97 c  0028          if substr(version,9,8) < '  20'  b4 then
 98 c  0031                  do;
 99 c  0031                  put skip list('  You Need Version 2');
100 c  004D                  stop;
101 c  0050                  end;
102 c  0050          putskip list(Zero Record Fill?'  );
103 c  006C          qet list(c);
104 c  0086          zerofill = (c = '  Y'   ! c = '  y'  ) &
```

```
105 c   00B5                substr(version,9,8) >= '  22'  b4;
106 c   00B5
107 c   00B5            /* read and process file name  */
108 c   00B5            put skip list('  Data Base Name:  ');
109 c   00D1            get list(fn);
110 c   00EB            fn = translate(fn,upper,lower);
111 c   0110
112 c   0110            /* process optional drive prefix */
113 c   0110            i = index(fn,'  :'  );
114 c   0120            if i = 0 then
115 c   0129                    drive = 0;
116 c   0131            else
117 c   0131            if i = 2 then
118 c   013B                    do;
119 c   013B                    /* convert character to drive code */
120 c   013B                    drive = index(upper,substr(fn,l,l));
121 c   0153                    if drive = 0 ! drive > 16 then
122 c   016C                            do;
123 c   016C                            put skip list('  Bad Drive Name'  );
124 c   0188                            stop;
125 c   018B                            end;
126 c   018B                    fn = substr(fn,i+l);
127 c   01A4                    end;
128 c   01A4
129 c   01A4            /* get file name and optional type */
130 c   01A4            i           index(fn,'  .'  );
131 c   01B4            if i = 0 then
132 c   01BD                    do;
133 c   01BD                    /* no file type specified, use DAT */
134 c   01BD                    fname = fn;
135 c   01CA                    ftype = '  DAT';
136 c   01D9                    end;
137 c   01D9            else
138 c   01D9                    do;
139 c   01D9                    fname = substr(fn,l,i-1);
140 c   01F5                    ftype = substr(fn,i+l);
141 c,  020F                    end;
142 c   020F
143 c   020F            /* clear the extent field */
144 c   020F            fext = 0;
145 c   0214
146 c   0214            if open(addr(database)) = -1 then
147 c   0225                    do;
148 c   0225                    put skip list('Creatinq New Database'  );
149 c   0241                    if make(addr(database)) = -1 then
150 c   0252                            do;
151 c   0252                            put skip list('  No Directory Space'  );
152 c   026E                            stop;
153 c   0274                            end;
154 c   0274                    end;
155 c   0274            else
156 c   0274                    do;
157 c   0274                    call filsiz(addr(database));
158 c   0280                    put skip list('  FilSize:'  ,rrec,'   Records'  );
159 c   02B2                    end;
160 c   02B2
161 c   02B2            /* main processing loop */
162 c   02B2                    do while( '  1'  b) ;
163 c   0282                    call setrec(addr(database));
164 c   02BE                    out skip list('  CurrenRecord'  ,rrec);
```

```
165 c   02E5                    put     skip list('  Read(0),Write(l),Quit(2)? ');
166 c   0301                    get     list(mode);
167 c   031A                    if mode < 2 then
168 c   0322                            do;
169 c   0322                            put skip list('Record Number? ');
170 c   033E                            get list(rrec);
171 c   035B                            rovf = 0;
172 c   0360                            end;
173 c   0360                    if mode = 0 then
174 c   0367                            do;
175 c   0367                            code = rdran(addr(database));
176 c   0376                            if code = 0 then
177 c   037D                                    do;
178 c   037D                                    if bitbuf(l) = '  00'  b4 then
179 c   0386                                            put skip list('  Zero Record'  );
180 c   03A5                                    else
181 c   03A5                                            put skip list(buffer);
182 c   03C2                                    end;
183 c   03C2                            else
184 c   03C2                                    put skip list('Return Code'  ,code);
185 c   03F0                            end;
186 c   03F0                    else
187 c   03F0                    if mode = 1 then
188 c   03F7                            do;
189 c   03F7                            put skip list('  Data: ');
190 c   0413                            get list(buffer);
191 c   042F                            if zerofill then
192 c   0436                                    code = wrranz(addr(database));
193 c   0448                            else
194 c   0448                                    code = wrran (addr(database));
195 c   0457                            if code ^= 0 then
196 c   045E                                    put skip list('  ReturnCode',code);
197 c   048C                            end;
198 c   048C                    else
199 c   048C                    if mode = 2 then
200 c   0494                            do;
201 c   0494                            if close(addr(database)) = -1 then
202 c   04A5                                    put skip list('  Read/only'  );
203 c   04C1                            stop;
204 c   04C7                            end;
205 c   04C7                    end;
206 a   04C7            end diorand;

