SC33-0006-3
File No. S360/S370-29

Program Product

OS
PL/I Optimizing Compiler: Programmer's Guide

Program Numbers 5734-PL1
5734-LM4
5734-LM5

(These program products are available as composite package 5734-PL3)

Third Edition (December 1974)

This is a major revision of, and obsoletes, SC33-0006-2. This edition applies to Version 1 Release 2 Modification 2 of the PL/I Optimizing Compiler and to all subsequent releases until otherwise indicated in new editions or Technical Newsletters. Changes will continually be made to the information herein; before using this publication in connection with the operation of IBM systems, consult the latest IBM System/360 and System/370 Bibliography, Order No. 0360;GA22-6822-0360, for the editions that are applicable and current.

Changes or additions to the text and figures are indicated by a vertical line to the left of the change. Chapter 4 has been restructured.

Requests for copies of IBM publications should be made to your IBM representative or to the IBM branch office serving your locality.

A form for reader's comments is provided at the back of this publication. If the form has been removed, comments may be addressed to IBM United Kingdom Laboratories Ltd., Programming Publications, Hursley Park, Winchester, Hampshire, England. Comments become the property of IBM.

© Copyright International Business Machines Corporation 1971,1972,1973,1974

Preface

This publication is a guide to the use of the PL/I Optimizing Compiler (Program No. 5734-PL1) in a batch environment of the IBM Operating System. It explains how to use the compiler to execute PL/I programs and describes the operating system features that may be required by a PL/I programmer. It does not describe the language implemented by the compiler, nor does it explain how to use the compiler in an operating system with the Time Sharing Option (TSO); these are the functions of the manuals listed under "Associated Publications," below.

The compiler is designed to operate under Release 20.1 of the IBM Operating System and under all subsequent releases and modifications unless otherwise stated in a revision of the Program Product Specifications. The compiler also operates under Release 1.0 and all subsequent releases of the Conversational Monitor System (CMS) component of the Virtual Machine Facility/370 (VM/370).

An MFT, MVT, VS1, or VS2 version of the Operating System is required. Note that PL/I multitasking facilities can be used only on an MVT or VS2 system.

For execution of a PL/I program, the optimizing compiler employs subroutines from the OS PL/I Resident Library (Program No. 5734-LM4) and the OS PL/I Transient Library (Program No. 5734-LM5), and this programmer's guide assumes the availability of these program products.

Different release levels of the OS PL/I Optimizing Compiler and the PL/I Resident and Transient libraries will be compatible in execution provided that the following conditions are satisfied:

1. The release level of the transient library is equal to or greater than the release level of the resident library.

2. The release level of the resident library is equal to or greater than the release level of the compiler.

The first three chapters cover basic topics, and are intended primarily for casual (non-specialist) programmers or for newcomers to IBM System/360 or IBM System/370. The reader is assumed to have only an elementary grasp of PL/I and the basic concepts of data processing. These chapters introduce the reader to the operating system, and explain how to run a PL/I program and how to define a data set.

The rest of the manual contains more detailed information on the optimizing compiler, and provides general guidance and reference information on operating system features that are likely to be required by the PL/I applications programmer. Most of this information is equally relevant to the use of the compiler in a batch or TSO environment.

Chapter 4 describes the optimizing compiler, the data sets it requires, its optional facilities, and the listings it produces. Chapter 5 contains similar information for the linkage editor and loader, one of which is needed in addition to the compiler to prepare a PL/I program for execution.

Chapters 6 through 10 are concerned with the various types of data sets that can be created and accessed by a PL/I program, and explain how to define these data sets.

Chapter 11 describes the standard cataloged procedures provided by IBM for the optimizing compiler, and explains how to modify them.

Chapter 12 deals with the facilities available for debugging PL/I programs.

Chapter 13 explains how to link programs written in PL/I with those written in assembler language. (The optimizing compiler implements language designed to facilitate communication between programs written in PL/I and those written in FORTRAN, COBOL, and ASSEMBLER; these facilities are described in the language reference manual listed under "Associated Publications," below.)

Chapters 14 and 15 are concerned with the use of built-in subroutines included in the resident library to provide direct interface between PL/I programs and the operating system sort/merge and checkpoint/restart facilities.

A series of appendixes supply sundry reference information.

Associated Publications

The language implemented by the optimizing compiler is described in the following publication:

OS PL/I Optimizing and Checkout Compilers: Language Reference Manual, Order No. GC33-0009

For information on how to use the compiler in a TSO environment refer to:

OS Time Sharing Option: PL/I Optimizing Compiler, Order No. SC33-0029

For information on how to use the compiler under the Conversational Monitor System of VM/370, refer to:

PL/I Optimizing Compiler: CMS User's Guide, Order No. SC33-0037

The diagnostic messages issued by the compiler and the transient library are listed in the following publication, together with explanations, where necessary, and suggested programmer response:

OS PL/I Optimizing Compiler: Messages, Order No. SC33-0027

Recommended Publications

The following publications are referred to in this programmer's guide. They contain additional details about particular topics discussed in this manual.

OS PL/I Optimizing Compiler: Execution Logic, Order No. SC33-0025

OS Introduction, Order No. GC28-6534

OS Job Control Language Reference, Order No. GC28-6704

OS Time Sharing Option, Terminal User's Guide, Order No. GC28-6763

OS Linkage Editor and Loader, Order No. GC28-6538

OS System Programmer's Guide, Order No. GC28-6550

OS Utilities, Order No. GC28-6586

OS Sort/Merge, Order No. SC28-6543

OS Sort/Merge: Programmer's Guide, Order No. SC33-4007

OS/VS Sort/Merge: Programmer's Guide, Order No. SC33-4035

OS Supervisor and Data Management Macro Instructions, Order No. GC28-6647

OS Programmer's Guide to Debugging, Order No. GC28-6670

Terminal Commands and Compiler Options: Reference Summary, Order No. SX33-6005

Availability of Publications

The availability of a publication is indicated by its use key, the first letter in the order number. The use keys are

G - General: available to users of IBM systems, products, and services without charge, in quantities to meet their normal requirements; can also be purchased by anyone through IBM branch offices.

S - Sell: can be purchased by anyone through IBM branch offices.

Contents

Figures

Chapter 1: Introduction

The Optimizing Compiler

The PL/I Optimizing Compiler is a processing program that translates PL/I source programs, diagnosing errors as it does so, into IBM System/360 machine instructions. These machine instructions make up an object program. (Later in this chapter there is a description of how an object program is prepared for execution.)

The compiler is designed to produce efficient object programs either with or without optimization. This optimization, which is optional, can be specified by the programmer by means of a compiler option. (See Chapter 4 for details.)

If optimization is specified, the machine instructions generated will be optimized if necessary, to produce a very efficient object program.

If optimization is not specified, compilation time will be reduced.

The optimizing compiler can also be used conversationally. It can be invoked from a remote terminal to compile and execute a PL/I source program, and return the results to the terminal or to a printer.

The optimizing compiler requires a minimum of 50K bytes of main storage when used with MFT and a minimum of 52K when used with MVT. (For minimum storage under OS/VS see Appendix G.) In any case it will work more efficiently with larger amounts of main storage.

The Operating System

The optimizing compiler must be executed through the IBM Operating System. This operating system is used with both System/360 and System/370.

The operating system relieves the programmer of routine and time-consuming tasks by controlling the allocation of storage space and input/output devices. The throughput of the system is increased because the operating system can process a stream of jobs without intervention by the operator.

The operating system comprises a control program and a number of processing programs. The control program supervises the execution of all processing programs, and provides services that are required by the processing programs during their execution. The processing programs include such programs as compilers, the linkage editor, and the loader (described later in this chapter). The operating system is described in the publication OS Introduction.

The optimizing compiler can be used with four operating system control programs:

- MFT (Multiprogramming with a Fixed number of Tasks) permits up to fifteen jobs to be processed concurrently, each job occupying a separate area of main storage termed a partition.
- MVT (Multiprogramming with a Variable number of Tasks) permits up to fifteen jobs to be processed concurrently, each job occupying a separate area of main storage termed a region.
- VS1 and VS2 (Virtual Storage) employ addressable auxiliary storage that appears to the user as main storage. In use VS1 and VS2 are generally similar to MFT and MVT respectively; the differences are explained in Appendix G. Except as explained in the appendix, all information in this manual about MFT applies to VS1, and all information about MVT applies to VS2.

TIME SHARING OPTION

An optional facility of the MVT operating system is the Time Sharing Option (TSO). One or more regions can be allocated to TSO and several users can have concurrent access to the system. Each user enters his jobs from a remote terminal and can receive the results at the terminal. (To contrast it with this "conversational" mode of operation, the more conventional method of submitting jobs through the system operator is called batch operation.)

This programmer's guide forms a complete guide to the use of the optimizing compiler in a batch environment. It also provides essential background and reference information for the TSO user; however, instructions on how to use TSO and how to use the optimizing compiler with TSO are contained in the publications TSO Terminal

User's Guide and TSO: PL/I Optimizing Compiler.

JOBS AND JOB STEPS

In a batch environment, the order of processing jobs is determined by a user-defined job class and/or priority. Thus the order in which jobs are processed may differ from the order in which they are entered. Consequently jobs should be independent of each other.

A job comprises one or more job steps, each of which involves the execution of a program. Since job steps are always processed one-by-one in the order in which they appear, they can be interdependent. For example, the output from one job step can be used as the input to a later one, and the processing of a job step can be made dependent on the successful completion of a previous job step.

JOB CONTROL LANGUAGE

Job control language (JCL) is the means by which a programmer defines his jobs and job steps to the operating system; it allows the programmer to describe the work he wants the operating system to do, and to specify the input/output facilities he requires.

Chapter 2, "How to Run a PL/I Program," illustrates the use of JCL statements that are essential for the PL/I programmer. These statements are:

- JOB statement, which identifies the start of a job.
- EXEC statement, which identifies a job step and, in particular, specifies the program to be executed, either directly or by means of a cataloged procedure (described later in this chapter).
- DD (data definition) statement, which defines the input/output facilities required by the program executed in the job step.
- /* (delimiter) statement, which separates data in the input stream from the job control statements that follow this data.

JOB, EXEC, and DD statements have the same format, and Figure 1-1 shows an example of a JOB statement on a punched card. These three statements are identified by the character sequence // in columns 1 and 2. Each statement can contain four fields -- name, operation, operand, and comments -- that are separated by one or more blanks. The name field always starts in column 3.

A full description of job control language is given in the publications OS Job Control Language User's Guide and OS Job Control Language Reference.

Cataloged Procedures

Regularly-used sets of job control statements can be prepared once, given a name, stored in a system library, and the name entered into the catalog for that library. Such a set of statements is termed a cataloged procedure. A cataloged procedure comprises one or more job steps (though it is not a job, because it must not contain a JOB statement). It is included in a job by specifying its name in an EXEC statement instead of the name of a program.

Several IBM-supplied cataloged procedures are available for use with the optimizing compiler. Chapter 11 describes these procedures and how to use them.

EXECUTING A PL/I PROGRAM

The process of executing a PL/I program requires a minimum of two job steps.

A compilation job step is always required. In this step the optimizing compiler translates the PL/I source program into a set of machine instructions called an object module. This object module does not include all the machine instructions required to represent the source program. In many instances the compiler merely inserts references to subroutines that are stored in the OS PL/I Resident Library.

To include the required subroutines from the resident library, the object module must be processed by one of two processing programs, the linkage editor and the loader. Subroutines from the resident library may contain references to other subroutines stored in the OS PL/I Transient Library. The subroutines from the transient library do not become a permanent part of the compiled program; they are loaded into main storage when needed during execution of the PL/I program, and the storage they occupy is released when they are no longer needed.

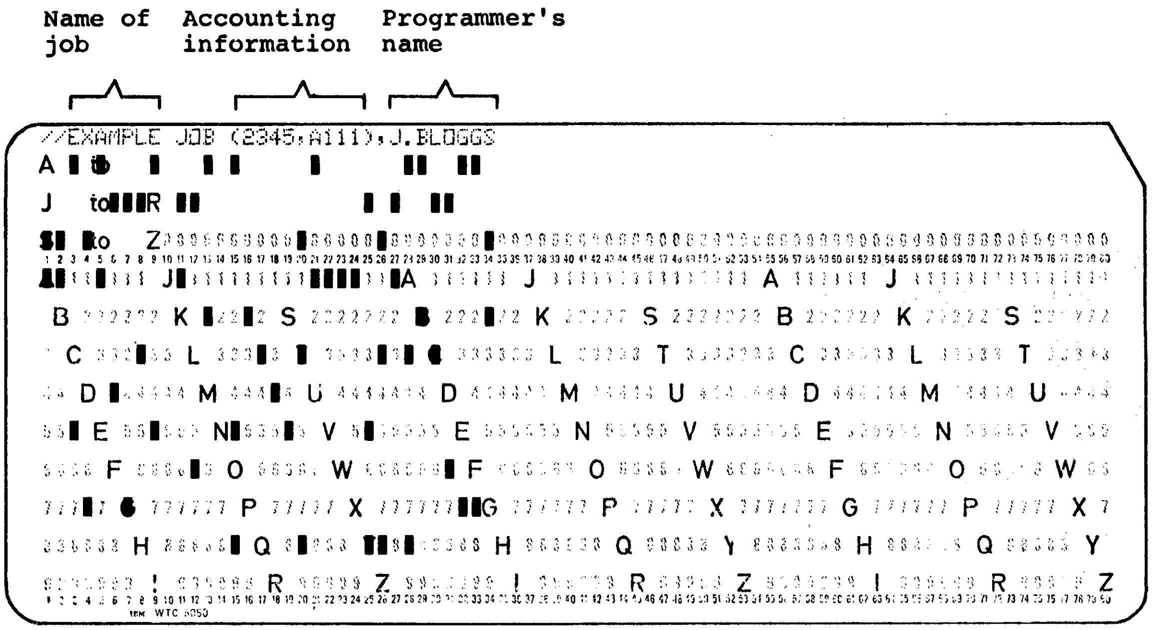


Figure 1-1. A JOB statement

When using the linkage editor, two further job steps are required after compilation. In the first of these steps, the linkage editor converts the object module into a form suitable for execution, and includes subroutines, referred to by the compiler, from the resident library. The program in this form is called a load module. In the final job step, this load module is loaded into main storage and executed.

When using the loader, only one more job step is required after compilation. The loader processes the object module, includes the appropriate library subroutines, and executes the resultant executable program immediately.

Both the linkage editor and the loader can combine separately produced object modules and previously processed load modules. However, they differ in one important respect: the linkage editor produces a load module, which it always places in a library, where it can be permanently stored and called whenever it is required; the loader creates only temporary executable programs in main storage, where they are executed immediately.

The linkage editor also has several facilities that are not provided by the loader; for example, it can divide a program that is too large for the space available in main storage, so that it can be loaded and executed segment by segment.

The loader is intended primarily for use when testing programs and for processing programs that will be executed only once.

Chapter 2: How to Run a PL/I Program

The job control statements shown in Figure 2-1 are sufficient to compile and execute a PL/I program that comprises only one external procedure.

This program uses only punched-card input and printed output. For other forms of input/output refer to Chapter 3. The listing produced includes only the standard default items. Many other items can be included by specifying the appropriate compiler options in the EXEC statement. The compiler listing and all the compiler options are described in Chapter 4. The linkage editor listing and the linkage editor options are described in Chapter 5. Appendix F is a sample PL/I program that includes most of the listing items discussed in these two chapters.

The example in Figure 2-1 uses the cataloged procedure PLIXCLG. Several other cataloged procedures are supplied by IBM for use with the optimizing compiler (for example, for compilation only). The use of these other cataloged procedures is described in Chapter 4.

An alternative method of specifying compiler options is by use of the PROCESS statement, which is described in Chapter 4. An example of a PROCESS statement is:

```
* PROCESS MACRO,OPT(TIME);
```

JOB statement

EXAMPLE is the name of the job. You can use any name that does not have more than eight alphameric or national characters; the first character must not be numeric. The job name identifies the job within the operating system; it is essential. The parameters required in the JOB statement depend on the conventions established for your installation.

EXEC statement

PLIXCLG is the name of a cataloged procedure supplied by IBM. When the operating system meets this name, it replaces the EXEC statement with a set of JCL statements that have been written previously and cataloged in a system library. The cataloged procedure contains three procedure steps:

- PLI The compiler processes the PL/I program and translates it into a set of machine instructions called an object module.
- LKED The linkage editor produces a load module from the object module produced by the compiler.
- GO The load module produced by the linkage editor is loaded into main storage and executed.

DD statement

This statement indicates that the statements to be processed in procedure step PLI follow immediately in the card deck. SYSIN is the name that the compiler uses to refer to the device on which it expects to find this data. (In this case, the device is the card reader, and the data is the PL/I program.)

Delimiter statement

This statement indicates the end of the data (that is, the PL/I program).

DD statement

This statement indicates that the data to be processed by the program (in procedure step GO) follows immediately in the card deck.

Delimiter statement

This statement indicates the end of the data.

PL/I source statements

```
//EXAMPLE JOB (6487,N14),JONES,MSGLEVEL=1
//STEP1 EXEC PLIXCLG
//PLI.SYSIN     DD *
EX001:   PROCEDURE OPTIONS(MAIN);
         DECLARE (A,B,C) FIXED DECIMAL(3);
         ON ENDFILE(SYSIN) GO TO FINISH;
NEXT:    GET FILE(SYSIN) DATA(A,B);
         C=A+B;
         PUT FILE(SYSPRINT)SKIP DATA(A,B,C);
         GO TO NEXT;
FINISH:  END;
/*
//GO.SYSIN DD *
A=131 B=75;
A=2 B=907;
A=-14 B=14;
A=341 B=429;
A=245 B=102;
/*
```

Data to be processed by the PL/I program

Figure 2-1. How to run a PL/I program

Chapter 3: How to Create and Access a Data Set

Information Required	Parameter of DD statement
Type of output device to which the data set will be transmitted.	UNIT=
Serial number of the volume (tape reel, disk pack, etc.) that will contain the data set.	VOLUME=SER= (or VOL=SER=)
Name of the data set.	DSNAME= (or DSN=)
Type of records in the data set.	DCB= (see appendix A)
Amount of auxiliary storage required for the data set (direct-access devices only).	SPACE=
Disposition of the data set on entry to, and at the end of the job step.	DISP=

Figure 3-1. Information to be specified when creating a data set

A data set is any collection of data in auxiliary storage that can be created or accessed by a program. It can be punched onto cards or a reel of paper tape; or it can be recorded on magnetic tape or on a direct-access device such as a magnetic disk or drum. A printed listing can also be a data set, but it cannot be read by a program.

Data sets that are created or accessed by PL/I programs must have one of the following types of organization:

CONSECUTIVE

INDEXED

REGIONAL

Teleprocessing

The items of data in a CONSECUTIVE data set are recorded in the order in which you present them, and can be accessed only in the order in which they were presented or, in the case of magnetic tape, in the reverse order. The items of data in INDEXED and REGIONAL data sets are arranged according to "keys" that you supply when you create the data sets. Teleprocessing data sets are organized as consecutive groups of data items.

This chapter explains how to create and access CONSECUTIVE data sets stored on magnetic tape or on a direct-access device. It is intended to provide an introduction to the subject of data management, and to meet the needs of those programmers who do not require the full input/output facilities of PL/I and the operating system. Chapters 6 through 9 contain a full explanation of the relationship between the data management facilities provided by PL/I and those provided by the operating system, and they explain how to create and access all the types of data sets referred to above.

Using a Data Set

To create or access a data set, you must not only include the appropriate input and output statements in your PL/I program, but you must also supply certain information to the operating system in a DD statement. A DD statement defines a data set and specifies how it will be handled. The information contained in a DD statement enables the operating system to allocate the necessary auxiliary storage devices, and allows the compiler to use the data management routines of the operating system to transmit data between main storage and auxiliary storage.

The language reference manual for this compiler describes the input and output statements that you will need to use in your PL/I program. Essentially, you must declare a <u>file</u> (explicitly or contextually) and open it (explicitly or implicitly) before you can begin to transmit data. A file is the means provided in PL/I for accessing a data set, and is related to a particular data set only while the file is open; when you close the file, the data set is no longer available to your program. This arrangement allows you to use the same file to access different data sets at different times, and to use different files to access the same data set.

Storage Device	Parameters of DD Statement		
	When required	What you must state	Parameters
All	Always	Output device	UNIT= cr SYSOUT=
		Block size[1]	DCB=(BLKSIZE=...)
Direct access only	Always	Auxiliary storage space required	SPACE=
Direct access and standard labeled magnetic tape	Data set to be used by another job step but only required by this job	Disposition	DISP=
	Data set to be kept after end of job	Disposition	DISP=
		Name of data set	DSN=
	Data set to be on particular volume	Volume serial number	VOL=SER=

[1]Alternatively, you can specify the block size in your PL/I program by using the ENVIRONMENT attribute.

Figure 3-2. Creating a CONSECUTIVE data set: essential parameters of DD statement

You must provide a DD statement for each data set that you will use in each job step. If you use the same data set in more than one job step, each job step that refers to this data set must include a DD statement for the data set.

If you are using a cataloged procedure, such as PLIXCLG (described in Chapters 2 and 10), the DD statement for any data set processed by your program must be associated with the appropriate step of the procedure by qualifying the name of the DD statement with the name of the procedure step. For example:

```
//GO.RESULTS DD ...
```

would indicate a DD statement named RESULTS in procedure step GO, as in the example in Figure 3-5. The name of the DD statement is known as its "ddname".

How to Create a Data Set

The information that you should specify when you create a data set is listed in Figure 3-1, which also shows the parameters of the DD statement that you should use.

The following paragraphs discuss the use of these parameters in creating a CONSECUTIVE data set. Figure 3-2 summarizes this discussion, Figure 3-4 is an example of creating this type of data set, and the subparameters of the DCB parameter are described in Appendix A. The job control language reference publication explains how to code a DD statement.

TYPE OF OUTPUT DEVICE (UNIT=)

You must always indicate the type of output device (for example, magnetic tape or disk drive, card punch, or printer) on which you want to create your data set. Usually the simplest way to do this is to use the UNIT parameter, although for a printer or a card punch it is often more convenient to use one of the special forms of DD statement discussed under "Special-purpose Parameters," later in this chapter.

In the UNIT parameter, you can specify either the type number of the unit (for example, 2311 for a disk drive) or the name of a group of devices (for example, SYSDA for any direct-access device). The group names are established for a system during system generation.

VOLUME SERIAL NUMBER (VOLUME=SER=)

A unit of auxiliary storage such as a reel of magnetic tape or a magnetic disk pack is termed a volume; a volume can contain one or more data sets, and a data set can extend to more than one volume. A volume is identified by a serial number that is recorded within it (and usually printed on the label attached to it). Although a deck of cards, a printed listing, and a reel of paper tape can be considered to be volumes, they do not have serial numbers.

Specify a volume serial number only if you want to place the data set in a particular volume. If you omit the VOLUME parameter, the operating system will print in your program listing the serial number of the volume in which it placed the data set.

The VOLUME parameter has several subparameters. To specify a volume serial number, you need only the SER (serial number) subparameter (for example, VOLUME=SER=12345).

NAME OF DATA SET (DSNAME=)

You must name a new data set if you want to keep it for future jobs. If the data set is temporary (required only for the job in which it is created), you can still name it, but you need not; if you omit the DSNAME parameter, the operating system will assume that the data set is temporary, and will give it a temporary name. Alternatively, you can specify your own temporary name by prefixing it with the characters &&. For example:

```
DSNAME=&&TEMP
```

This is especially useful if you want to use the temporary data set in more than one step of your job. The cataloged procedures supplied with the optimizing compiler contain examples of such use.

RECORD TYPE (DCB=)

You can give record-type information either in your PL/I program (in the ENVIRONMENT attribute or LINESIZE option) or in a DD statement. This discussion refers only to the DD statement, and does not apply if you decide to give the information in your program; refer to the language reference manual for this compiler for a description of the ENVIRONMENT attribute and the LINESIZE option.

The type of record in a data set is defined by its format, its physical length (block size), and the length of the subsections (logical record length) which together can be considered to make up a physical record.

The records in a data set must have one of the following formats:

F fixed length

V variable length (D- or V-format)

U undefined length

F-, D-, and V-format records can be blocked (FB, DB, or VB) or unblocked (F, D, or V); V-format records can be spanned. (A spanned record is a record whose length can exceed the size of a block. If this occurs, the record is divided into segments and accommodated in two or more consecutive blocks. D-format indicates that the record is in an ASCII data set. (See the language reference manual for this compiler for details of ASCII data sets.) In most cases, you must specify a block size. If you do not specify a record length, unblocked records of length equal to the block size are assumed. If you are using a PRINT file to produce printed output, you do not need to specify a block size in your DD statement or in your PL/I program; in the absence of other information, the compiler supplies a default line size of 120 characters.

To give record-type information in a DD statement, use the RECFM (record format), BLKSIZE (block size), and LRECL (logical record length) subparameters of the DCB parameter. The DCB parameter passes information to the operating system for inclusion in the data control block, a table maintained by the data management routines of the operating system for each data set in a job step; it contains a description of the data set and how it will be used. If your DCB parameter includes more than one subparameter, you must enclose the list in parentheses. For example:

```
DCB=(RECFM=FB,BLKSIZE=1000,LRECL=50)
```

AUXILIARY STORAGE REQUIRED (SPACE=)

When creating a data set on a direct-access device, you must always specify the amount of auxiliary storage that the data set will need. Use the SPACE parameter to specify the number of cylinders, tracks, or blocks that the data set will need. If you intend to extend the data set in a later job or job step, ensure that your original space allocation is sufficient for future needs; you cannot make a further allocation later. If the SPACE parameter appears in a DD statement for a non-direct-access device, it is ignored.

DISPOSITION OF DATA SET (DISP=)

To keep a data set for use in a later job step or job, you must use the DISP parameter to specify how you want it to be handled. You can pass it to another job step, keep it for use in a later job, or enter its name in the system catalog. If you want to keep the data set, but do not want to include its name in the system catalog, the operating system will request the operator to demount the volume in which it resides and keep it for you. If you omit the DISP parameter, the operating system will assume that the data set is temporary and will delete it at the end of the job step.

The DISP parameter can contain two positional subparameters. The first specifies whether the data set is new or already exists, and the second specifies what is to be done with it at the end of the job step. If you omit the first, you must indicate its absence by a comma. For example:

```
DISP=(,CATLG)
```

specifies that the data set is to be cataloged at the end of the job step. The omission of the first subparameter means that the data set is assumed by default to be new.

How to Access a Data Set

To access (that is, read or update) an existing data set, your DD statement should include information similar to that given when the data set is created. However, for data sets on labeled magnetic tape or on direct-access devices, you can omit several parameters because the information they contain is recorded with the data set by the operating system when the data set is created; Figure 3-3 summarizes the essential information and Figure 3-5 is an example of accessing this type of data set. The subparameters of the DCB parameter are described in Appendix A, and the job control language reference publication explains how to code a DD statement.

Except in the special case of data in the input stream (described under "Special-purpose Parameters," later in this chapter), you must always include the name of the data set (DSNAME) and its disposition (DISP).

TYPE OF INPUT DEVICE (UNIT=)

You can omit the UNIT parameter if the data set is cataloged or if it is created with DISP=(NEW,PASS) in a previous job step of the same job. Otherwise, it must always appear. (PASS specifies that the data set is to be passed for use by a subsequent job step in the same job).

VOLUME SERIAL NUMBER (VOLUME=SER=)

You can omit the VOLUME parameter if the data set is cataloged or if it is created with DISP=(,PASS) in a previous job step of the same job. Otherwise it must always appear.

NAME OF DATA SET (DSNAME=)

The DSNAME parameter can either refer back to the DD statement that defined the data set in a previous job step, or it can give the actual name of the data set. (You would have to use the former method to refer to an unnamed temporary data set.)

RECORD TYPE (DCB=)

You can omit the DCB parameter if the record information is specified in your PL/I program, using the ENVIRONMENT attribute, or if you are accessing a data set on a direct-access device or standard labeled magnetic tape. Otherwise you must specify the DCB parameter for punched cards, paper tape, or unlabeled magnetic tape.

AUXILIARY STORAGE REQUIRED (SPACE=)

You cannot add to, or otherwise modify, the space allocation made for a data set when it is created. Accordingly, the SPACE parameter is never required in a DD statement for an existing data set.

Parameters of DD Statement

When required		What you must state	Parameters
Always		Name of data set	DSN=
		Disposition of data set	DISP=
If data set not cataloged	All devices	Input device	UNIT=
	Magnetic tape and direct access	Volume serial number	VOL=SER=
For punched cards, paper tape, or unlabeled magnetic tape		Block size[1]	DCB=(BLKSIZE=...)

[1]Alternatively, you can specify the block size in your PL/I program by using the ENVIRONMENT attribute.

Figure 3-3. Accessing a CONSECUTIVE data set: essential parameters of DD statement

DISPOSITION OF DATA SET (DISP=)

Except for unit record devices (such as card readers), you must always include the DISP parameter to indicate to the operating system that the data set exists. Code DISP=SHR if you want to read the data set, DISP=OLD if you want to read and/or overwrite it, or DISP=MOD if you want to add records to the end of it.

Special-purpose Parameters

Three parameters of the DD statement have special significance because you can use a very simple form of DD statement; they are:

SYSOUT=

*

DATA

SYSOUT= is particularly useful for printed or punched-card output, and * and DATA allow you to include data in the input stream.

System Output (SYSOUT=)

A system output device is any unit (but usually a printer or a card punch) that is used in common by all jobs. The computer operator allocates all the system output devices to specific classes according to the type of device. The usual convention is for class A to refer to a printer and class B to a card punch; the IBM-supplied cataloged procedures assume that this convention is followed.

To route your output through a system output device, use the SYSOUT parameter in your DD statement. For example, to punch cards, use the DD statement:

```
//GO.PUNCH DD SYSOUT=B
```

Data in the Input Stream (* and DATA)

A convenient way to introduce data to your program is to include it in the input stream with your job control statements. Data in the input stream must, like job control statements, be in the form of 80-byte records (usually punched cards), and must be immediately preceded by a DD statement with the single parameter * in its operand field. For example:

```
//GO.SYSIN DD *
```

To indicate the end of the data, you may optionally include a delimiter job control statement (/*). If you omit the /* delimiter, the end of the data is determined by the next job control statement (commencing // in the first two columns) in the input stream.

If your data includes records that start with // in the first two columns use the parameter DATA. For example:

```
//OPT3#4   JOB
//STEP1   EXEC   PLIXCLG
//PLI.SYSIN   DD   *
 CREATE: PROC OPTIONS(MAIN);

         DCL PUNCH FILE STREAM OUTPUT,
             DISK FILE RECORD OUTPUT SEQUENTIAL,
              1 RECORD,
                2(A,B,C,X1,X2) FLOAT DEC(6) COMPLEX;

         ON ENDFILE(SYSIN) GO TO FINISH;

         OPEN FILE(PUNCH), FILE(DISK);
 NEXT:   GET FILE(SYSIN) LIST(A,B,C);
         X1=(-B+SQRT(B**2-4*A*C))/(2*A);
         X2=(-B-SQRT(B**2-4*A*C))/(2*A);
         PUT FILE(PUNCH) EDIT(RECORD) (C(E(16,9)));
         WRITE FILE(DISK) FROM(RECORD);
         GO TO NEXT;
 FINISH: CLOSE FILE(PUNCH), FILE(DISK);
         END CREATE;
/*
//GO.PUNCH DD SYSOUT=B
//GO.DISK  DD DSN=ROOTS,UNIT=2311,VOL=SER=D186,DISP=(NEW,KEEP),
//         SPACE=(TRK,(1,1)),DCB=(RECFM=FB,BLKSIZE=400,LRECL=40)
//GO.SYSIN DD *
5 12 4
4 -10 4
5 16 2
4 -12 10
5 12 9
29 -20 4
/*
```

Figure 3-4. Creating a CONSECUTIVE data set

```
//OPT3#5  JOB
//STEP1  EXEC  PLIXCLG
//PLI.SYSIN  DD  *
 ACCESS: PROC OPTIONS(MAIN);

         DCL RESULTS FILE RECORD INPUT SEQUENTIAL,
              1 RECORD,
                2(A,B,C,X1,X2) FLOAT DEC(6) COMPLEX;

         ON ENDFILE(RESULTS) GO TO FINISH;

         PUT FILE(SYSPRINT) EDIT('A','B','C','X1','X2')
           (X(7),3(A,X(23)),A,X(22),A);
         OPEN FILE(RESULTS);
 NEXT:   READ FILE(RESULTS) INTO(RECORD);
         PUT FILE(SYSPRINT) SKIP EDIT(RECORD) (C(F(12,2)));
         GO TO NEXT;
 FINISH: CLOSE FILE(RESULTS);
         END ACCESS;
/*
//GO.RESULTS DD DSN=ROOTS,UNIT=2311,VOL=SER=D186,DISP=(OLD,KEEP)
```

Figure 3-5. Accessing a CONSECUTIVE data set

```
//GO.SYSIN DD DATA
```

In this case, you must always indicate the end of the data by the job control delimiter statement (/*).

Standard Files

PL/I includes two standard files, SYSIN for input and SYSPRINT for output. If your program includes a GET statement without the FILE or STRING option, the compiler uses the file name SYSIN; if it includes a PUT statement without the FILE option, the compiler uses the name SYSPRINT.

If you use one of the IBM-supplied cataloged procedures to execute your program, you will not need to include a DD statement for SYSPRINT; procedure step GO always includes the statement:

```
//SYSPRINT DD SYSOUT=A
```

The block size is normally supplied by the compiler; you need not specify it yourself, unless you want blocked output.

If your program uses SYSIN, either explicitly or implicitly, you must always include a corresponding DD statement.

Examples

Two examples of simple applications for CONSECUTIVE data sets are shown in Figures 3-4 and 3-5; both use the cataloged procedure PLIXCLG supplied by IBM.

The first program evaluates the familiar expression for the roots of a quadratic equation and stores the results in a data set on a disk pack and on punched cards. The last but one DD statement (//GO.DISK...) specifies that the newly created data set is to be given the name ROOTS and is to be stored in a volume with serial number D186 on a 2311 Disk Storage Drive. It specifies that fixed-length records, 40 bytes in length, are to be grouped together in blocks, each 400 bytes long. It specifies that the data set is new and that it is to be kept on the volume at the end of the job step; and it specifies that one track of the disk storage drive is to be allocated to the data set with one additional track to be used if more space is required.

The second program accesses the data set on the disk pack created in the first program and prints the results.

Chapter 4: The Compiler

This chapter describes the optimizing compiler and the job control statements required to invoke it, and defines the data sets it uses. It describes the compiler options, the listing produced by the compiler, batched compilation, and the preprocessor, all of which are introduced briefly below.

The optimizing compiler translates the PL/I statements of the source program into machine instructions. A set of machine instructions such as is produced for an external PL/I procedure by the compiler is termed an object module. If several sets of PL/I statements, each set corresponding to an external procedure and separated by appropriate control statements, are present, the compiler can create two or more object modules in a single job step.

However, the compiler does not generate all the machine instructions required to represent the source program. Instead, for frequently used sets of instructions such as those that allocate main storage or those that transmit data between main storage and auxiliary storage, it inserts into the object module references to standard subroutines. These subroutines are stored either in the OS PL/I Resident Library or in the OS PL/I Transient Library.

An object module produced by the compiler is not ready for execution until the appropriate subroutines from the resident library have been included; this is the task of either one of two processing programs, the linkage editor and the loader, described in Chapter 5. An object module that has been processed by the linkage editor is referred to as a load module; an object module that has been processed by the loader is referred to as an executable program.

Subroutines from the transient library do not form a permanent part of the load module or executable program. Instead, they are loaded as required during execution, and the storage they occupy is released when they are no longer needed.

While it is processing a PL/I program, the compiler produces a listing that contains information about the program and the object module derived from it, together with messages relating to errors or other conditions detected during compilation. Much of this information is optional, and is supplied either by default or by specifying appropriate options when the compiler is invoked.

The compiler also includes a preprocessor (or compile-time processor) that enables you to modify source statements or insert additional source statements before compilation commences.

Compiler options, discussed under "Optional Facilities," later in this chapter, can be used for purposes other than to specify the information to be listed. For example, the preprocessor can be used independently to process source programs that are to be compiled later, or the compiler can be used merely to check the syntax of the statements of the source program. Also, continuation of processing through syntax checking and compilation can be made conditional on successful preprocessing.

Description of the Compiler

The compiler consists of a number of load modules, referred to as phases, each of which can be loaded individually into main storage for execution. A simplified flow diagram is shown in Figure 4-1. The first phase to be loaded is a resident control phase, which remains in main storage throughout compilation. This phase consists of a number of service routines that provide facilities required during execution of the remaining phases. One of these routines communicates with the supervisor program of the operating system for the sequential loading of the remaining phases, which are referred to as processing phases.