CODE SIZE = 04C7
DATN AREA = 0183
```

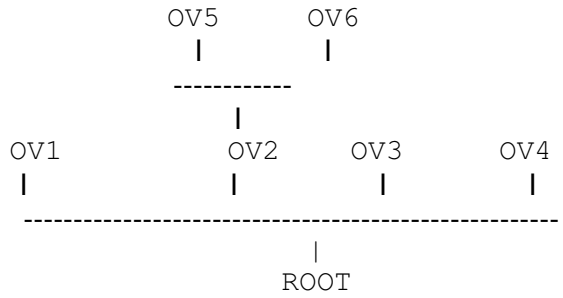
APPENDIX E

OVERLAYS AND PILE LOCATION CONTROLS

This appendix describes several additional features incorporated into LINK-80 and LIB-80 in release versions later than 1.0, including extensions to process run-time overlays, and controls for location of source, intermediate, and destination files. Use of the automatic PL/I-80 library search "request item" is included, along with a description of new command line error reporting formats. Additional LIB-80 facilities are also included for deleting or replacing various modules in a subprogram library.

E.1.0. OVERLAYS

LINK may be used to produce a simple tree structure of overlays as shown in the diagram below:



In addition to producing ROOT.COM and ROOT.SYM files, LINK will produce an OVL file and a SYM file for each overlay specified in the command line. The OVL file consists of a 256-byte header containing the load address and length of the overlay, followed by the absolute object code. The origin of an overlay is the highest address of th: module below it on the 'tree' rounded up to the next 128-byte boundary. The stack and free space for the PL/I program will be located at the top of the highest overlay linked, rounded up to the next 128-byte boundary. This address is written to the console upon completion of the entire link and is patched into the root module in the location '?MEMRY'. The SYM file contains only those symbols which have not been declared in another module lower in the 'tree'.

The following restrictions must be observed when producing a system of overlays with PL/I-80 and LINK:

Each overlay has one entry point by which it is entered. This entry point is assumed by the overlay manager to be at the base (load address) of the overlay.

No upward references are allowed from a module to an entry point in an overlay higher on the tree, other than the main entry point of the overlay as described in 1. Downward references to entry points in overlays lower on the tree or in the root module are allowed.

The overlays are not relocatable. Hence the root module must be a COM file.

Common blocks (Externals in PL/I) which are declared in one module may not be initialized by a module higher in the tree. Any attempt to do so will be ignored by LINK.

Overlays may be nested to a depth of 5 levels.

The default buffer located at 80H is used by the overlay manager, so user programs should not depend on data stored in this buffer.

E.1.1. USING OVERLAYS IN PL/I PROGRAMS

There are two ways to use overlays in a PL/I program. The first method is very straightfor--7ard, and will suffice for most applications. However, it has the restrictions that all overlays must be on the default drive, and overlay names may not be determined at run-time. The second method does not have these restrictions, and involves a slightly more complicated calling sequence.

To use the first method, an overlay is simply declared as an entry constant in the module where it is referenced. As an entry constant, it may have parameters declared in a parameter list. The overlay itself is simply a PL/I procedure, or group of procedures. For example, the following program is a root module having one overlay:

```
root: procedure options (main);
   declare ovl entry (char (15));
   put skip list (‘root');
   call ovl ('overlay l');
   end root;
```

The overlay OV1.PLI appears as follows:

```
ovl: procedure (c);
   declare c char (15);
   put skip list (c)
   end ovl;
```

Note that if parameters are passed to an overlay, it is the programmer's responsibility to ensure that the number and type of the parameters are the same in the calling program and the overlay itself.

To link these two programs into an overlay system, the following link command would be used:

```
LINK ROOT(OV1)
```

(The command line syntax for linking overlays is described in detail in a later section.)

LINK will produce four files from this command: ROOT.COM, ROOT.SYM, OVl.OVL and OV1.SYM. When ROOT.COM is executed, it will first put the message 'root' out at the console. The 'call ovl' statement will transfer control to the overlay manager. The overlay manager loads the file OVl.OVL from the default drive at the proper location above ROOT.COM and transfers control to it, passing the char (15) parameter in the normal manner. The overlay then executes, producing the message ᴀ overlay 1' at the console. It then return s directly to the statement following the 'call ov1' in root.pli, and execution continues from that point.

Using this method, if the overlay manager determines that the requested overlay is already in memory, the overlay will not be reloaded before control is transferred to it. There are several important notes regarding this first overlay method:

The name associated with the overlay in the call and entry statements is the actual name of the OVL file loaded by the overlay manager, so the two names must agree. Since symbol names are truncated to 6 characters in the REL file produced by PL/I-80, the names of the OVL files must be limited to 6 characters.

The name of the entry point to an overlay (the name of the procedure) need not agree with the name used in the calling sequence. The same name should be used to avoid confusion.

The overlay manager will only load overlays from the default drive (the drive which was the default drive when execution of the root module began, regardless of any changes to the default drive which may have occurred since then).

The names of the overlays are fixed - the source program must be edited, recompiled and relinked to change the names of the overlays.

No non-standard PL/I statements are needed (the program is transportable to other systems).

In some applications it is useful to have greater flexibility with overlays, such as the ability to load overlays from different drives, or the ability to determine the name of an overlay at run-time, say from the keyboard or from a disk file. This is accomplished using a second overlay method.

In this case, an explicit entry point into the overlay manager must be declared in the PL/I program as follows:

```
declare ?ovlay entry (char (10), fixed (1));
```

The first parameter is a character string specifying the name of the overlay to load and an optional drive code in the standard CP/M format 'd:filename'. The second parameter is the load flag. If the load flag is 1, the overlay manager will load the specified overlay whether or not it is already in memory. If the load flag is 0, the overlay will only be loaded if it is not already in memory.

The 'call ?ovlay' statement tells the overlay manager to load the requested overlay, if needed. The overlay manager returns to the calling program, which must then perform a dummy call to execute the overlay just processed by the overlay manager. This allows a parameter list to be passed to the overlay.

The example shown in the first method above would appear as follows:

```
root: procedure options (main);
   declare ?ovlay entry (char (10), fixed (1));
   declare dummy entry (char (15));
   declare name char (10);
   put skip list (‘root'); name = 'OV1';
   call ?ovlay (name, 0);
   call dummy ('overlay 1');
   end root;
```

OV1.PLI would be the same as before.

At run-time the overlay manager would load OV1.OVL from the default drive, since that is the current value of the variable 'name', and then return to the calling program (in this case, root). At this point, the argument 'overlay 1' would be set up according to the PL/I-80 parameter passing conventions. The 'call dummy' transfers control to the overlay manager, which would simply transfer control to the base address of the overlay whose name was just processed. When OV1 is finished, it returns to the statement following the 'call dummy’ statement. **Note that while in the example above, 'name' was set to 'OV1'** in an **assignment statement, the overlay name** could have been supplied as a character string derived from some other source,

such as the operator's keyboard. Several important points must be observed when using the second overlay technique:

A drive code may be specified so overlays may be loaded from drives other than the default drive. If no drive is specified, the default drive is used as described in Method 1.

Since the name of the overlay is specified in the character string (and not by the entry symbol), it may be up to 8 characters in length.

If there are any parameters in the dummy call following the ^call ?ovlay', they must agree in number and type with the parameters in the procedure declaration in the overlay.

E.1.2. SPECIFYING OVERLAYS IN THE COMMAND LINE

The syntax for specifying overlays is similar to that for linking without overlays, except that each overlay specification is enclosed in parentheses. An overlay specification may be in one of the following forms:

```
link root(ovl)
link root(ovl,part2,part3)
link root(ovl=partl,part2,part3)
```

The first command produces the file OVl.OVL from a file OV1.REL, while the second command produces the OVl.OVL file from OV1.REL, PART2.REL, and PART3.REL. In the last case, the OV1.OVL file is produced from PART1.RLE, PART2.REL, and PART3.REL.

Note that a left parenthesis, which indicates the start of a new overlay specification, also indicates the end of the group preceding it. In other words, the following command line is invalid and will be flagged as an error:

```
LINK ROOT(OV1),MOREROOT
```

All files to be included at any point on the 'tree' must appear together, without any intervening overlay specifications. Thus the following command is valid:

```
LINK ROOT,MOREROOT(OV1)
```

Any filename in the command line may be followed by a number of link switches enclosed in square brackets, as described in the LINK-80 Operator's Guide. Note that the overlay specifications are not set

off from the root module or from each other with commas. Spaces may be used to improve readability.

Nesting of overlays is indicated in the command line by nesting parentheses. The following command line could be used to link the overlay system shown on the first page of the overlay description:

```
LINK ROOT (OV1) (OV2 (OV5) (OV6)) (OV3) (OV4)
```

E.1.3. SAMPLE LINK EXECUTION

In the following sample link operation, notice that OV1 is flagged as an undefined symbol. LINK is simply indicating that OV1 has not been defined in the current module, so it is assumed to be either the name of an overlay or a dummy entry point to an overlay. When linking overlays, each entry variable which refers to an overlay (by actual name or a dummy entry) will appear as an undefined symbol. No symbols other than these actual or dummy overlay entry points should be undefined.