The resident control phase also causes a transient control phase to be loaded, the function of which is to initialize the operating environment in accordance with options specified by the programmer.

Each processing phase performs a single function or a set of related functions. Some of these phases must be loaded and executed for every compilation; the requirement for other phases depends on the content of the source program or on the optional facilities selected. Apart from the phases that provide diagnostic information, each phase is executed once only.

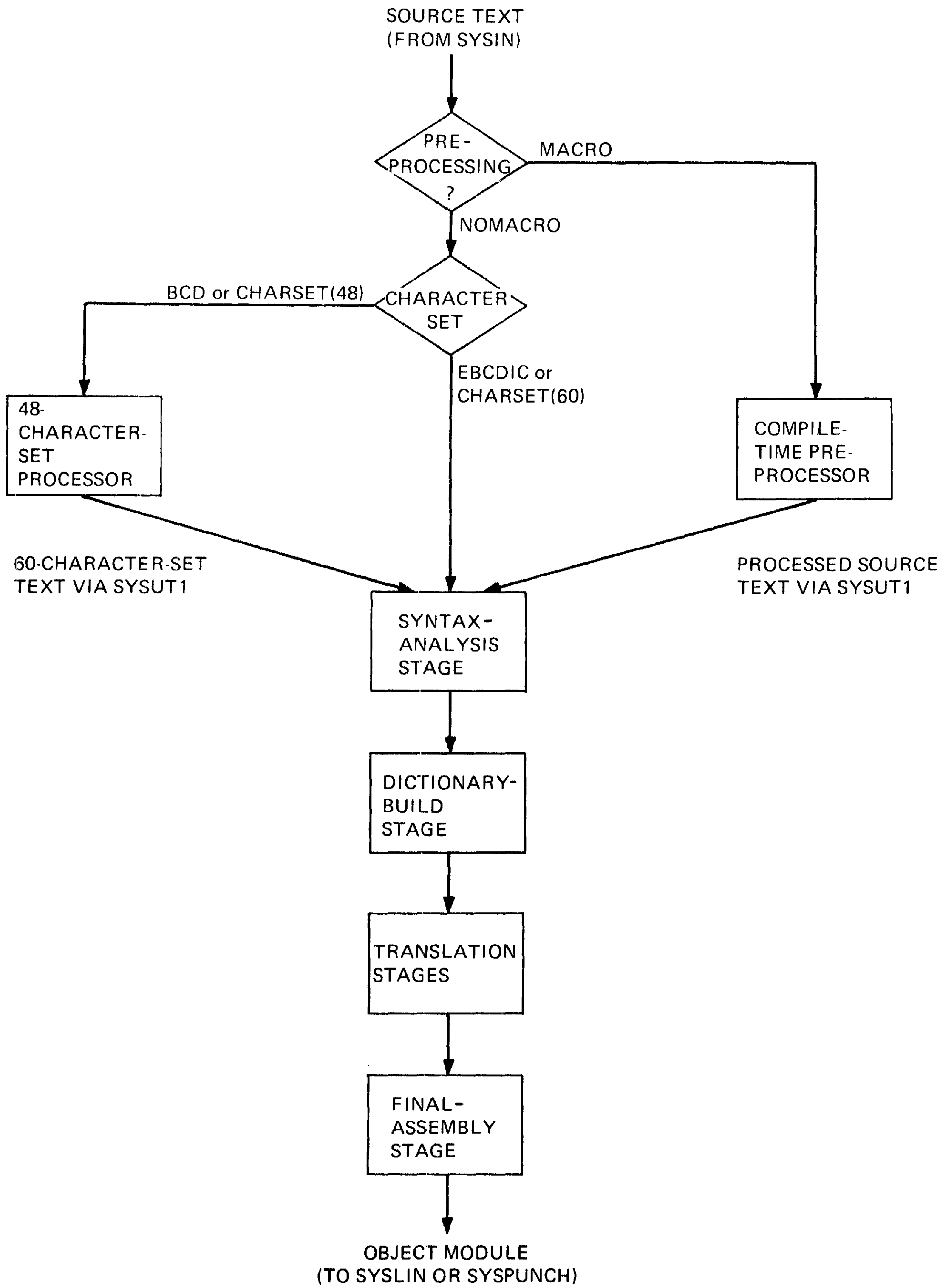


Figure 4-1. Simplified flow diagram of the compiler

Input to the compiler is known throughout all stages of the compilation process as text. Initially, this text comprises the PL/I statements of the source program. At the end of compilation, it comprises the machine instructions substituted by the compiler for the source text, together with the inserted references to resident library subroutines for use by the linkage editor or by the loader.

The source text must be in the form of a data set defined by a DD statement with the name SYSIN; frequently, this data set is a deck of punched cards. The source text is passed to the syntax-analysis stage either directly or after processing by one of the following preprocessor phases:

1. If the source text is in the PL/I 48-character set or in BCD, the 48-character-set preprocessor translates it into the 60-character set. To use the 48-character-set processor, specify the CHARSET(48) or CHARSET(BCD) options.

2. If the source text contains preprocessor statements, the preprocessor executes these statements in order to modify the source text or to introduce additional statements. Also, if the source text is in the PL/I 48-character set or in BCD (as specified by the CHARSET(48) or CHARSET(BCD) options), the preprocessor automatically translates it into the 60-character set. To use the preprocessor, specify the MACRO compiler option.

Both preprocessor phases store the translated source text in the data set defined by the DD statement with the name SYSUT1.

The syntax-analysis stage takes its input either from this data set or from the data set defined by the DD statement with the name SYSIN. This stage analyzes the syntax of the PL/I statements and removes any comments and non-significant blank characters.

After syntax analysis, the dictionary-build stage creates a dictionary containing entries for all identifiers in the source text. The compiler uses this dictionary to communicate descriptions of the elements of the source text and the object module between phases. The dictionary-build stage of the compiler replaces all identifiers and attribute declarations in the source text with references to dictionary entries.

Further processing of the text involves several compiler stages, known as translation stages, which:

- Translate the text from the PL/I syntactic form into an internal syntactic form.

- Rearrange the text to facilitate further translation (for example, by replacing array assignments with do-loops that contain element assignments).

- Map arrays and structures to ensure correct boundary alignment.

- Translate the text into a series of fixed-length tables, each with a format that can be used to define machine instructions.

- Allocate main storage for static variables and generate inline code to allow storage to be allocated automatically during execution. (In certain cases resident library subroutines may also be called to allocate storage during execution.)

The final-assembly stage translates the text tables into machine instructions, and creates the external symbol dictionary (ESD) and relocation dictionary (RLD) required by the linkage editor and by the loader.

The external symbol dictionary includes the names of subroutines that are referred to in the object module but are not part of the module and that are to be included by the linkage editor or by the loader; these names, which are termed external references, include the names of all the PL/I resident library subroutines that will be required when the object module is executed. (These resident library subroutines may, in their turn, contain external references to other resident library subroutines required for execution).

The relocation dictionary contains information that enables absolute storage addresses to be assigned to locations within the load module when it is loaded for execution.

The external symbol dictionary and the relocation dictionary are described in Chapter 5, which also explains how the linkage editor and the loader use them.

Job Control Statements for Compilation

Although you will probably use cataloged procedures rather than supply all the job control statements required for a job step that invokes the compiler, you should be familiar with these statements so that you

Standard ddname	Contents of data set	Possible device classes	Record format (RECFM)	Record size (LRECL)	Buffers	
					BUFNO	BLKSIZE
SYSIN (or SYSCIN)	Input to the compiler	SYSSQ	F,FB,U VB,V	<101(100) <105(104)	2	200
SYSLIN	Object module	SYSSQ	FB	80	2	80
SYSPUNCH	Preprocessor output, compiler output	SYSSQ SYSCP	FB	80	2	80
SYSUT1	Temporary workfile	SYSDA	F	1091,1691,3491 or 4051 according to available space	-	-
SYSPRINT	Listing, including messages	SYSSQ	VBA	125	2	129
SYSLIB	Source statements for preprocessor	SYSDA	F,FB	<101	-	-

Notes:

1. The possible device classes are:

   SYSSQ Magnetic-tape or direct-access device.

   SYSDA Direct-access device.

   SYSCP Card-punch device.

2. Any block size can be specified except for SYSLIB and SYSUT1. Block size for SYSLIB depends on the options specified. If the INCLUDE option is specified, the maximum block size is 4260 bytes. If MACRO is specified, for SIZE values below 60K bytes, the maximum is 400 bytes; above 60K bytes, the block size maximum is the value of LRECL for SYSUT1. The block size for SYSUT1 is always provided by the compiler.

3. If the record format is not specified in a DD statement, the default value (underlined) is provided by the compiler.

4. The compiler will attempt to obtain source input from SYSCIN if a DD statement for this data set is provided. Otherwise it will obtain its input from SYSIN.

5. The numbers in parentheses in the "Record size" column are the defaults which can be overridden by the user. Where no parentheses are present, the value is fixed and cannot be altered.

Figure 4-2. Compiler standard data sets

can make the best use of the compiler, and if necessary, override the statements of the cataloged procedures.

The IBM-supplied cataloged procedures that include a compilation procedure step are as follows:

PLIXC	Compile only.
PLIXCL	Compile and link-edit.
PLIXCLG	Compile, link-edit, and execute.
PLIXCG	Compile, load, and execute.

The following paragraphs describe the essential job control statements for compilation. The IBM-supplied cataloged procedures are described in Chapter 11 and include examples of these statements.

EXEC STATEMENT

The basic EXEC statement is:

```
//stepname EXEC PGM=IEL0AA
```

The PARM parameter of the EXEC statement can be used to specify one or more of the optional facilities provided by the compiler. These facilities are described under "Optional Facilities," later in this chapter.

DD STATEMENTS FOR THE STANDARD DATA SETS

The compiler requires several standard data sets, the number depending on the optional facilities specified. You must define these data sets in DD statements with the standard ddnames which are shown, together with other characteristics of the data sets, in Figure 4-2. The DD statements SYSIN, SYSUT1, and SYSPRINT are always required.

You can store any of the standard data sets on a direct-access device, in which case, you must include the SPACE parameter in the DD statement that defines the data set to specify the amount of auxiliary storage required. The amount of auxiliary storage allocated in the IBM-supplied cataloged procedures should suffice for most applications.

Input (SYSIN, or SYSCIN)

Input to the compiler must be a data set defined by a DD statement with the name SYSIN or SYSCIN; this data set must have CONSECUTIVE organization. The input must be one or more external PL/I procedures; if you want to compile more than one external procedure in a single job or job step, precede each procedure, except possibly the first, with a PROCESS statement (described under "Batched Compilation," later in this chapter).

Eighty-column punched cards are commonly used as the input medium for PL/I source programs. However, the input data set may be on a direct-access device, magnetic tape, or paper tape. The input data set may contain either fixed-length records, blocked or unblocked, variable-length records, or undefined-length records; the maximum record size is 100 bytes. The compiler always reserves 200 bytes of main storage (100 bytes each) for two buffers for this data set; however, you may specify a block size of more than 100 bytes, provided that sufficient main storage is available to the compiler. (See the discussion of the SIZE option under "Optional Facilities," later in this chapter.)

Output (SYSLIN, SYSPUNCH)

Output (that is, one or more object modules) from the compiler can be stored in either the data set defined by the DD statement with the name SYSLIN (if you specify the OBJECT compiler option) or in the data set defined by the DD statement with the name SYSPUNCH (if you specify the DECK compiler option). You may specify both options in one program, when the output will be stored in both data sets.

The object module is always in the form of 80-byte fixed-length records, blocked or unblocked. The compiler always reserves two buffers of 80 bytes each; however, you may specify a block size of more than 80 bytes, provided that sufficient main storage is available to the compiler. (See the discussion of the SIZE option under "Optional Facilities," later in this chapter.) The data set defined by the DD statement with the name SYSPUNCH is also used to store the output from the preprocessor if you specify the MDECK compiler option.

Temporary Workfile (SYSUT1)

The compiler requires a data set for use as a temporary workfile. It is defined by a DD statement with the name SYSUT1, and is known as the spill file. It must be on a direct-access device. The spill file is used as a logical extension to main storage and is used by the compiler and by the preprocessor to contain text and dictionary information.

Four record sizes are given in Figure 4-2 for SYSUT1. For storage devices other than the 3330, the first three sizes correspond to the amount of storage available to the compiler, as shown in Figure 4-3.

Storage	Record Size
50-55K	1091
56-69K	1691
over 69K	3491

Figure 4-3. Record sizes for SYSUT1

A record size of 4051 is used on the 3330.

Note that the DD statements given in this publication and in the cataloged procedures for SYSUT1 request a space allocation in blocks of 1024 bytes; this is to ensure adequate secondary allocations of direct-access storage space are acquired.

Dedicated Data Sets: If a job being run under MVT has several job steps, and each job step requires a data set for use as a temporary workfile, the result is a considerable overhead in time and space. To reduce this as far as possible, you can use dedicated data sets. These are data sets that are created by the operating system when the job is selected for processing. They can be used by each job step that requires a temporary workfile. Dedicated data sets are normally allocated by the initiator and deleted when it terminates. More information on using dedicated data sets is given in Chapter 11.

Listing (SYSPRINT)

The compiler generates a listing that includes all the source statements that it processed, information relating to the object module, and, when necessary, messages. Most of the information included in the listing is optional, and you can specify those parts that you require by including the appropriate compiler options. The information that may appear, and the associated compiler options, are described under "Compiler Listing," later in this chapter.

You must define the data set in which you wish the compiler to store its listing in a DD statement with the name SYSPRINT. This data set must have CONSECUTIVE organization. Although the listing is usually printed, it can be stored on any magnetic-tape or direct-access device. For printed output, the following statement will suffice if your installation follows the convention that output class A refers to a printer:

```
//SYSPRINT DD SYSOUT=A
```

The compiler always reserves 258 bytes of main storage (129 bytes each) for two buffers for this data set; however, you may specify a block size of more than 129 bytes, provided that sufficient main storage is available to the compiler. (See the discussion of the SIZE option under "Optional Facilities," later in this chapter.)

Source Statement Library (SYSLIB)

If you use the preprocessor %INCLUDE statement to introduce source statements into the PL/I program from a library, you can either define the library in a DD statement with the name SYSLIB, or you can choose your own ddname (or ddnames) and specify a ddname in each %INCLUDE statement. (See "Compile-time Processing," later in this chapter.)

EXAMPLE OF COMPILER JCL

A typical sequence of job control statements for compiling a PL/I program is shown in Figure 4-4. The DECK and NOOBJECT compiler options, described below, have been specified to obtain an object module as a card deck only. Job control statements for link editing an object module in the form of a card deck are shown in Chapter 5.

Optional Facilities

The compiler provides a number of optional facilities, both at compile time and at

```
//COMP      JOB
//STEP1     EXEC PGM=IEL0AA,PARM='DECK,NOOBJECT'
//SYSPUNCH   DD  SYSOUT=B
//SYSUT1    DD UNIT=SYSDA,SPACE=(1024,(60,60),,CONTIG)
//SYSPRINT DD SYSOUT=A
//SYSIN     DD *
            .
            .
            .
   (insert here the PL/I program to be compiled)
            .
            .
            .
/*
```

Figure 4-4. Typical job control statements for compiling a PL/I program

execution time. Options that can be specified at compile time are known as compiler options. Options that can be specified at execution time are known as execution-time options.

Execution-time and compiler options, their abbreviated forms, and their defaults (as supplied by IBM) are shown in Figures 4-5 and 4-7. An installation can modify or delete defaults according to local requirements; check for any modified defaults at your installation. Deleted compiler options can be reinstated for a compilation by means of the CONTROL compiler option.

| Also provided is the ability to pass an |argument to the PL/I main procedure. This |facility is described in the section |"Specifying Execution-Time Options in the |EXEC Statement," later in this chapter.

SPECIFYING COMPILER OPTIONS

For each compilation, the IBM or installation default for a compiler option will apply unless it is overridden by specifying the option in a PROCESS statement or in the PARM parameter of an EXEC statement.

An option specified in the PARM parameter overrides the default value, and an option specified in a PROCESS statement overrides both that specified in the PARM parameter and the default value.

Where conflicting attributes are specified either explicitly or implicitly by the specification of other options, the latest implied or explicit option is accepted. No diagnostic message is issued to indicate that any options are overridden in this way.

|Specifying Compiler Options in the EXEC Statement

To specify options in the EXEC statement, code PARM= followed by the list of options, in any order (except that CONTROL, if used, must be first) separating the options with commas and enclosing the list within single quotation marks, for example:

```
//STEP1 EXEC PGM=IEL0AA,PARM='OBJECT,LIST'
```

Any option that has quotation marks, for example MARGINI('c'), must have the quotation marks duplicated. The length of the option list must not exceed 256 characters, including the separating commas (note that only the first 100 characters are printed out on the listing). However, many of the options have an abbreviated form that you can use to save space. If you need to continue the statement onto another line, you must enclose the list of options in parentheses (instead of in quotation marks) enclose the options list on each line in quotation marks, and ensure that the last comma on each line except the last is outside of the quotation marks. An example covering all the above points is as follows:

```
//STEP1 EXEC PGM=IEL0AA,PARM=('AG,A',
|//         'C,ESD,F(I),FLOW(10,1)',
// 'M,MI(''X''),NEST,STG,X')
```

If you are using a cataloged procedure, and wish to specify options explicitly, you must include the PARM parameter in the EXEC statement that invokes it, qualifying the keyword PARM with the name of the procedure step that invokes the compiler, for example:

```
//STEP1 EXEC PLIXCLG,PARM.PLI='A,LIST,ESD'
```

Specifying Compiler Options in the PROCESS Statement

To specify options in the PROCESS statement, code as follows:

```
* PROCESS options;
```

where "options" is a list of compiler options. The list of options must be terminated with a semicolon and should not extend beyond the default right-hand source margin. The asterisk must appear in the first byte of the record (card column 1), and the keyword PROCESS may follow in the next byte (column) or after any number of blanks. Option keywords must be separated by a comma and/or at least one blank.

Blanks are permitted before and after any non-blank delimiter in the list, with the exception of strings within quotation marks, for example MARGINI('*'), in which optional blanks should not be inserted.