```
A>LINK ROOT(OV1)
LINK 1. 1

PLILIB   RQST   ROOT     0100   ISYSINI  1A15   /SYSPRI/lA3A

UNDEFINED SYMBOLS:

Ov1

ABSOLUTE     0000
CODE SIZE    18BC  (0100-19BB)
DATA SIZE    02A9  (lA90-lD38)
COMMON SIZE  OOD4  (19BC-lA8F)
USE FACTOR     4E

LINKING OV1.OVL

PLILIB   RQST

ABSOLUTE     0000
CODE SIZE    0024 (lD80-lDA3)
DATA SIZE0002 (lDA4-IDA5)
COMMON SIZE  0000
USE FACTOR     09
MODULE TOP   lEO0
```

```
A>ROOT

root overlay 1
End of Execution
A>
```

E.1.4. RUN-TIME ERROR MESSAGES

The overlay manager may produce one of the following error messages:

ERROR (8) OVERLAY, NO FILE d:filename.OVL The indicated file could not be found.

ERROR (9) OVERLAY, DRIVE d:filename.OVL
An invalid drive code was passed as a parameter to ?ovlay.

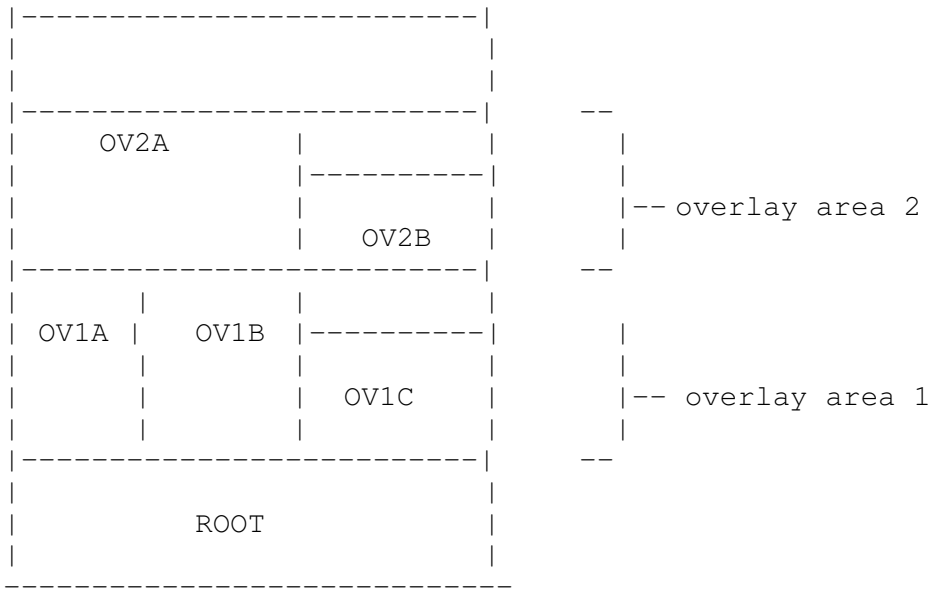
ERROR (10) OVERLAY, SIZE d:filename.OVL
The indicated overlay would overwrite the PL/I stack and/or free space if it were loaded.

ERROR (11) OVERLAY, NESTING d:filename.OVL Loading the indicated overlay would exceed the maximum nesting depth.

ERROR (12) OVERLAY, READ d:filename.OVL
Disk read error during overlay load, probably caused by premature EOF.

E.1.5. OTHER OVERLAY SYSTEMS

A system of overlays may also be produced which is not a tree structure, but rather contains a number of separate overlay areas, as shown in the figure below:



In such a system, the root module can reference any of the overlays. An overlay may reference entry points in the root module or the main entry point of any overlay which is not in the same overlay area.

Linking a system of overlays as shown above is done in a number of steps. One link must be performed for each overlay area, since the address of the top of the overlay area must be supplied to LINK when linking the next higher overlay area. For example, the command