The number of characters is limited only by the length of the record. If you do not wish to specify any options, code:

```
* PROCESS;
```

Should it be necessary to continue the PROCESS statement onto the next card or record, terminate the first part of the list after any delimiter, up to the default right-hand margin, and continue on the next card or record. Option keywords or keyword arguments may be split, if required, when continuing onto the next record, provided that the keyword or argument string terminates in the right-hand source margin, and the remainder of the string starts in column 1 of the next record. A PROCESS statement may be continued in several statements, or a new PROCESS statement started.

COMPILER OPTIONS

The compiler options are of the following types:

1. Simple pairs of keywords: a positive form (for example, NEST) that requests a facility, and an alternative negative form (for example, NONEST) that rejects that facility.
2. Keywords that permit you to provide a value-list that qualifies the option (for example, NOCOMPILE(E)).
3. A combination of 1 and 2 above.

The following paragraphs describe the options in alphabetic order. For those options that specify that the compiler is to list information, only a brief description is included; the generated listing is described under "Compiler Listing," later in this chapter.

Figure 4-5 lists all the compiler options with their abbreviated forms and their standard default values for batch mode. Defaults under TSO are given in the TSO User's Guide for this compiler.

AGGREGATE Option

The AGGREGATE option specifies that the compiler is to include in the compiler listing an aggregate length table, giving the lengths of all arrays and major structures in the source program.

ATTRIBUTES Option

The ATTRIBUTES option specifies that the compiler is to include in the compiler listing a table of source-program identifiers and their attributes. If both ATTRIBUTES and XREF apply, the two tables are combined.

CHARSET Option

The CHARSET option specifies the character set and data code that you have used to create the source program. The compiler will accept source programs written in the 60-character set or the 48-character set, and in the Extended Binary Coded Decimal Interchange Code (EBCDIC) or Binary Coded Decimal (BCD).

<u>60- or 48-character Set</u>: If the source program is written in the 60-character set, specify CHARSET(60); if it is written in the 48-character set, specify CHARSET(48). The language reference manual for this compiler lists both of these character sets. (The compiler will accept source programs written in either character set if CHARSET(48) is specified, however, if the reserved keywords, for example, CAT or LE are used as identifiers, errors may occur.)

<u>BCD or EBCDIC</u>: If the source program is written in BCD, specify CHARSET(BCD); if it is written in EBCDIC, specify CHARSET(EBCDIC). The language reference manual for this compiler lists the EBCDIC

<table>
<tr><th>Compiler Option</th><th>Abbreviated Name</th><th>IBM Default</th></tr>
<tr><td>AGGREGATE|NOAGGREGATE</td><td>AG|NAG</td><td>NOAGGREGATE</td></tr>
<tr><td>ATTRIBUTES|NOATTRIBUTES</td><td>A|NA</td><td>NOATTRIBUTES</td></tr>
<tr><td>CHARSET([48|60][EBCDIC|BCD])</td><td>CS([48|60][EB|B])</td><td>CHARSET(60 EBCDIC)</td></tr>
<tr><td>COMPILE|NOCOMPILE[(W|E|S)]</td><td>C|NC[(W|E|S)]</td><td>NOCOMPILE(S)</td></tr>
<tr><td>CONTROL('password')</td><td>-</td><td>-</td></tr>
<tr><td>COUNT|NOCOUNT</td><td>CT|NCT</td><td>NOCOUNT</td></tr>
<tr><td>DECK|NODECK</td><td>D|ND</td><td>NODECK</td></tr>
<tr><td>DUMP|NODUMP</td><td>DU|NDU</td><td>-</td></tr>
<tr><td>ESD|NOESD</td><td>-</td><td>NOESD</td></tr>
<tr><td>FLAG[(I|W|E|S)]</td><td>F[(I|W|E|S)]</td><td>FLAG(I)</td></tr>
<tr><td>FLOW[(n,m)]|NOFLOW</td><td>-</td><td>NOFLOW</td></tr>
<tr><td>GONUMBER|NOGONUMBER</td><td>GN|NGN</td><td>NOGONUMBER</td></tr>
<tr><td>GOSTMT|NOGSTMT</td><td>GS|NGS</td><td>NOGOSTMT</td></tr>
<tr><td>IMPRECISE|NOIMPRECISE</td><td>IMP|NIMP</td><td>NOIMPRECISE</td></tr>
<tr><td>INCLUDE|NOINCLUDE</td><td>INC|NINC</td><td>NOINCLUDE</td></tr>
<tr><td>INSOURCE|NOINSOURCE</td><td>IS|NIS</td><td>INSOURCE</td></tr>
<tr><td>LINECOUNT(n)</td><td>LC(n)</td><td>LINECOUNT(55)</td></tr>
<tr><td>LIST[(n,m)]|NOLIST</td><td>-</td><td>NOLIST</td></tr>
<tr><td>LMESSAGE|SMESSAGE</td><td>LMSG|SMSG</td><td>LMESSAGE</td></tr>
<tr><td>MACRO|NOMACRO</td><td>M|NM</td><td>NOMACRO</td></tr>
<tr><td>MAP|NOMAP</td><td>-</td><td>NOMAP</td></tr>
<tr><td>MARGINI('c')|NOMARGINI</td><td>MI('c')|NMI</td><td>NOMARGINI</td></tr>
<tr><td>MARGINS(m,n[,c])</td><td>MAR(m,n[,c])</td><td>MARGINS(2,72,0) or
MARGINS(10,100,0)
(see text)</td></tr>
<tr><td>MDECK|NOMDECK</td><td>MD|NMD</td><td>NOMDECK</td></tr>
<tr><td>NAME('name')</td><td>N('name')</td><td>-</td></tr>
<tr><td>NEST|NONEST</td><td>-</td><td>NONEST</td></tr>
<tr><td>NUMBER|NONUMBER</td><td>NUM|NNUM</td><td>NONUMBER</td></tr>
<tr><td>OBJECT|NOOBJECT</td><td>OBJ|NOBJ</td><td>OBJECT</td></tr>
<tr><td>OFFSET|NOOFFSET</td><td>OF|NOF</td><td>NOOFFSET</td></tr>
<tr><td>OPTIMIZE(TIME|0|2)|NOOPTIMIZE</td><td>OPT(TIME|0|2)|NOPT</td><td>NOOPTIMIZE</td></tr>
<tr><td>OPTIONS|NOOPTIONS</td><td>OP|NOP</td><td>OPTIONS</td></tr>
<tr><td>SEQUENCE(m,n)|NOSEQUENCE</td><td>SEQ(m,n)|NSEQ</td><td>NOSEQUENCE</td></tr>
<tr><td>SIZE([-]yyyyyyyy|[-]yyyyyK|MAX)</td><td>SZ([-]yyyyyyyy|[-]yyyyyK|MAX)</td><td>SIZE(MAX)</td></tr>
<tr><td>SOURCE|NOSOURCE</td><td>S|NS</td><td>SOURCE</td></tr>
<tr><td>STMT|NOSTMT</td><td>-</td><td>STMT</td></tr>
<tr><td>STORAGE|NOSTORAGE</td><td>STG|NSTG</td><td>NOSTORAGE</td></tr>
<tr><td>SYNTAX|NOSYNTAX[(W|E|S)]</td><td>SYN|NSYN[(W|E|S)]</td><td>NOSYNTAX(S)</td></tr>
<tr><td>TERMINAL[(opt-list)]|NOTERMINAL</td><td>TERM[(opt-list)]|NTERM</td><td>NOTERMINAL</td></tr>
<tr><td>XREF|NOXREF</td><td>X|NX</td><td>NOXREF</td></tr>
</table>

Figure 4-5. Compiler options, abbreviations, and defaults in batch mode

representation of both the 48-character set and the 60-character set.

If both arguments (48 or 60, EBCDIC or BCD) are specified, they may be in any order and should be separated by a blank or by a comma.

COMPILE Option

The COMPILE option specifies that the compiler is to compile the source program unless an unrecoverable error was detected during preprocessing or syntax checking. The NOCOMPILE option without an argument causes processing to stop unconditionally after syntax checking. With an argument, continuation depends on the severity of errors detected so far, as follows:

NOCOMPILE(W) No compilation if a warning, error, severe error, or unrecoverable error is detected.

NOCOMPILE(E) No compilation if error, severe error, or unrecoverable error is detected.

NOCOMPILE(S) No compilation if a severe error or unrecoverable error is detected.

If the compilation is terminated by the NOCOMPILE option, the cross-reference listing and attribute listing may be produced; the other listings that follow the source program will not be produced.

CONTROL Option

The CONTROL option specifies that any compiler options deleted for your installation are to be available for this compilation. You must still specify the appropriate keywords to use the options. The CONTROL option must be specified with a password that is established for each installation; use of an incorrect password will cause processing to be terminated. The CONTROL option, if used, must be specified first in the list of options. It has the format:

CONTROL('password')

where "password" is a character string, not exceeding eight characters.

COUNT Option

The COUNT option specifies that the compiler is to produce code to enable the number of times each statement is executed to be counted at execution time.

The COUNT option implies the GOSTMT option if the STMT option applies, or the GONUMBER option if the NUMBER option applies.

DECK Option

The DECK option specifies that the compiler is to produce an object module in the form of 80-column card images and store it in the data set defined by the DD statement with the name SYSPUNCH. Columns 73-76 of each card contain a code to identify the object module; this code comprises the first four characters of the first label in the external procedure represented by the object module. Columns 77-80 contain a 4-digit decimal number: the first card is numbered 0001, the second 0002, and so on.

DUMP Option

The DUMP option specifies that the compiler is to produce a formatted dump of main storage if the compilation terminates abnormally (usually due to an I/O error or compiler error). This dump is written on the data set associated with SYSPRINT.

ESD Option

The ESD option specifies that the external symbol dictionary (ESD) is to be listed in the compiler listing.

FLAG Option

The FLAG option specifies the minimum severity of error that requires a message to be listed in the compiler listing. The format of the FLAG option is given in Figure 4-6.

FLAG(I)	List all messages.
FLAG(W)	List all except informatory messages. If you specify FLAG, FLAG(W) is assumed.
FLAG(E)	List all except warning and informatory messages.
FLAG(S)	List only severe error and unrecoverable error messages.

Figure 4-6. Format of the FLAG option

FLOW Option

The FLOW option specifies that the compiler is to produce code to enable the flow of control to be listed when the program is executed. The format of the FLOW option is:

FLOW[(n,m)]

where "n" is the maximum number of entries to be included in the lists. It should not exceed 32768.

"m" is the maximum number of procedures for which the lists are to be generated. It should not exceed 32768.

The IBM default, if (n,m) is not specified, is (25,10).

The output produced by the FLOW option is described under "Execution-Time FLOW Option" later in this chapter.

GONUMBER Option

The GONUMBER option specifies that the compiler is to produce additional information that will allow line numbers from the source program to be included in execution-time messages. Alternatively, these line numbers can be derived by using the offset address, which is always included in execution-time messages, and the table produced by the OFFSET option. (The NUMBER option must also apply.)

Use of the GONUMBER option implies NUMBER, NOSTMT, and NOGOSTMT.

GOSTMT Option

The GOSTMT option specifies that the compiler is to produce additional information that will allow statement numbers from the source program to be included in execution-time messages. Alternatively, these statement numbers can be derived by using the offset address, which is always included in execution-time messages, and the table produced by the OFFSET option. (The STMT option must also apply.)

Use of the GOSTMT, NOGONUMBER option implies STMT and NONUMBER.

IMPRECISE Option

The IMPRECISE option specifies that the compiler is to include extra text in the object module to localize imprecise interrupts when executing the program with an IBM System/360 Model 91 or 195 (see Appendix D). This extra text is generated for ON statements (to ensure that if interrupts occur, the correct on-units will be entered), for null statements, and for ENTRY statements. The correct line or statement numbers will not necessarily appear in execution-time messages. If you need more accurate identification of the statement in error, insert null statements at suitable points in your program.

INCLUDE Option

The INCLUDE option requests the compiler to handle the inclusion of PL/I source statements for programs that use the %INCLUDE statement. For programs that use the %INCLUDE statement but no other PL/I preprocessor statements, this method is faster than using the preprocessor. If the MACRO option is also specified, the INCLUDE option has no effect.

INSOURCE Option

The INSOURCE option specifies that the compiler is to include a listing of the source program (including preprocessor statements) in the compiler listing. This option is applicable only when the preprocessor is used, therefore the MACRO option must also apply.

LINECOUNT Option

The LINECOUNT option specifies the number of lines to be included in each page of the compiler listing, including heading lines and blank lines. The format of the LINECOUNT option is:

LINECOUNT(n)

where "n" is the number of lines. It must be in the range 1 through 32767, but only headings are generated if you specify less than 7.

LIST Option

The LIST option specifies that the compiler is to include a listing of the object module (in a form similar to IBM System/360 assembler language instructions) in the compiler listing. The format of the list option is:

LIST[(m[,n])]

where "m" is the number of the first source statement for which an object listing is required and "n" is the number of the last source statement for which an object listing is required. If "n" is omitted, only statement "m" is listed. If the option NUMBER applies, "m" and "n" must be specified as line numbers.

LMESSAGE Option

The LMESSAGE and SMESSAGE options specify that the compiler is to produce messages in a long form (specify LMESSAGE) or in a short form (specify SMESSAGE). Short messages can have advantages in a TSO environment due to the comparatively slow printing speed of a terminal.

MACRO Option

The MACRO option specifies that the source program is to be processed by the preprocessor.

MAP Option

The MAP option specifies that the compiler is to produce tables showing the organization of the static storage for the object module. These tables consist of a static internal storage map and the static external control sections. The MAP option is normally used with the LIST option.

MARGINI Option

The MARGINI option specifies that the compiler is to include a specified character in the column preceding the left-hand margin, and in the column following the right-hand margin of the listings resulting from the INSOURCE and SOURCE options. Any text in the source input which precedes the left-hand margin will be shifted left one column, and any text that follows the right-hand margin will be shifted right one column. For variable-length input records that do not extend as far as the right-hand margin, the character is inserted in the column following the end of the record. Thus text outside the source margins can be easily detected.

The MARGINI option has the format:

MARGINI('c')

where "c" is the character to be printed as the margin indicator.

MARGINS Option

The MARGINS option specifies the extent of the part of each input line or record that contains PL/I statements. The compiler will not process data that is outside these limits (but it will include it in the source listings).

The option can also specify the position of an American National Standard (ANS) printer control character to format the listing produced if the SOURCE option applies. This is an alternative to using %PAGE and %SKIP statements (described in the language reference manual for this compiler). If you do not use either method, the input records will be listed without any intervening blank lines. The format of the MARGINS option is:

MARGINS(m,n[,c])

where "m" is the column number of the left-hand margin. It should not exceed 100.

"n" is the column number of the right-hand margin. It should be greater than m, but not greater than 100.

"c" is the column number of the ANS printer control character. It should not exceed 100 and should be outside the values specified for m and n. Only the following control characters can be used:

(blank)	Skip one line before printing.
0	Skip two lines before printing.
-	Skip three lines before printing.
+	No skip before printing.
1	Start new page.

The standard IBM-supplied default for fixed-length records is MARGINS(2,72,0); that for variable-length and undefined-length records is MARGINS (10,100,0). A zero value for "c" specifies that there is no printer control character.

MDECK Option

The MDECK option specifies that the preprocessor is to produce a copy of its output (see MACRO option) and store it in the data set defined by the DD statement with the name SYSPUNCH. The last four bytes of each record in SYSUT1 are not copied, thus this option allows you to retain the output from the preprocessor as a deck of 80-column punched cards.

NAME Option

The NAME option specifies that the compiler is to place a linkage editor NAME statement as the last statement of the object module. When processed by the linkage editor, this NAME statement indicates that primary input is complete and causes the specified name to be assigned to the load module created from the preceding input (since the last NAME statement).

It is required if you want the linkage editor to create more than one load module from the object modules produced by batched compilation (see later in this chapter).

If you do not use this option, the linkage editor will use the member name specified in the DD statement defining the load module data set. You can also use the NAME option to cause the linkage editor to substitute a new load module for an existing load module with the same name in the library. The format of the NAME option is:

NAME('name')

where "name" has from one through eight characters, and begins with an alphabetic character. The linkage editor NAME statement is described in Chapter 5.

NEST Option

The NEST option specifies that the listing resulting from the SOURCE option will indicate, for each statement, the block level and the do-group level.

NUMBER Option

The NUMBER option specifies that the numbers specified in the sequence fields in the source input records are to be used to derive the statement numbers in the listings resulting from the AGGREGATE, ATTRIBUTES, LIST, OFFSET, SOURCE and XREF options.

If NONUMBER is specified, STMT and NOGONUMBER are implied. NUMBER is implied by NOSTMT or GONUMBER.

The position of the sequence field can be specified in the SEQUENCE option. Alternatively the following default positions are assumed:

- First 8 columns for undefined-length or variable-length source input records. In this case, 8 is added to the values used in the MARGINS option.
- Last 8 columns for fixed-length source input records.

These defaults are the positions used for line-numbers generated by TSO; thus it is not necessary to specify the SEQUENCE option, or change the MARGINS defaults, when using line numbers generated by TSO. Note that the preprocessor output has fixed-length records irrespective of the original primary input. Any sequence numbers in the primary input are repositioned in columns 73-80.

The line number is calculated from the five right-hand characters of the sequence number (or the number specified, if less than five). These characters are converted to decimal digits if necessary. Each time a sequence number is found that is not greater than the preceding line number, a new line number is formed by adding the minimum integral multiple of 100,000 necessary to produce a line number that is greater than the preceding one. If the sequence field consists only of blanks, the new line number is formed by adding 10 to the preceding one. The maximum line number permitted by the compiler is 134,000,000; numbers that would normally exceed this are set to this maximum value. Only eight digits are printed in the source listing; line numbers of 100,000,000 or over will be printed without the leading "1" digit.

If there is more than one statement on a line, a suffix is used to identify the actual statement in the messages. For example, the second statement beginning on the line numbered 40 will be identified by the number 40.2. The maximum value for this suffix is 31. Thus the thirty-first and subsequent statements on a line have the same number.

OBJECT Option

The OBJECT option specifies that the compiler is to store the object module that it creates in the data set defined by the DD statement with the name SYSLIN.

OFFSET Option

The OFFSET option specifies that the compiler is to print a table of statement or line numbers for each procedure with their offset addresses relative to the primary entry point of the procedure. This information is of use in identifying the statement being executed when an error occurs and a listing of the object module (obtained by using the LIST option) is available. If GOSTMT applies, statement numbers, as well as offset addresses, will be included in execution-time messages. If GONUMBER applies, line numbers, as well as offset addresses, will be included in execution-time messages.

A method of determining statement or line numbers from the offsets given in error messages is given under the heading "Statement Offset Addresses" later in this chapter.

OPTIMIZE Option

The OPTIMIZE option specifies the type of optimization required:

NOOPTIMIZE	specifies fast compilation speed, but inhibits optimization for faster execution and reduced main storage requirements.
OPTIMIZE (TIME)	specifies that the compiler is to optimize the machine instructions generated to produce a very efficient object program. A secondary effect of this type of optimization can be a reduction in the amount of main storage required for the object module. The use of OPTIMIZE(TIME) could result in a substantial increase in compile time over NOOPTIMIZE.
OPTIMIZE(0)	is the equivalent of NOOPTIMIZE.
OPTIMIZE(2)	is the equivalent of OPTIMIZE(TIME).

The language reference manual for this compiler includes a full discussion of optimization.

OPTIONS Option

The OPTIONS option specifies that the compiler is to include in the compiler listing, a list showing the compiler options, to be used during this compilation. This list includes all those applied by default, those specified in the PARM parameter of an EXEC statement, and those specified in a PROCESS statement.

SEQUENCE Option

The SEQUENCE option specifies the extent of the part of each input line or record that contains a sequence number. This number is included in the source listings produced by the INSOURCE and SOURCE option. Also, if the NUMBER option applies, line numbers will be derived from these sequence numbers and will be included in the source listings in place of statement numbers. No attempt is made to sort the input lines or records into the specified sequence. The SEQUENCE option has the format:

```
SEQUENCE(m,n)
```

where "m" specifies the column number of the left-hand margin.

"n" specifies the column number of the right-hand margin.

The extent specified should not overlap with the source program (as specified in the MARGINS option).

SIZE Option

This option can be used to limit the amount of main storage used by the compiler. This is of value, for example, when dynamically invoking the compiler, to ensure that space is left for other purposes. The SIZE option can be expressed in five forms:

SIZE(yyyyyyyy)	specifies that yyyyyyyy bytes of main storage are to be requested. Leading zeros are not required.
SIZE(yyyyyK)	specifies that yyyyyK bytes of main storage are to be requested (1K=1024). Leading zeros are not required.
SIZE(-yyyyyy)	specifies that the compiler is to obtain as much main storage as it can, and then

	release yyyyyy bytes to the operating system. Leading zeros are not required.
SIZE(-yyyK)	specifies that the compiler is to obtain as much main storage as it can, and then release yyyK bytes to the operating system (1K=1024). Leading zeros are not required.
SIZE(MAX)	specifies that the compiler is to obtain as much main storage as it can.

The IBM default, and the most usual value to be used, is SIZE(MAX), which permits the compiler to use as much main storage in the partition or region as it can.

When a limit is specified, the amount of main storage used by the compiler depends on how the operating system has been generated, and the method used for storage allocation. The compiler assumes that buffers, data management routines, and processing phases take up a fixed amount of main storage, but this amount can vary unknown to the compiler.

The negative forms can be useful when a certain amount of space must be left free and the maximum size is unknown, or can vary because the job is run in regions of different sizes.

Under MFT the compiler will operate in a partition of 50K bytes or more of main storage, using its default values for file specifications. Under MVT a region of 52K bytes or more is required.

After the compiler has loaded its initial phases and opened all files, it attempts to allocate space for working storage.

If SIZE(MAX) is specified it obtains all space remaining in the region or partition (after allowance for subsequent data management storage areas). If a limit is specified then this amount is requested. If the amount available is less than specified, but is more than the minimum workspace required, compilation proceeds. If insufficient storage is available, compilation is terminated. This latter situation should arise only if the region or partition is too small, that is, less than 50K, or if too much space for buffers has been requested. The value cannot exceed the main storage available for the job step and cannot be changed after processing has begun.

This means, that in a batched compilation, the value established when the compiler is invoked cannot be changed for later programs in the batch. Thus it is ignored if specified in a PROCESS statement.

In a TSO environment, an additional 10K to 30K bytes must be allowed for TSO. The actual size required for TSO depends on which routines are placed in the link-pack area (a common main storage pool available to all regions).

SMESSAGE Option

See LMESSAGE option.

SOURCE Option

The SOURCE option specifies that the compiler is to include in the compiler listing a listing of the source program. The source program listed is either the original source input or, if the MACRO option applies, the output from the preprocessor.

STMT Option

The STMT option specifies that statements in the source program are to be counted, and that this "statement number" is used to identify statements in the compiler listings resulting from the AGGREGATE, ATTRIBUTES, LIST, OFFSET, SOURCE, and XREF options. STMT is implied by NONUMBER or GOSTMT. If NOSTMT is specified, NUMBER and NOGOSTMT are implied.

STORAGE Option

The STORAGE option specifies that the compiler is to include in the compiler listing a table giving the main storage requirements for the object module.

SYNTAX Option

The SYNTAX option specifies that the compiler is to continue into syntax checking after initialization (or after preprocessing if the MACRO option applies) unless an unrecoverable error is detected.

The NOSYNTAX option without an argument causes processing to stop unconditionally after initialization (or preprocessing). With an argument, continuation depends on the severity of errors detected so far, as follows:

NOSYNTAX(W)	No syntax checking if a warning, error, severe error, or unrecoverable error is detected.
NOSYNTAX(E)	No syntax checking if an error, severe error, or unrecoverable error is detected.
NOSYNTAX(S)	No syntax checking if a severe error or unrecoverable error is detected.

If the SOURCE option applies, the compiler will generate a source listing even if syntax checking is not performed.

If the compilation is terminated by the NOSYNTAX option, the cross-reference listing, attribute listing, and other listings that follow the source program will not be produced.

The use of this option can prevent wasted runs when debugging a PL/I program that uses the preprocessor.

TERMINAL Option

The TERMINAL option is applicable only in a TSO environment. It specifies that some or all of the compiler listing produced during compilation is to be printed at the terminal. If TERMINAL is specified without an argument, diagnostic and informatory messages are printed at the terminal. You can add an argument, which takes the form of an option list, to specify other parts of the compiler listing that are to be printed at the terminal.

The listing at the terminal is independent of that written on SYSPRINT. However, if SYSPRINT is associated with the terminal, only one copy of each option requested will be printed even if it is requested in the TERMINAL option and also as an independent option. The following option keywords, their negative forms, or their abbreviated forms, can be specified in the option list:

AGGREGATE, ATTRIBUTES, ESD, INSOURCE, LIST, MAP, OPTIONS, SOURCE, STORAGE, and XREF.

The other options that relate to the listing (that is, FLAG, GONUMBER, GOSTMT, LINECOUNT, LMESSAGE/SMESSAGE, MARGINI, NEST, and NUMBER) will be the same as for the SYSPRINT listing.

XREF Option

The XREF option specifies that the compiler is to include in the compiler listing a list of all identifiers used in the PL/I program together with the numbers of the statements in which they are declared or referenced. Note that label references on END statements are not included, reference lists for structures may be incomplete, and arrays of structures are always listed with bounds of (*). If both ATTRIBUTES and XREF apply, the two tables are combined.

SPECIFYING EXECUTION-TIME OPTIONS

For each execution, the IBM or installation default for an execution-time option will apply unless it is overridden by a PLIXOPT string in the source program or by the PARM parameter of the EXEC statement for the execution step.

An option specified in the PLIXOPT string overrides the default value, and an option specified in the PARM parameter overrides that specified in the PLIXOPT string.

|Specifying Execution-Time Options in the PLIXOPT String

Execution-time options can be specified in a source program by means of the following declaration:

```
DCL PLIXOPT CHAR(len) VAR INIT('strg')
            STATIC EXTERNAL;
```

where "strg" is a list of options separated by commas, and "len" is a |constant equal to or greater than the length of "strg".

If more than one external procedure in a job declares PLIXOPT as STATIC EXTERNAL, only the first string will be link-edited and available at execution time.

The PLIXOPT string is ignored in a Checkout Compiler/Optimizing Compiler mixture environment.

Specifying Execution-Time Options in the EXEC Statement

The method of coding the PARM parameter in an EXEC statement is given under the heading "Specifying Compiler Options in the EXEC Statement" earlier in this chapter.

If you are using a cataloged procedure, you must qualify the keyword PARM with the name of the execution step; for example:

```
//STEP  EXEC   PLIXCLG,PARM.GO=('ISA(10K)',
//             REPORT)
```

You can also use the PARM field to pass an argument to the PL/I main procedure. To do so, place the argument, preceded by a slash, after the execution-time options. For example:

```
//GO EXEC PGM=OPT,PARM='ISASIZE(10K),
//          REPORT/ARGUMENT'
```

If you wish to pass an argument without specifying options, it must be preceded by a slash. For example:

```
//GO EXEC PGM=OPT,PARM='/ARGUMENT'
```

EXECUTION-TIME OPTIONS

The following paragraphs describe the execution-time options, which can be specified in the EXEC statement or in the PLIXOPT string.

COUNT specifies that a count is to be kept of the number of times each statement in the program is executed and that the results are to be printed when the program terminates. This option is discussed in greater detail under the heading "Execution-Time COUNT Option" later in this chapter.

NOCOUNT specifies that statement counting is not to be performed.

FLOW[(n,m)] specifies that a list of the most recent transfers of control in the execution of the program is to be generated. This option is discussed in greater detail under the heading "Execution-Time FLOW Option" later in this chapter.

NOFLOW specifies that a flow list is not to be produced.

ISASIZE specifies the amount of main storage initially acquired by the PL/I program at execution time. This storage is known as the initial storage area (ISA). The option has the format:

ISASIZE([x][,y][,z])

where "x" is the initial storage allocation for the major task,

where "y" is the initial storage allocation for each subtask within the total storage available to the compiler. This value can be used in a multitasking program to prevent a new storage request (with its accompanying time overhead) each time a block is entered during the execution of the subtasks. If you specify enough storage for a whole subtask, these additional requests are not made,

and where "z" is the maximum number of subtasks that will be active at any one time.

All storage values must be in bytes or K bytes. If "x" is omitted and "y" or "z" is specified, or if "y" is omitted and "z" is specified, then the separating commas must be used to indicate that a value is missing.

If the multitasking arguments ("y" and "z") are specified for a program that was linkedited without the multitasking library, they will be ignored, and a diagnostic message will be issued.

The ISA is used for the dynamic allocation of the main storage required by PL/I blocks as they are entered, and by controlled and based variables as they are allocated. If the ISA is large enough to contain these blocks PL/I storage handling will not acquire any more storage from the system.

If ISASIZE is not specified, then in a non-multitasking environment the IBM default value is calculated as follows:

(m - n)/2

where "m" is the region size for the GO step, and "n" is the load module length. This value is rounded up to a 2K boundary. In a multitasking environment, the default is 8K bytes for the major task and 8K bytes for each subtask. The default value for the maximum number of active subtasks is 20.

Note that if an initial storage allocation is too large, that is, most variables in STATIC and few controlled and based allocations, there will be a considerable amount of wasted main storage in the ISA. In some cases this may cause the program to terminate abnormally, because there is insufficient storage available for dynamically-loaded modules and for data areas required by the operating system.

If the initial storage allocation is too small, then dynamic main storage requirements will be less efficiently met by individual requests to the system. Furthermore, the defaults may not appear in the storage report given by the REPORT option. If a default ISASIZE is used initially and proves to be too small, then the ISASIZE finally used, which appears in the ~~which appears in the~~ report, may be less than the default. For instance in a multitasking environment the major task's ISASIZE will default to 8K bytes. If this task has an AUTOMATIC character string variable of say 20K bytes the ISA will be too small. Certain control blocks are placed first in the ISA and occupy about 1K bytes of it. The DSA, which will be greater than 20K because it includes storage for automatic variables, is then allocated. Since there is no room for it in the ISA, more storage is made available from the remainder of the region. However to avoid wastage of storage the unused part of the ISA is freed beforehand. Thus the length of the initial storage allocation will be approximately 1K bytes and this length will be printed in the report.

The execution-time option REPORT is available to enable the programmer to determine exactly what his storage requirements are, apart from I/O requirements.

REPORT specifies that a report of certain program management activity is to be printed. The report will be automatically output to a data set with the ddname PLIDUMP or PL1DUMP on program termination. This includes, for example, the amount of storage that was specified in the ISASIZE option, the length of the initial storage area, and the amount of PL/I storage required. This option may be abbreviated to R. The use of the report is described in "Execution-time Storage Requirements", below.

NOREPORT specifies that a report is not required. This option may be abbreviated to NR.

STAE specifies that when an ABEND occurs, the PL/I library routines are to attempt to raise the ERROR condition or to produce a diagnostic message and a PLIDUMP.

NOSTAE specifies that on program initialization, a STAE macro instruction is not to be issued.

SPIE specifies that when a program interrupt occurs, the PL/I error handler is to be invoked. Under certain circumstances the ERROR condition will be raised.

NOSPIE specifies that on program initialization, a SPIE macro instruction is not to be issued. This option must not be used if extended precision variables are used in the PL/I source program.

The execution-time options are discussed in greater detail in the publication OS PL/I Optimizing Compiler: Execution Logic.

Execution-time Storage Requirements

At execution time there are three separate areas of main storage.

The first area is the load module. Its length can be obtained from the linkage editor output listing.

The second area is the initial storage area (ISA). Its length can be specified by the ISASIZE execution-time option or supplied by default. If supplied by default in a non-multitasking environment, it will be approximately half of the main storage available after the load module has been loaded. In a multitasking environment, it will be 8K bytes for the major task and 8K bytes for each subtask. The ISA will include:

- Dynamic block requirements. These lengths can be obtained from the table produced by the STORAGE compiler option.

- Variable data areas, that is, varying-length strings and arrays, whose bounds or dimensions are not known at compile time. The programmer must calculate these lengths himself.
- Controlled and based variables. These lengths should be known to the programmer.

The third area consists of the remainder of main storage. It is retained by the system and is made available on specific main storage requests for overflow from the ISA and for I/O requirements, that is, file control blocks, buffers, system I/O modules and also for PL/I transient library modules (that is, storage overflow, program initialization, and I/O transmission modules).

The storage requirements in this third area can be calculated only with difficulty. The simplest way is to use the Storage Management Facilities (SMF) as described in the publication _OS Introduction_ to determine the total main storage requirements for the job. This figure is only meaningful if an accurate figure for the ISA has been supplied.

The length of the ISA can greatly affect the performance of the program. If it is too large there will be wasted storage in the ISA which might result in insufficient main storage being available for I/O requirements and transient library modules requirements.

If it is too small then dynamic main storage requirements will be met by specific requests to the system (that is, from the third area of main storage) resulting in slow execution. The programmer's total ISA requirements can be determined either by calculation or by using the REPORT execution-time option.

This can most easily be done in one of two ways:

1. If sufficient main storage is available, specify an ISASIZE larger than will be required. The report will then give the amount of this ISA used and this figure will be the optimum ISASIZE.
2. If there is a shortage of main storage specify an ISASIZE of 1, which will ensure that the program will run if at all possible and the report will still give the amount of main storage which should be allocated to the ISA.

Note that for optimum efficiency, the ISA should contain all dynamic main storage requirements. If however, certain blocks are entered only occasionally, or controlled or based variables allocated only briefly, these variables could well be permitted to remain outside the ISA. So long as these allocations do not clash with a larger I/O requirement the program may run in a smaller main storage area.

Execution-Time COUNT Option

Statement count information can be obtained at execution time only if one of the compiler options COUNT or FLOW was specified at compile time (see "Compiler Options" earlier in this chapter.) If FLOW but not COUNT was specified at compile time, COUNT must be specified at execution to obtain count information. If COUNT was specified at compile time, count information will be produced unless NOCOUNT is specified at execution time.

| Count information can be produced only when a statement number table exists. If COUNT is specified at compile time, a table is automatically produced. If only FLOW is specified at compile time, and COUNT is specified at execution time, then to obtain count information, GOSTMT or GONUMBER must also be specified at compile time.

Count output is written on the PLIDUMP file, or on the SYSPRINT file if no dump file is provided. The output has the following format:

```
PROCEDURE name1
    FROM        TO    COUNT
       1        20        1
      21        30       10
       .         .        .
       .         .        .
     200       210        1

PROCEDURE name2
    FROM        TO    COUNT
       1        10        5
       .         .        .
       .         .        .
```

Three such columns are printed per page.

To draw attention to statements that have not been executed, ranges for which the count is zero are listed separately after the main tables.

The count tables are printed when the program terminates. If a procedure is invoked with one of the multitasking options, the count table for the invocation is printed when the task terminates.

If an invocation is terminated as a result of the termination of another task, its count table cannot be printed, because it is impossible to determine the point at which it terminated. In these circumstances, only the count table for the first task to terminate can be printed. For example, although a STOP statement will cause all tasks to be terminated, only the count table for the task containing the statement will be printed.

Execution-Time FLOW Option

Flow information can be obtained at execution time only if one of the compiler options COUNT or FLOW was specified at compile time (see "Compiler Options" earlier in this chapter.) If FLOW was not specified at compile time, it must be specified at execution time to obtain flow information. If FLOW was specified at compile time, flow information will be produced unless NOFLOW is specified at execution time.

The format of the execution-time FLOW option is the same as that of the compile-time FLOW option, that is:

```
FLOW[(n,m)]
```

If "n" and "m" are not specified at execution time, the values taken are as follows:

- If FLOW was specified or defaulted at compile time, the values of "n" and "m" specified or defaulted at compile time are taken.

- If NOFLOW was specified or defaulted at compile time, the IBM default values, (25,10), are taken.

Flow output is written on the SYSPRINT file whenever an on-unit with the SNAP option is executed. It is also included as part of PLIDUMP output if "T" is included in the dump options string.

The format of each line of flow output is:

```
sn1  TO  sn2  [IN name]
```

where sn1 is the number of the statement from which the branch was made (the <u>branch out</u> point).

sn2 is the number of the statement to which the branch was made (the <u>branch in</u> point).

name is the name of the procedure or the type of the on-unit that contains "sn2" if this is different from that containing "sn1".

The branches are listed in the order in which they occur. The last "n" branch-in/branch-out points and the last "m" procedures or on-units are listed. If more than "m" procedures or on-units are entered in the course of "n" branches, changes prior to the last "m" procedures or on-units are indicated by printing "UNKNOWN" for "name".

Compiler Listing

During compilation, the compiler generates a listing, most of which is optional, that contains information about the source program, the compilation, and the object module. It places this listing in the data set defined by the DD statement with the name SYSPRINT (usually output to a printer). In a TSO environment, you can also request a listing at your terminal (using the TERMINAL option). The following description of the listing refers to its appearance on a printed page.