```
LINK ROOT (OV1A)(OVlB)(OVIC)
```

generates the three overlays in overlay area 1, and indicates the top address of the module. This address is supplied as the load address in the next command:

```
LINK ROOT (OV2A[Lmod top]) (OV2B [Lmod top])
```

This command creates the overlays for overlay area 2 at the appropriate address. Note that the overlay area which is the highest in memory should be linked last, since the module top address is always written into the root module at the end of the link.

At some point after the entire system has been linked, it may be desirable to relink only one overlay, which may not be at the top overlay area. This may be done using the $OZ switch to prevent generation of a root module which would contain an erroneous ?MEMRY value.

It is the responsibility of the programmer to ensure that none of the overlays overlap, and that no overlay attempts to reference

another overlay in the same overlay area.

E.1.6. THE LINK-80 "$" SWITCH

The '$' switch is used to control the source and destination devices under LINK-80. The general form of the switch is:

$td

where 't' is a type and 'd' is a drive specifier. There are five types:

C - console

I - intermediate

L - library

0 - object

S - symbol

The drive specifier may be a letter in the range 'A' thru 'P' corresponding to one of sixteen logical drives, or one of the following special characters:

X - console

Y - printer

Z - byte bucket

$Cd - Console

Messages which normally appear at the console may be directed to the list device ($CY) or may be suppressed ($CZ). Once $CY or $CZ has been specified, $CX may be used later in the command line to redirect console messages to the console device.

$Id - Intermediate

Intermediate files generated by LINK are normally placed on the default drive. The $1 switch allows the user to specify another drive to be used by LINK for intermediate files.

$Ld - Library

LINK normally searches on the default drive for library files

which are automatically linked because of a request item in a REL file. The $L switch instructs LINK to search the specified drive for these library files.

$Od - Object

LINK normally generates an object file on the same drive as the first REL file in the command line, unless an output file with an explicit drive is included in the command. The $0 switch instructs LINK to place the object file on the drive specified by the character following the $0, or to suppress the generation of an object file if the character following the $0 is a 'Z'.

$Sd - Symbol

LINK normally generates a symbol file on the same drive as the first REL file in the command line, unless an output file with an explicit drive is included in the command. The $S switch instructs LINK to place the symbol file on the drive specified by the character following the $S, or to suppress the generation of a symbol file if the character following the $S is a 'Z'.

ᴀtd' character pairs following a '$A must not be separated by commas. The entire group of $ switches is set off from any other switches by a comma, as shown below:

```
LINK PART1[$SZ,$OD,$LB,Q1,PART2

LINK PART1[$SZODLB,Q1,PART2

LINK PART1[$SZ OD LBI,PART2[Q]
```

The three command lines above are equivalent.

The $I switch specifies the drive to be used for intermediate files during the entire link operation. The other '$' switches may be changed in the command line. The value of a '$A switch will remain in effect until it is changed as the command line is processed from left to right. This is generally useful only when linking overlays. For example:

```
LINK ROOT (OV1[$SZCZI)(OV2)(OV3)(OV4[$SACXI)
```

will suppress the SYM files and console output generated when OV1, OV2 and OV3 are linked. When OV4 is linked, the SYM file will be placed on drive A: and the console output will be sent to the console device.

The NR and NL switches used in LINK 1.0 to suppress the recording and listing of the symbol table are not recognized by LINK 1.1, since $SZ and $CZ can be used to perform these functions.

E.1.7. THE REQUEST ITEM

Version 1.1 of PL/I-80 uses the request item (a specific bit pattern in a REL file) to indicate to LINK that the PLILIB is to be searched. This is also how the Microsoft compilers link their run-time libraries. When LINK processes a library request, it first searches for an IRL file with the specified filename. If there is no IRL file, it searches for a REL file of that name. Failing in both searches, the error message

```
NO FILE: filename.REL
```

is produced, and LINK aborts. Libraries requested in this manner will appear in the symbol table listed at the console with a value of 'RQST'.

E.1.8. COMMAND LINE ERRORS

The error messages 'FILE NAME ERROR' and 'INVALID SYNTAX' are no longer generated. Instead, when a command line error of any kind is detected the command tail is echoed up to the point where the error occurred, followed by a question mark. For example:

```
LINK A, B, C; D A, B, C;?