An example of the listing produced for a typical PL/I program is given in appendix F.

Figure 4-7 specifies the components that can be included in the compiler listing, and the order in which they appear. The rest of this section then describes these in detail.

Of course, if compilation terminates before reaching a particular stage of processing, the corresponding listings will not appear.

System information will appear before and after the listings for each job step if these items use the same output class as the processing programs. The output class for system information is specified in the MSGCLASS parameter of the JOB statement. The level of information produced is specified in the MSGLEVEL parameter.

The listing comprises a small amount of standard information that always appears, together with those items of optional information specified or supplied by default. The listing at the terminal contains only the optional information that has been requested in the TERMINAL option.

Listings	Options required
Options used for the compilation	OPTIONS
Preprocessor input	MACRO and INSOURCE
Source program	SOURCE
Statement nesting level	NEST
Attribute table	ATTRIBUTES
Cross-reference table	XREF
Aggregate length table	AGGREGATE
Storage requirements	STORAGE
Statement offset addresses	SOURCE, OFFSET, NOSTMT
External symbol dictionary	ESD
Static internal storage map	MAP
Object listing	LIST
Messages	FLAG

Figure 4-7. Compiler listings and associated options

HEADING INFORMATION

The first page of the listing is identified by the name of the compiler, the compiler version number, the time compilation commenced (if the system has the timer feature), and the date; this page, and subsequent pages are numbered.

The listing either ends with a statement that no errors or warning conditions were detected during the compilation, or with one or more messages. The format of the messages is described under "Messages," later in this chapter. If the machine has the timer feature, the listing also ends with a statement of the CPU time taken for the compilation and the elapsed time during the compilation; these times will differ only in a multiprogramming environment.

The following paragraphs describe the optional parts of the listing in the order in which they appear.

OPTIONS USED FOR THE COMPILATION

If the option OPTIONS applies, a complete list of the options used for the compilation, including the default options, appears on the first page.

PREPROCESSOR INPUT

If both the options MACRO and INSOURCE apply, the input to the preprocessor is listed, one record per line, each line numbered sequentially at the left.

If the preprocessor detects an error, or the possibility of an error, it prints a message on the page or pages following the input listing. The format of these messages is exactly as described for the compiler messages described under "Messages," later in this chapter.

SOURCE PROGRAM

If the option SOURCE applies, the input to the compiler is listed, one record per line; if the input records contain printer control characters or %SKIP or %PAGE statements, the lines will be spaced accordingly.

If the option NUMBER applies, and the source program contains line numbers, these numbers are printed to the left of each line.

If the option STMT applies, the statements in the source program are numbered sequentially by the compiler, and the number of the first statement in the line appears to the left of each line in which a statement begins. When an END statement closes more than one group or block, all the implied END statements are included in the count. For example:

```
 1 P: PROC;
 2 X: BEGIN;
 3    IF A=B
        THEN A=1;
 4       ELSE DO;
 5             A=0;
 6             C=B;
 7        END X;
 9        D=E;
10        END;
```

If the source statements are generated by the preprocessor, columns 73-80 contain diagnostic information, as shown in Figure 4-8.

Column	Information
73-77	Input line number from which the source statement is generated. This number corresponds to the line number in the preprocessor input listing.
78,79	Two-digit number giving the maximum depth of replacement by the preprocessor for this line. If no replacement occurs, the columns are blank.
80	"E" signifying that an error has occurred while replacement is being attempted. If no error has occurred, the column is blank.

Figure 4-8. Contents of columns 73 to 80 of source statements

STATEMENT NESTING LEVEL

If the option NEST applies, the block level and the do-level are printed to the right of the statement or line number under the headings LEV and NT respectively, for example:

```
STMT LEV   NT

  1         0   A:PROC OPTIONS(MAIN);
  2     1   0     B:PROC(L);
  3     2   0       DO I=1 to 10;
  4     2   1          DO J=1 TO 10;
  5     2   2           X(I,J)=N;
  6     2   2              END;
  7     2   1          BEGIN;
  8     3   1              X=Y;
  9     3   1          END;
 10     2   1       END B;
 11     1   0     END A;
```

ATTRIBUTE AND CROSS-REFERENCE TABLE

If the option ATTRIBUTES applies, the compiler prints an attribute table containing a list of the identifiers in the source program together with their declared and default attributes. In this context, the attributes include any relevant options, such as REFER, and also descriptive comments, such as:

/*STRUCTURE*/

If the option XREF applies, the compiler prints a cross-reference table containing a list of the identifiers in the source program together with the numbers of the statements or lines in which they appear. If both ATTRIBUTES and XREF apply, the two tables are combined.

Attribute Table

If an identifier is declared explicitly, the number of the DECLARE statement is listed. An undeclared variable is indicated by asterisks. The statement numbers of statement labels and entry labels are also given.

The attributes INTERNAL and REAL are never included; they can be assumed unless the respective conflicting attributes, EXTERNAL and COMPLEX, appear.

For a file identifier, the attribute FILE always appears, and the attribute EXTERNAL appears if it applies; otherwise, only explicitly declared attributes are listed.

For an array, the dimension attribute is printed first; the bounds are printed as in the array declaration, but expressions are replaced by asterisks and structure levels other than base elements have their bounds replaced by asterisks.

For a character string or a bit string, the length, preceded by the word BIT or CHARACTER, is printed as in the declaration, but an expression is replaced by an asterisk.

Cross-reference Table

If the cross-reference table is combined with the attribute table, the numbers of the statements or lines in which an identifier appears follow the list of attributes for the identifier. The number of a statement in which an implicitly-pointer qualified based variable appears will be included not only in the list of statement numbers for that variable, but also in the list of statement numbers for the pointer associated with it implicitly.

| If a based variable is referenced without explicit pointer qualification, a reference to the implicit pointer used will be included in the cross-reference listing.

Note that an END statement that refers to a label does not have its statement number listed in the entry for the label.

Identifiers that are initialized during execution of prologue code on entry to a block will have the PROCEDURE or BEGIN statement number included in the list of statement numbers. For example, automatic variables with the INITIAL attribute in a single-block program will have a reference to statement number 1 in the cross-reference table.

The order in which the statement numbers appear for a particular identifier is subject to any reordering of blocks that has occurred during compilation. In general, the statement numbers for the outermost block are given first, followed on the next line by the statement numbers for the inner blocks.

| The PL/I text is expanded to a certain extent before the cross-reference list is produced. Consequently, an identifier within a statement may acquire multiple references to the same statement number. Common examples are the use of do-groups and statements involving aggregates.

AGGREGATE LENGTH TABLE

An aggregate length table is obtained by using the AGGREGATE option. The table shows how each aggregate in the program is mapped. It contains the following information:

- The statement number in which the aggregate is declared.
- The name of the aggregate and the element within the aggregate.
- The level number of each item in a structure.
- The number of dimensions in an array.
- The byte offset of each element from the beginning of the aggregate. (The bit offset for unaligned bit-string data is not given).
- The length of each element.
- The total length of each aggregate, structure and sub-structure.

| If there is padding between two structure elements, a /*PADDING*/ comment appears, with appropriate diagnostic information.

The table is completed with the sum of the lengths of all aggregates that do not contain adjustable elements.

The statement or line number identifies either the DECLARE statement for the aggregate, or, for a controlled aggregate, an ALLOCATE statement for the aggregate. An entry appears for each ALLOCATE statement involving a controlled aggregate, as such statements can have the effect of changing the length of the aggregate during execution. Allocation of a based aggregate does not have this effect, and only one entry, which is that corresponding to the DECLARE statement, appears.

The length of an aggregate may not be known during compilation, either because the aggregate contains elements having adjustable lengths or dimensions, or because the aggregate is dynamically defined. In these cases, the word "adjustable" or "defined" appears in the "length in bytes" column.

An entry for a COBOL mapped structure, that is, for a structure into which a COBOL record is read or from which a COBOL record is written, or for a structure passed to or from a COBOL program, has the word "COBOL" appended. Such an entry will appear only if the compiler determines that the COBOL and PL/I mapping for the structure is different, and creation of a temporary structure mapped according to COBOL rules is not suppressed by one of the options NOMAP, NOMAPIN, and NOMAPOUT.

An entry for a FORTRAN mapped array, that is, an array passed to or from a FORTRAN program, has the word "FORTRAN" appended.

If a COBOL or FORTRAN entry does appear it is additional to the entry for the PL/I mapped version of the structure.

STORAGE REQUIREMENTS

If the option STORAGE applies, the compiler lists the following information under the heading "Storage Requirements" on the page following the end of the aggregate length table:

- The storage area in bytes for each procedure.
- The storage area in bytes for each begin block.
- The storage area in bytes for each on-unit.
- The length of the program control section. The program control section is the part of the object module that contains the executable part of the program.
- The length of the static internal control section. This control section contains all storage for variables declared STATIC INTERNAL.

STATEMENT OFFSET ADDRESSES

If the option OFFSET applies, the compiler lists, for each primary entry point, the offsets at which statements occur. This information is found, under the heading "Table of Offsets and Statement Numbers," following the end of the storage requirements table.
t+1;unc

The following method can be used to find the statement number that corresponds to an offset given in an execution-time error message.

1. From the error message, find the offset that is calculated from a procedure or ON statement.
2. In the table of offsets, locate the offsets for the named procedure or on-unit, and within this section find the largest offset that is less than the offset given in the error message. Note the corresponding statement or line number.
3. In the source listing, refer to the statement or line number. If this is not a BEGIN statement, it is the statement at which the error occurred. If it is a BEGIN statement, locate the offsets for the begin block in the table of offsets (look for the statement or line number), and find the largest offset that is less than the begin block offset given in the error message. Note the statement or line number, and repeat from (3).

EXTERNAL SYMBOL DICTIONARY

If the option ESD applies, the compiler lists the contents of the external symbol dictionary (ESD).

The ESD is a table containing all the external symbols that appear in the object module. (The machine instructions in the object module are grouped together in what are termed control sections; an external symbol is a name that can be referred to in a control section other than the one in which it is defined.) The contents of an ESD appear under the following headings:

SYMBOL - An 8-character field that identifies the external symbol.

TYPE - Two characters from the following list to identify the type of entry:

- SD Section definition: the name of a control section within the object module.
- CM Common area: a type of control section that contains no data or executable instructions.
- ER External reference: an external symbol that is not defined in the object module.
- WX Weak external reference: an external symbol that is not defined in this module and that is not to be resolved unless an ER entry is encountered for the same reference.
- PR Pseudo-register: a field in a communications area, the task communications area (TCA), used by the compiler and by the library subroutines for handling files and controlled variables.
- LD Label definition: the name of an entry point to the external procedure other than that used as the name of the program control section.

ID - Four-digit hexadecimal number: all entries in the ESD, except LD-type entries, are numbered sequentially, commencing from 0001.

ADDR - Hexadecimal representation of the address of the external symbol.

LENGTH - The hexadecimal length in bytes of the control section (SD, CM, and PR entries only).

ESD Entries

The external symbol dictionary always starts with the following standard entries; the entries for an external procedure with the label NAME are shown in Figure 4-9.

- SD-type entry for PLISTART. This control section transfers control to the initialization routine IBMBPIR. When initialization is complete, control passes to the address stored in the control section PLIMAIN. (Initialization is required only once during the execution of a PL/I program, even if it calls another external procedure; in such a case, control passes directly to the entry point named in the CALL statement, and not to the address contained in PLIMAIN.)

EXTERNAL SYMBOL DICTIONARY

SYMBOL	TYPE	ID	ADDR	LENGTH
PLISTART	SD	0001	000000	000034
***NAME1	SD	0002	000000	000100
***NAME2	SD	0003	000000	000100
PLITABS	WX	0004	000000	
IBMBPIRA	ER	0005	000000	
IBMBPIRD	ER	0006	000000	
IBMBPIRC	ER	0007	000000	
PLICALLA	LD		000006	
PLICALLB	LD		00000A	
PLIMAIN	SD	0008	000000	000004

Figure 4-9. Standard entries in the ESD

- SD-type entry for the program control section (the control section that contains the executable instructions of the object module). This name is the first label of the external procedure, padded on the left with asterisks to seven characters if necessary, and extended on the right with the character 1.

- SD-type entry for the static internal control section (which contains main storage for all variables declared STATIC INTERNAL). This name is the first label of the external procedure, padded on the left with asterisks to seven characters if necessary, and extended on the right with the character 2.

- ER-type entry for IBMBPIRA, the entry point of the PL/I resident library subroutine that handles program initialization and termination.

Other ESD Entries

The remaining entries in the external symbol dictionary vary, but generally include the following:

- SD-type entry for the 4-byte control section PLIMAIN, which contains the address of the primary entry point to the external procedure. This control section is present only if the procedure statement includes the option MAIN.

- Weak external reference to PLITABS, a library subroutine that contains the standard or locally-defined tab setting for stream-oriented output.

- LD-type entries for all names of entry points to the external procedure.

- A PR-type entry for each block in compilation.

- ER-type entries for all the library subroutines and external procedures called by the source program. This list includes the names of resident library subroutines called directly by compiled code (first-level subroutines), and the names of other resident library subroutines that are called by the first-level subroutines.

- CM-type entries for non-string element variables declared STATIC EXTERNAL without the INITIAL attribute.

- SD-type entries for all other STATIC EXTERNAL variables and for external file names.

- PR-type entries for all file names. For external file names, the name of the pseudo-register is the same as the file name; for internal file names, the compiler generates names as for the display pseudo-registers.

- PR-type entries for all controlled variables. For external variables, the name of the variable is used for the pseudo-register name; for internal variables, the compiler generates names.

STATIC INTERNAL STORAGE MAP

If the option MAP applies, the compiler generates a listing of the contents of the static internal control section; this listing is termed the static internal storage map.

The MAP option also produces a Variable Storage Map. This map shows how PL/I data items are mapped in main storage. It names each PL/I identifier, its level, its offset from the start of the storage area in both decimal and hexadecimal form, its storage class, and the name of the PL/I block in which it is declared.

OBJECT LISTING

If the option LIST applies, the compiler generates a listing of the machine instructions of the object module, including any compiler-generated subroutines, in a form similar to IBM System/360 assembler language.

Both the static internal storage map and the object listing contain information that cannot be fully understood without a knowledge of the structure of the object module. This is beyond the scope of this manual, but a full description of the object module, the static internal storage map, and the object listing can be found in OS PL/I Optimizing Compiler: Execution Logic.

MESSAGES

If the preprocessor or the compiler detects an error, or the possibility of an error, they generate messages. Messages generated by the preprocessor appear in the listing immediately after the listing of the statements processed by the preprocessor. Messages generated by the compiler appear at the end of the listing. All messages are graded according to their severity, as follows:

- An informatory (I) message calls attention to a possible inefficiency in the program or gives other information generated by the compiler that may be of interest to the programmer.
- A warning (W) message calls attention to a possible error, although the statement to which it refers is syntactically valid.
- An error (E) message describes an error detected by the compiler for which the compiler has applied a "fix-up" with confidence. The resulting program will execute and will probably give correct results.
- A severe error (S) message specifies an error detected by the compiler for which the compiler cannot apply a "fix-up" with confidence. The resulting program will execute but will not give correct results.
- An unrecoverable error (U) message describes an error that forces termination of the compilation.

The compiler lists only those messages with a severity equal to or greater than that specified by the FLAG option, as shown in Figure 4-10.

Type of message	Option
Informatory	FLAG(I)
Warning	FLAG(W)
Error	FLAG(E)
Severe Error	FLAG(S)
Unrecoverable Error	Always listed

Figure 4-10. Selecting the lowest severity of messages to be printed, using the FLAG option

Each message is identified by an 8-character code of the form IELnnnnI, where:

- The first three characters "IEL" identify the message as coming from the optimizing compiler.
- The next four characters are a 4-digit message number.
- The last character "I" is an operating system code for the operator indicating that the message is for information only.

The text of each message, an explanation, and any recommended programmer response, are given in the messages publication for this compiler.

RETURN CODES

For every compilation job or job step, the compiler generates a return code that indicates to the operating system the degree of success or failure it achieved. This code appears in the "end of step" message that follows the listing of the job control statements and job scheduler messages for each step. The meanings of the codes are given in Figure 4-11.

Return Code	Meaning
0000	No error detected; compilation completed; successful execution anticipated.
0004	Possible error (warning) detected; compilation completed; successful execution probable.
0008	Error detected; compilation completed; successful execution probable.
0012	Severe error detected; compilation may have been completed; successful execution improbable.
0016	Unrecoverable error detected; compilation terminated abnormally; successful execution impossible.

Figure 4-11. Return codes from compilation of a PL/I program

Batched Compilation

Batched compilation allows the compiler to compile more than one external PL/I procedure in a single job step. The compiler creates an object module for each external procedure and stores it sequentially either in the data set defined by the DD statement with the name SYSPUNCH, or in the data set defined by the DD statement with the name SYSLIN. Batched compilation can increase compiler throughput by reducing operating system and compiler initialization overheads.

To specify batched compilation, include a compiler PROCESS statement as the first statement of each external procedure except possibly the first. The PROCESS statements identify the start of each external procedure and allow compiler options to be specified individually for each compilation. The first procedure may require a PROCESS statement of its own, because the options in the PARM parameter of the EXEC statement apply to all procedures in the batch, and may conflict with the requirements of subsequent procedures.

The method of coding a PROCESS statement and the options that may be included are described under "Optional Facilities," earlier in this chapter. The options specified in a PROCESS statement apply to the compilation of the source statements between that PROCESS statement and the next PROCESS statement. Options other than these, either the defaults or those specified in the PARM field, will also apply to the compilation of these source statements. Two options, the SIZE option and the NAME option have a particular significance in batched compilations, and are discussed below.

SIZE Option

In a batched compilation, the SIZE specified in the first procedure of a batch (by a PROCESS or EXEC statement, or by default) is used throughout. If SIZE is specified in subsequent procedures of the batch, it is diagnosed and ignored. The compiler does not reorganize its storage between procedures of a batch.

NAME Option

The NAME option specifies that the compiler is to place a linkage editor NAME statement as the last statement of the object module. The use of this option in the PARM parameter of the EXEC statement, or in a PROCESS statement determines how the object modules produced by a batched compilation will be handled by the linkage editor. When the batch of object modules is link-edited, the linkage editor combines all the object modules between one NAME statement and the preceding NAME statement into a single load module; it takes the name of the load module from the NAME statement that follows the last object module that is to be included. When combining two object modules into one load module, the NAME option should not be used in the EXEC statement. An example of the use of the NAME option is given in Figure 4-12.

```
|//    EXEC PLIXC,PARM.PLI='LIST'
                  .
                  .
                  .
|* PROCESS NAME('A');
   ALPHA: PROC OPTIONS(MAIN);
                  .
                  .
                  .
          END ALPHA;
 * PROCESS;
   BETA: PROC;
                  .
                  .
                  .
          END BETA;
 * PROCESS NAME('B');
   GAMMA: PROC;
                  .
                  .
                  .
          END GAMMA;
```

Figure 4-12. Use of the NAME option in batched compilation

Compilation of the PL/I procedures ALPHA, BETA, and GAMMA, would result in the following object modules and NAME statements:

```
Object module for ALPHA
     NAME A (R)
Object module for BETA
Object module for GAMMA
     NAME B (R)
```

From this sequence of object modules and control statements, the linkage editor would produce two load modules, one named A containing the object module for the external PL/I procedure ALPHA, and the other named B containing the object modules for the external PL/I procedures BETA and GAMMA.

You should not specify the option NAME if you intend to process the object modules with the loader. The loader processes all object modules into a single load module; if there is more than one name, the loader recognizes the first one only and ignores the others.

Return Codes in Batched Compilation

The return code generated by a batched compilation is the highest code that would be returned if the procedures were compiled separately.

JOB CONTROL LANGUAGE FOR BATCHED PROCESSING

The only special consideration relating to JCL for batched processing refers to the data set defined by the DD statement with the name SYSLIN. If you include the option OBJECT, ensure that this DD statement contains the parameter DISP=(MOD,KEEP) or DISP=(MOD,PASS). (The IBM-supplied cataloged procedures specify DISP=(MOD,PASS).) If you do not specify DISP=MOD, successive object modules will overwrite the preceding modules.

Examples of Batched Compilations

If the external procedures are components of a language program and need to be executed together, they can be link-edited together and executed in subsequent job steps. Cataloged procedure PLIXCG can be used, as shown in Figure 4-13.

```
//OPT4#13 JOB
//STEP1 EXEC PLIXCG
//PLI.SYSIN DD *
           First PL/I source module
* PROCESS;
           Second PL/I source module
* PROCESS;
           Third PL/I source module
/*
//GO.SYSIN DD *
           Data processed by combined
           PL/I modules

/*
```

Figure 4-13. Example of batched compilation, including execution

```
//OPT4#14 JOB
//STEP1 EXEC PLIXCL,
//PARM.PLI='NAME('PROG1')',
//PARM.LKED=LIST
//PLI.SYSIN DD *
           First PL/I source program
* PROCESS NAME('PROG2');
           Second PL/I source program
* PROCESS NAME('PROG3');
           Third PL/I source program
/*
//LKED.SYSLMOD DD DSN=PUBPGM,
//DISP=OLD
```

Figure 4-14. Example of batched compilation, excluding execution

If the external procedures are independent programs to be invoked individually from a load module library, cataloged procedure PLIXCL can be used. For example, a job that contains three compile-and-link-edit operations can be run as a single batched compilation, as shown in Figure 4-14.

One of these programs, such as PROG2, can be invoked from the load module library as follows:

```
//OPTEX JOB
//JOBLIB DD DSNAME=PUBPGM,DISP=SHR
//J2 EXEC PGM=PROG2
//SYSIN DD *
          Data processed by program PROG2
/*
```

Compile-time Processing (preprocessing)

The preprocessing facilities of the compiler are described in the language reference manual for this compiler. You can include in a PL/I program statements that, when executed by the preprocessor stage of the compiler, modify the source program or cause additional source statements to be included from a library. The following discussion supplements the information contained in the language reference manual by providing some illustrations of the use of the preprocessor and explaining how to establish and use source statement libraries.

INVOKING THE PREPROCESSOR

The preprocessor stage of the compiler is executed if you specify the compiler option MACRO. The compiler and the preprocessor use the data set defined by the DD statement with the name SYSUT1 during processing. They also use this data set to store the preprocessed source program until compilation begins. The IBM-supplied cataloged procedures for compilation all include a DD statement with the name SYSUT1.

The term MACRO owes its origin to the similarity of some applications of the preprocessor to the macro language available with such processors as the IBM System/360 Assembler. Such a macro language allows you to write a single instruction in a program to represent a sequence of instructions that have previously been defined.

The format of the preprocessor output is given in Figure 4-15.

Column 1	Printer control character, if any, transferred from the position specified in the MARGINS option.
Columns 2-72	Source program. If the original source program used more than 71 columns, then additional lines are included for any lines that need continuation. If the original source program used less than 71 columns, then extra blanks are added on the right.
Columns 73-80	Sequence number, right-aligned. If either SEQUENCE or NUMBER apply, this is taken from the sequence number field. Otherwise, it is a preprocessor generated number, in the range 1 through 99999. This sequence number will be used in the listing produced by the INSOURCE and SOURCE options, and in any preprocessor diagnostic messages.
Column 81	blank
Columns 82,83	Two-digit number giving the maximum depth of replacement by the preprocessor for this line. If no replacement occurs, the columns are blank.
Column 84	"E" signifying that an error has occurred while replacement is being attempted. If no error has occurred, the column is blank.

Figure 4-15. Format of the preprocessor output

Three other compiler options, MDECK, INSOURCE, and SYNTAX, are meaningful only when you also specify the MACRO option. All are described earlier in this chapter.

A simple example of the use of the preprocessor to produce a source deck for a procedure SUBFUN is shown in Figure 4-16;

```
//OPT4#16     JOB
//STEP1  EXEC  PLIXC,PARM.PLI='MACRO,NOSYNTAX,MDECK'
//PLI.SYSPUNCH  DD  DSNAME=NEWLIB(SUBPROC),DISP=(NEW,CATLG),UNIT=2311,
//        VOL=SER=D186,SPACE=(CYL,(1,1,1))
//PLI.SYSIN  DD  *
  SUBFUN: PROC(CITY);

     DCL IN FILE RECORD,
         1 DATA,
                 2 NAME CHAR(10),
                 2 POP FIXED(7),
         CITY CHAR(10);

     %DCL USE CHAR;
     %USE='SUB'  /* FOR FUNCTION, SUBSTITUTE %USE='FUN' */;

 NEXT: READ FILE(IN) INTO(DATA);
     IF NAME=CITY THEN DO;
     %IF USE='FUN' %THEN %GOTO L1;
     NO=POP; END;
     %GO TO L2;
 %L1:; RETURN(POP); END;
 %L2:;  ELSE GO TO NEXT;
     END SUBFUN;
/*
```

Figure 4-16. Using the preprocessor to create a member of a source program library

according to the value assigned to the preprocessor variable USE, the source statements will represent either a subroutine or a function.

THE %INCLUDE STATEMENT

The language reference manual for this compiler describes how to use the %INCLUDE statement to incorporate source statements from a library into a PL/I program. (A library is a type of data set that can be used for the storage of other data sets, termed members.) A set of source statements that you may wish to insert into a PL/I program by means of a %INCLUDE statement must exist as a data set (member) within a library. Creating a library and placing members in this library, are described in Chapter 10.

The %INCLUDE statement includes one or more pairs of identifiers. Each pair of identifiers specifies the name of a DD statement that defines a library and, in parentheses, the name of a member of the library. For example, the statement:

```
    %INCLUDE DD1(INVERT),DD2(LOOPX);
```

specifies that the source statements in member INVERT of the library defined by the DD statement with the name DD1, and those in member LOOPX of the library defined by the DD statement with the name DD2, are to be inserted consecutively into the source program generated by the preprocessor. The compilation job step must include appropriate DD statements.

If you omit the ddname from any pair of identifiers in a %INCLUDE statement, the preprocessor assumes the ddname SYSLIB. In such a case, you must include a DD statement with the name SYSLIB. (The IBM-supplied cataloged procedures do not include a DD statement with this name in the compilation procedure step.)

The preprocessor will not recognize a PROCESS statement in a source statement module included by a %INCLUDE statement. The presence of such a PROCESS statement will result in an error in the compilation.

The use of a %INCLUDE statement to include the source statements for SUBPROC in the procedure TEST is shown in Figure 4-17. The library NEWLIB is defined in the DD statement with the qualified name PLI.SYSLIB, which is added to the statements of the cataloged procedure PLIXCLG for this job. Since the source statement library is defined by a DD statement with the name SYSLIB, the %INCLUDE statement need not include a ddname.

It is not necessary to invoke the preprocessor if your source program, and any text to be included, contains no

```
//OPT4#17 JOB
//STEP1   EXEC    PLIXCLG,PARM.PLI='MACRO,OBJECT'
//PLI.SYSLIB  DD  DSNAME=NEWLIB,DISP=OLD
//PLI.SYSIN  DD  *
  TEST: PROC OPTIONS(MAIN);

         DCL NAME CHAR(10),
             NO FIXED(7);

         ON ENDFILE(SYSIN) GO TO FINISH;

 AGAIN: GET FILE(SYSIN) LIST(NAME);
         CALL SUBFUN(NAME);
         PUT DATA(NAME,NO);
         GO TO AGAIN;
   %INCLUDE SUBPROC;
  FINISH: END TEST;
/*
//GO.IN  DD  DSNAME=POPLIST,DISP=OLD
//GO.SYSIN DD *
'ABERDEEN'
'DONCASTER'
/*
```

Figure 4-17. Including source statements from a library

preprocessor statements other than %INCLUDE. Under these circumstances, faster inclusion of text can be obtained by specifying the INCLUDE compiler option.

Dynamic Invocation of the Compiler

You can invoke the optimizing compiler from an assembler language program by using one of the macro instructions ATTACH, CALL, LINK, or XCTL. The following information supplements the description of these macro instructions given in the manual OS/360 Supervisor and Data Management Macro Instructions.

To invoke the compiler specify IEL0AA as the entry point name.

You can pass three address parameters to the compiler:

1. The address of a compiler option list.
2. The address of a list of ddnames for the data sets used by the compiler.
3. The address of a page number that is to be used for the first page of the compiler listing on SYSPRINT.

These addresses must be in adjacent fullwords, aligned on a fullword boundary. Register 1 must point to the first address in the list, and the first (left-hand) bit of the last address must be set to 1, to indicate the end of the list.

Note: If you want to pass parameters in an XCTL macro instruction, you must use the execute (E) form of the macro instruction. Remember also that the XCTL macro instruction indicates to the control program that the load module containing the XCTL macro instruction is completed. Thus the parameters must be established in a portion of main storage outside the load module containing the XCTL macro instruction, in case the load module is deleted before the compiler can use the parameters.

The format of the three parameters for all the macro instructions is described below.

OPTION LIST

The option list must begin on a halfword boundary. The first two bytes contain a binary count of the number of bytes in the list (excluding the count field). The remainder of the list can comprise any of the compiler option keywords, separated by one or more blanks, a comma, or both of these.

Entry	Standard ddname
1	SYSLIN
2	not applicable
3	not applicable
4	SYSLIB
5	SYSIN
6	SYSPRINT
7	SYSPUNCH
8	SYSUT1
9	not applicable
10	not applicable
11	not applicable
12	not applicable
13	not applicable
14	SYSCIN

Figure 4-18. The sequence of entries in the ddname list

DDNAME LIST

The ddname list must begin on a halfword boundary. The first two bytes contain a binary count of the number of bytes in the list (excluding the count field). Each entry in the list must occupy an 8-byte field; the sequence of entries is given in Figure 4-18.

If a ddname is shorter than eight bytes, fill the field with blanks on the right. If you omit an entry, fill its field with binary zeros; however you may omit entries at the end of the list entirely.

PAGE NUMBER

The page number is contained in a 6-byte field beginning on a halfword boundary. The first halfword must contain the binary value 4 (the length of the remainder of the field). The last four bytes contain the page number in binary form.

The compiler will add 1 to the last page number used in the compiler listing and put this value in the page-number field before returning control to the invoking routine. Thus, if the compiler is reinvoked, page numbering will be continuous.

Chapter 5: The Linkage Editor and the Loader

This chapter describes two processing programs of the operating system, the linkage editor and the loader. It explains the basic differences between them, describes the processing done by them, the JCL required to invoke them and, for the linkage editor, the additional processing it can do. Both processing programs are fully described in OS: Linkage Editor and Loader.

The object module produced by the compiler from a PL/I program always requires further processing before it can be executed. This further processing, the resolution of external references inserted by the compiler, is performed either by the linkage editor or by the loader, both of which convert an object module into an executable program, which in the case of the linkage editor, is termed a load module.

The linkage editor and the loader require the same type of input, perform the same basic processing, and produce a similar type of output. The basic differences between the two programs lie in the subsequent form and handling of this output.

Basic Differences

The linkage editor converts an object module into a load module, and stores it in a program library in auxiliary storage. The load module becomes a permanent member of that library and can be retrieved at any time for execution in either the job that created it, or in any other job.

The loader, on the other hand, processes the object module, loads the processed output directly into main storage, and executes it immediately. The loader is essentially a one-shot program checkout facility; once the load module has been executed, it cannot be used again without reinvoking the loader. To keep a load module for later execution, or to provide an overlay structure, you must use the linkage editor.

When using the linkage editor, three job steps are required -- compilation, link editing, and execution. When using the loader, only two job steps are required -- compilation and execution.

Choice of Program

If your installation includes both programs, the choice of program will depend on whether or not you want to retain a permanent copy of the load module, and on whether you want to use one of the facilities provided only by the linkage editor. All object modules acceptable to the linkage editor are acceptable to the loader; all load modules produced by the linkage editor, except those produced with the NE (not editable) attribute[1], are also acceptable to the loader. The differences between the two programs are summarized below.

Linkage Editor

- The linkage editor converts an object module into a load module and stores it in a partitioned data set (program library) in auxiliary storage.
- The linkage editor can produce one or more load modules in a single step (for example, output from batch compilation).
- The linkage editor can accept input from other sources as well as from its primary input source and from the automatic call library (SYSLIB).
- The linkage editor can provide an overlay structure for a program.

Loader

- The loader converts an object module into an executable program in main storage, and executes it immediately.
- The loader can produce only one load module in a single job step no matter how many object modules are produced (for example, the output from a batch compilation).

----

[1]The NE attribute is given to a load module that has no external symbol dictionary (ESD); a load module without an ESD cannot be processed again, either by the linkage editor or by the loader.

- The loader can accept input from its primary input source and from the automatic call library (SYSLIB).

Performance Considerations

If you use the loader, you will gain the advantage of a considerable saving in both time and auxiliary storage when running your PL/I program. Although the execution time will be unchanged, both the scheduling time and the processing time will be reduced, and much less auxiliary storage will be needed. These savings are achieved as follows:

Scheduling Time: Scheduling time for the loader is much less than that for link editing and execution because the loader needs only one job step.

Processing Time: The time taken to process an object module by the loader is approximately half that taken by the linkage editor to process the same module. This is achieved by the elimination of certain input/output operations required by the linkage editor, and by a reduction in module access time by the use of chained scheduling and improved buffering in the loader program.

Auxiliary Storage: The amount of auxiliary storage required by the loader when your job is compiled, loaded, and executed as a single job step, is much less than that required by the linkage editor because two of the standard data sets used by the linkage editor are not needed. If the loader input is to consist of existing load modules the auxiliary storage required for these can be reduced by storing them with unresolved external references. These external references are resolved by the loader.

Module Structure

Object and load modules have very similar structures; they differ only in that a load module that has been processed by the linkage editor contains certain descriptive information required by the operating system; in particular, the module is marked as "executable" or "not executable". A module comprises the following information:

- Text (TXT)
- External symbol dictionary (ESD)
- Relocation dictionary (RLD)
- END instruction

Text

The text of an object or load module consists of the machine instructions that represent the PL/I statements of the source program. These instructions are grouped together in what are termed control sections; a control section is the smallest group of machine instructions that can be processed by the linkage editor. An object module produced by the optimizing compiler includes the following control sections:

- Program control section: contains the executable instructions of the object module.
- Static internal control section: contains storage for all variables declared STATIC INTERNAL and for constants and static system blocks.
- Control sections termed common areas one common area is created for each EXTERNAL file name and for each non-string element variable declared STATIC EXTERNAL without the INITIAL attribute.
- PLISTART: execution of a PL/I program always starts with this control section, which passes control to the appropriate initialization subroutine; when initialization is complete, control passes to the address stored in the control section PLIMAIN.
- Control sections for all PL/I library subroutines to be included with the program.

External Symbol Dictionary

The external symbol dictionary (ESD) is a table containing all the external symbols that appear in the object module. An external symbol is a name that can be referred to in a control section other than the one in which it is defined.

The names of the control sections are themselves external symbols, as are the names of variables declared with the EXTERNAL attribute and entry names in the external procedure of a PL/I program. References to external symbols defined elsewhere are also considered to be external symbols; they are known as external references. Such external references in an object module always include the names of the subroutines from

Column	Information
33	The number of IDR entries that follow. This is always "1" for the optimizing compiler.
34 to 41	The program number of the compiler. (5734-PL1 for the optimizing compiler.)
44 to 47	The release number of the compiler. For example, '0102' indicates Release 1.2.
48 to 53	The date in day-month-year form.

Figure 5-1. The CSECT IDR information

either the OS PL/I Resident Library or the OS PL/I Transient Library that will be required for execution. They may also include calls to your own subroutines that are not part of the PL/I subroutine library, nor already included within the object module. The linkage editor or loader locates all the subroutines referred to, and includes them in the load module, or executable program respectively.

Relocation Dictionary

At execution time, the machine instructions in a load module use the following two methods of addressing locations in main storage:

1. Names used only within a control section have addresses relative to the starting point of the control section.
2. Other names (external names) have absolute addresses so that any control section can refer to them.

The relocation dictionary (RLD) contains information that enables absolute addresses to be assigned to locations within the load module when it is loaded into main storage for execution. These addresses cannot be determined earlier because the starting address is not known until the module is loaded. The relocation dictionaries from all the input modules are combined into a single relocation dictionary when a load module is produced.

END Instruction

This specifies the compiler-generated control section PLISTART as the entry point for the object module. It also contains "CSECT IDR" information for processing by the linkage editor. The CSECT IDR information is given in Figure 5-1.

Linkage Editor

The linkage editor is an operating system processing program that produces load modules. It always stores the load modules in a library, from which the job scheduler can call them for execution.

The input to the linkage editor can include object modules, load modules, and control statements that specify how the input is to be processed. The output from the linkage editor comprises one or more load modules.