LINK LONGFILENAME
LONGFILEN?
```

E.1.9. ADDITIONAL LIB-80 FACILITIES

Modules in a library may be deleted or replaced in a single command. The names of the modules to be affected are enclosed in angle brackets immediately following the name of the source file containing the modules. The following examples demonstrate the use of this feature.

```
lib newlib=oldlib<modl>

lib newlib=oldlib<modl=filel>

lib newlib=oldlib<modl=>

lib newlib=oldlib<modl,mod2=file2,mod3=>
```

In the first case, a new library NEWLIB.REL is created which is the same as OLDLIB.REL except that the module MOD1 is replaced by the

contents of the file MOD1.REL. This form should be used if the name of the module being replaced is the same as the filename of the REL file replacing the module.

In the second case, the module MOD1 is replaced by the contents of the file FILE1.REL in the new library NEWLIB.REL. This form is used to replace a module when the name of the module is not the same as the name of the file which is to replace it. Note that this form must be used if the filename has more than 6 characters, since module names in the REL file are truncated to 6 characters.

When the third command is used, NEWLIB.REL is created from OLDLIB.REL without the module MOD1.

The last command form demonstrates that a number of replace and/or delete instructions may be included within the angle brackets.

E.2.0. MULTI-LINE COMMANDS

If a command does not fit on a single line (126 characters), the command may be extended by terminating the command line with an ampersand W. The ampersand may appear after any character of the command, and need not follow a file name. LINK-80 responds with an asterisk (*) on the next line. At this point the command line may be continued. Any number of lines ending with an ampersand may be entered. The last line of the command is terminated with a carriage return. Note that XSUB may be used to submit multi-line LTNK-80 commands.

Example:

```
A>link main, iomodl, iomod2, iomod3, iomod4, iomod5,&
LINK 1.3
*libl[s], lib2fsl, lib3fsl, lib4&
*[s], lastmodrp2000&
*,d2001

( . . . symbol table and memory map . . .
```

APPENDIX F

XREF

XREF is an assembly-language cross reference utility that can be applied to print (PRN) files produced by MAC or RMAC in order to provide a summary of variable usage throughout the program. The purpose of this appendix is to provide the information necessary for operation of the XREF utility.

F.1.0. XREF OPERATION

XREF is normally invoked by issuing the command:

```
XREF filename
```

where the "filename" refers to two input files prepared using MAC or RMAC with assumed (and unspecified) file types of "PRN" and "SYM" and one output file with an assumed (and unspecified) file type of "XRF". Specifically, XREF reads the file "filename.PRN" line by line, attaches a line number prefix to each line and writes each prefixed line to the output file "filename.XRF". During this process, each line is scanned for any symbols that exist in the file "filename.SYM". Upon completion of this copy operation, XREF appends to the file "filename.XRF" a cross reference report that lists all the line numbers where each symbol in "filename.SYM" appears. In addition each line number reference where the referenced symbol is the firs token on the line is flagged with a "#" character. Also, the value of each symbol, as determined by MAC or RMAC and placed in the symbol table file "filename.SYM", is reported for each symbol.

As an option, the "filename" specification can be prefaced with a drive code in the standard CP/M format [d:]. When the drive code i s specified all the files described above are associated with the specified drive. Otherwise, the files are associated with the default drive. Another option allows the user to direct the output file directly to the "LST:" device instead of to the file "filename.XRF". This option is invoked by adding the string "$p" to the command line as follows:

```
XREF filename $p
```

XREF allocates space for symbols and symbol references dynamically during execution. If no memory is available for an attempted symbol or symbol reference allocation, an error message is issued and XREF is terminated.

F.1.1. XREF ERROR MESSAGES

No SYM file - This message is issued if the file "filename.SYM" is not present on the default or specified drive.

No PRN file - This message is issued if the file "filename.PRN" is not present on the default or specified drive.

Symbol table overflow - This message is issued if no space is available for an attempted symbol allocation.

Invalid SYM file format - This message is issued when an invalid "filename.SYM" file is read. Specifically, a line in the SYM file not terminated with a CRLF will force this error message.

Symbol table reference overflow - This message is issued if no space is available for an attempted symbol reference allocation.

"filename.XRF" make error - This message is issued if BDOS returns an error code after a "filename.XRF" make request. This error code usually indicates that no directory space exists on the default or specified drive.

"filename.XRF" close error - This message is issued if BDOS returns an error code after a "filename.XRF" close request.

"filename.XRF" write error - This message is issued if BDOS returns an error code after a "filename.XRF" write request. This error code usually indicates that no unallocated data blocks are available or no directory space exists on the default or specified drive.