In addition to its primary function of converting object modules into load modules, the linkage editor can also be used to:

- Combine previously link-edited load modules.
- Modify existing load modules.
- Construct an overlay structure.

A load module constructed as an overlay structure can be executed in an area of main storage that is not large enough to contain the entire module at one time. The linkage editor divides the load module into segments that can be loaded and executed in turn.

LINKAGE EDITOR PROCESSING

A PL/I program, compiled by the optimizing compiler, cannot be executed until the appropriate library subroutines have been included. These subroutines are included in two ways:

1. By inclusion in the load module during link editing.
2. By dynamic call during execution.

The first method is used for most of the PL/I resident library subroutines; the following paragraphs describe how the linkage editor locates them. The second is

```
     SYSLIN
 (primary input)
┌────────────────┐
│                │
│  PL/I object   │
│  module        │--------┐
│                │        │                                SYSLMOD (load
└────────────────┘        │                                module library)
                          │        ┌────────────────┐      ┌────────────────┐
                          └------->│                │      │                │
                                   │    linkage     │----->│ load module    │
                                   │    editor      │      │                │
                          ┌------->│                │      │                │
                          │        └────────────────┘      └────────────────┘
┌────────────────┐        │
│                │        │
│  PL/I library  │        │
│  (SYS1.PLIBASE)│--------┘
│                │
└────────────────┘
      SYSLIB
   (call library)
```

Figure 5-2. Basic linkage editor processing

used for the PL/I transient library subroutines, for example those concerned with input and output (including those used for opening and closing files), and those that generate execution-time messages.

In basic processing, as shown in Figure 5-2, the linkage editor accepts from its primary input source a data set defined by the DD statement with the name SYSLIN. For a PL/I program, this input is the object module produced by the compiler. The linkage editor uses the external symbol dictionary in this object module to determine whether the module includes any external references for which there are no corresponding external symbols in the module: it attempts to resolve such references by a method termed <u>automatic library call</u>.

External symbol resolution by automatic library call involves a search of the data set defined by the DD statement with the name SYSLIB; for a PL/I program, this will be the PL/I resident library. The linkage editor locates the subroutines in which the external symbols are defined (if such subroutines exist), and includes them in the load module.

The linkage editor always places its output (that is, the load module) in the data set defined by the DD statement with the name SYSLMOD.

Any linkage editor processing additional to the basic processing described above must be specified by linkage editor control statements placed in the primary input. These control statements are described in "Additional Processing," later in this chapter.

<u>Main Storage Requirements</u>

The F-level linkage editor has three different versions requiring differing amounts of main storage: 44K, 88K, and 128K bytes. The F-level linkage editor is described in the linkage editor and loader publication.

Job Control Language for the Linkage Editor

Although you will probably use cataloged procedures rather than supply all the job control language (JCL) required for a job step that invokes the linkage editor, you should be familiar with these JCL statements so that you can make the best use of the linkage editor and, if necessary, override the statements of the cataloged procedures.

The IBM-supplied cataloged procedures that include a link-edit procedure step are:

PLIXCL	Compile and link edit
PLIXCLG	Compile, link edit, and execute
PLIXLG	Link edit and execute

The following paragraphs describe the essential JCL statements for link editing. The IBM-supplied cataloged procedures are described in Chapter 11 and include examples of these statements.

EXEC STATEMENT

The name of the linkage editor is of the form IEWLFxxx, where "xxx" indicates the amount of main storage required for its execution, as shown in Figure 5-3.

xxx	Amount of main storage
440	44K
880	88K
128	128K

Figure 5-3. Main storage requirements for linkage editor IEWLFxxx

The aliases IEWL or LINKEDIT are often used for the linkage editor and normally refer to the version at your installation with the largest design level. You should find out what versions are available at your installation.

The basic EXEC statement is:

```
//stepname EXEC PGM=IEWL
```

By using the PARM parameter of the EXEC statement, you can select one or more of the optional facilities provided by the linkage editor; these facilities are described in "Optional Facilities," later in this chapter.

DD STATEMENTS FOR THE STANDARD DATA SETS

The linkage editor always requires four standard data sets. You must define these data sets in DD statements with the ddnames SYSLIN, SYSLMOD, SYSUT1, and SYSPRINT.

A fifth data set, defined by a DD statement with the name SYSLIB, is necessary if you want to use automatic library call. The five data set names, together with other characteristics of the data sets, are shown in Figure 5-4.

Primary Input (SYSLIN)

Primary input to the linkage editor must be a standard data set defined by a DD statement with the name SYSLIN; this data set must have consecutive organization. The input must comprise one or more object modules and/or linkage editor control statements; a load module cannot be part of the primary input, although it can be introduced by the control statement INCLUDE. For a PL/I program, the primary input is usually a data set containing an object module produced by the compiler. This data set may be on magnetic tape or on a direct-access device, or you can include it in the input job stream. In all cases, the input must be in the form of 80-byte F-format records.

The IBM-supplied cataloged procedure PLIXLG includes the DD statement:

```
//SYSLIN DD DDNAME=SYSIN
```

This statement specifies that the primary input data set may be defined in a DD statement with the name SYSIN. If you use this cataloged procedure, specify this DD statement by using the qualified ddname LKED.SYSIN. For example, to link edit and execute an object module placed in the input stream, you can use the following statements:

```
//LEGC          JOB
//STEP1         EXEC PLIXLG
//LKED.SYSIN    DD *
          .
          .
          (insert here the object module to be
          link edited and executed)
          .
          .
/*
```

If object modules with identically named control sections appear in the primary input, the linkage editor processes only the first appearance of that control section.

You can include load modules or object modules from one or more libraries in the primary input by using a linkage editor INCLUDE statement as described in "Additional Processing," later in this chapter.

ddname	Contents	Possible device classes[1]
SYSLIN	Primary input data, normally the compiler output	UNIT=SYSSQ or input jcb stream (specified by DD *)
SYSLMOD	Load module	UNIT=SYSDA
SYSUT1	Temporary workspace	UNIT=SYSDA
SYSPRINT	Listing, including messages	UNIT=SYSSQ (or SYSOUT=)
SYSLIB	Automatic call library (normally the PL/I resident library)	UNIT=SYSDA

[1]SYSSQ Magnetic tape or direct-access device
SYSDA Direct access device

Figure 5-4. Linkage editor standard data sets

Output (SYSLMOD)

Output (that is, one or more load modules) from the linkage editor is always stored in a data set defined by the DD statement with the name SYSLMOD, unless you specify otherwise. This data set is usually called a library; libraries are fully described in Chapter 10.

The IBM-supplied cataloged procedures include the following DD statement:

```
//SYSLMOD DD DSNAME=&&GOSET(GO),
//     UNIT=SYSDA,
//     DISP=(MOD,PASS),
//     SPACE=(1024,(50,20,1),RLSE))
```

This statement defines a temporary library named &&GCSET and assigns the member name GO to the load module produced by the linkage editor. To retain the lcad module after execution of the job, replace this DD statement with one that defines a permanent library. For example, assume that you have a permanent library called USLIB on 2311 disk pack serial number 371; to name the load module MCD1 and place it in this library, code:

```
//LKED.SYSLMOD DD DSNAME=USLIB(MOD1),
//     UNIT=2311,VCL=SER=371,DISP=CLD
```

The size of a load module must nct exceed 512K bytes for programs executed under MFT; a much larger load module is allowed for MVT. The SPACE parameter in the DD statement with the name SYSLMOD used in the IBM-supplied cataloged procedures allows for an initial allocation of 50K bytes and, if necessary, 15 further allocations of 20K bytes (a tctal cf 350K bytes); this should suffice for most applications.

Temporary Workspace (SYSUT1)

The linkage editor requires a data set for use as temporary workspace. It is defined by a DD statement with the name SYSUT1. This data set must be on a direct-access device. The following statement contains the essential parameters:

```
//SYSUT1 DD UNIT=SYSDA,
// SPACE=(1024,(200,20))
```

You should normally never need to alter the DD statement with the name SYSUT1 in an IBM-supplied cataloged procedure, except to increase the SPACE allccaticn when processing very large programs.

If your installation supports dedicated workfiles, these can be used tc prcvide temporary workspace for the link-edit job step, as described in Chapter 11.

Automatic Call Library (SYSLIB)

Unless you specify otherwise, the linkage editor will always attempt to resolve external references by automatic library call (see "Linkage Editor Processing," earlier in this chapter). Tc enable it to do this, you must define the data set or data sets to be searched in a DD statement with the name SYSLIB. (To define second and subsequent data sets, include additional, unnamed, DD statements immediately after the DD statement SYSLIB; the data sets so defined will be treated as a single continuous data set for the duration of the job step.)

For a PL/I program, the DD statement SYSLIB will normally define the PL/I resident library. The subroutines of the resident library are stored in two data sets, SYS1.PLIBASE (the base library) and SYS1.PLITASK (the multitasking library). The base library contains all the resident library subroutines required by a non-multitasking program. The multitasking library contains subroutines that are peculiar to multitasking, together with multitasking variants of some of the base library subroutines.

For link editing a non-multitasking program, specify only the base library in the SYSLIB DD statement. The following DD statement will usually suffice:

```
//SYSLIB DD DSN=SYS1.PLIBASE,DISP=OLD
```

For link editing a multitasking program, specify both the multitasking library and the base library. When attempting to resolve an external reference, the linkage editor will first search the multitasking library; if it cannot find the required subroutine, it will then search the base library. To ensure that the search is carried out in the correct sequence, the DD statements defining the two sections of the library must be in the correct sequence: multitasking library first, base library second. The following DD statements will usually suffice:

```
//SYSLIB DD DSNAME=SYS1.PLITASK,DISP=OLD
//        DD DSNAME=SYS1.PLIBASE,DISP=OLD
```

Listing (SYSPRINT)

The linkage editor generates a listing that includes reference tables relating to the load modules that it produces and also, when necessary, messages. The information that may appear is described under "Listing Produced by the Linkage Editor," later in this chapter.

You must define the data set on which you wish the linkage editor to store its listing in a DD statement with the name SYSPRINT. This data set must have consecutive organization. Although the listing is usually printed, it can be stored on any magnetic-tape cr direct-access device. For printed output, the following statement will suffice:

```
//SYSPRINT DD SYSOUT=A
```

EXAMPLE OF LINKAGE EDITOR JCL

A typical sequence of job control statements for link editing an object module is shown in Figure 5-5. The DD statement SYSLIN indicates that the object module will follow immediately in the input stream; for example, it might be an object deck created by invoking the optimizing compiler with the DECK option, as described in Chapter 4. The DD statement with the name SYSLMOD specifies that the linkage editor is to name the load module LKEX, and that it is to place it in a new library named MODLIB; the keyword NEW in the DISP parameter indicates to the operating system that this DD statement specifies the creation of a library.

Optional Facilities

The linkage editor provides a number of optional facilities that are selected by including the appropriate keywords from the following list in the PARM parameter of the EXEC statement that invokes it:

```
LIST
MAP or XREF
LET or XCAL
NCAL
SIZE
```

Code PARM= followed by the list of options, separating the options with commas and enclosing the list within single quotation marks, for example:

```
//STEPA EXEC PGM=IEWL,PARM='LIST,MAP'
```

If you are using a cataloged procedure, you must include the PARM parameter in the EXEC statement that invokes the procedure and qualify the keyword PARM with the name of the procedure step that invokes the linkage editor, for example:

```
//STEPA EXEC PLIXCLG,PARM.LKED='LIST,XREF'
```

The linkage editor options are of two types:

1. Simple keywords, for example, LIST, that specifies a facility. LET, LIST, MAP, NCAL, XCAL, and XREF are of this type.

```
//LINK      JOB
//STEP1     EXEC PGM=IEWL
//SYSLMOD   DD DSNAME=MODLIB(LKEX),UNIT=2311,VOL=SER=D186
//             SPACE=(CYL,(10,10,1)),DISP=(NEW,KEEP)
//SYSUT1    DD UNIT=SYSDA,SPACE=(1024,(200,20))
//SYSPRINT DD SYSOUT=A
//SYSLIB    DD DSNAME=SYS1.PL1BASE,DISP=OLD
//SYSLIN    DD *
                 .
                 .
    (insert here the object module to be link-edited)
                 .
                 .
/*
```

Figure 5-5. Typical job control statements for link editing a PL/I program

2. Keywords that permit you to assign a value to a function (for example, SIZE=10K).

The linkage editor options are described in the following sections, in alphabetic order.

LET Option

The LET option specifies that the linkage editor is to mark the load module as "executable" even if slight errors or abnormal conditions have been found during link editing provided these do not exceed severity 2.

LIST Option

The LIST option specifies that all linkage editor control statements processed should be listed in the data set defined by the DD statement with the name SYSPRINT.

MAP Option

The MAP option specifies that the linkage editor is to produce a map of the load module showing the relative locations and lengths of all control sections in the load module.

NCAL Option

The NCAL option specifies that no external references are to be resolved by automatic library call. However, the load module is marked "executable" provided that there are no errors.

You can use the NCAL option to conserve auxiliary storage in private libraries, since, by preventing the resolution of external references during link editing, you can store load modules without the relevant library subroutines; the DD statement with the name SYSLIB is not required. Before executing these load modules, you must link edit them again to resolve the external references, but the load module created need exist only while it is being executed. You can use this technique to combine separately compiled PL/I procedures into a single load module.

SIZE Option

The SIZE option specifies the amount of main storage, in bytes, to be allocated to the linkage editor. The format of the SIZE option is:

```
SIZE=(m[,n])
```

where "m" is the amount of main storage in bytes or K bytes (where K=1024) to be allocated to the linkage editor; it must include "n" and it must be greater than "n."

and "n" which is optional, is the amount of main storage (in bytes or K bytes) to be allocated to the load module buffer.

Figure 5-6 gives values for "m" and "n" for the three versions of the F-level linkage editor.

Version	m(minimum)	n (Min)	n (Max)	m-n (Min)
44K	44K	6K	100K	38K
88K	88K	6K	100K	44K
128K	128K	6K	100K	66K

Figure 5-6. Coding the SIZE option

If you specify SIZE incorrectly, or if you omit it, default values set at system generation are used. If you specify SIZE greater than the region or partition size, the maximum amount of main storage will be used.

XCAL Option

The XCAL option specifies that the linkage editor will mark the load module as "executable" even if slight errors or abnormal conditions, including improper branches between control sections, have been found during link editing. XCAL, which implies LET, applies only to an overlay structure.

XREF Option

The XREF option specifies that the linkage editor is to print a map of the load module and a cross-reference list of all the external references in each control section. XREF implies MAP.

Listing Produced by the Linkage Editor

The linkage editor generates a listing, most of which is optional, that contains information about the link-editing process and the load module that it produces. It places this listing in the data set defined by the DD statement with the name SYSPRINT (usually output to a printer). The following description of the listing refers to its appearance on a printed page.

The listing comprises a small amount of standard information that always appears, together with those items of optional information specified in the PARM parameter of the EXEC statement that invokes the linkage editor, or that are applied by default. The optional components of the listing and the corresponding linkage editor options are as shown in Figure 5-7.

Listings	Options Required
Control statements processed by the linkage editor	LIST
Map of the load module	MAP or XREF
Cross-reference table	XREF

Figure 5-7. Linkage editor listings and associated options

The first page of the listing is identified by the linkage editor version and level number followed by a list of the linkage editor options used.

The following paragraphs describe the optional components of the listing in the order in which they appear.

An example of the listing produced for a typical PL/I program is given in Appendix F.

Diagnostic Messages and Control Statements

The linkage editor generates messages, describing errors or conditions, detected during link editing, that may lead to error. These messages are listed immediately after the heading information on page 1 of the linkage editor listing. They are listed again at the end of the linkage editor listing under the heading "Diagnostic Message Directory" which is described later in this chapter.

If you have specified the option LIST, the names of all control statements processed by the linkage editor are listed immediately preceding the messages, and are identified by the 7-character code IEW0000.

Each message is identified by a similar 7-character code of the form IEWnnnx, where:

- The first three characters "IEW" identify the message as coming from the linkage editor.
- The next three characters are a 3-digit

message number.

- The last character "x" is a severity code. The possible severity codes and their meanings are given in Figure 5-8.

Severity Code	Meaning
0	A condition that will not cause an error during execution. The load module is marked as "executable".
1	A condition that may cause an error during execution. The load module is marked as "executable".
2	An error that could make execution impossible. The load module is marked as "not executable" unless you have specified the option LET.
3	An error that will make execution impossible. The load module is marked as "not executable".
4	An error that makes recovery impossible. Linkage editor processing is terminated, and no output other than messages is produced.

Figure 5-8. Diagnostic message severity codes

At the end of the listing, immediately preceding the "Diagnostic Message Directory" (described later in this chapter), the linkage editor places a statement of the disposition of the load module. The disposition statements, with one exception, are self-explanatory; the exception is:

****modulename DOES NOT EXIST BUT HAS BEEN ADDED TO DATA SET

This appears when the NAME statement has been used to add a new module to the data set defined by the DD statement with the name SYSLMOD. The use of the NAME statement is described under "Module Name," later in this chapter. If you name a new module by including its name in the DSNAME parameter of the DD statement with the name SYSLMOD, the linkage editor assumes that you want to replace an existing module (even if the data set is new).

DIAGNOSTIC MESSAGE DIRECTORY

When processing of a load module has been completed, the linkage editor lists in full all the messages whose numbers appear in the preceding list. The text of each message, an explanation, and any recommended programmer response, are given in the linkage editor and loader publication.

The warning message IEW0461, together with a return code of 0004, frequently appears in the linkage editor listing for a PL/I program. It refers to external references that have not been resolved because NCAL is specified. The references occur in PL/I library subroutines that are link edited with your program as a result of automatic library call. Some library subroutines may, in turn, call other library subroutines. For those secondary subroutines that are required, the compiler generates another external symbol dictionary containing alternative names for the subroutines. These new references can be resolved, and the required subroutines placed in the new load module. If the secondary subroutines in turn call other subroutines, the process is repeated.

MODULE MAP

The linkage editor listing includes a module map only if you specify the options MAP or XREF. The map lists all the control sections in the load module and all the entry point names in each control section. The control sections are listed in order of appearance in the load module; alongside each control section name is its address relative to the start of the load module (address 0) and its length in bytes. The entry points within the load module appear on the printed listing below and to the right of the control sections in which they are defined; each entry point name is accompanied by its address relative to the start of the load module.

Each control section that is included by automatic library call is indicated by an asterisk. For an overlay structure, the control sections are arranged by segment in the order in which they are specified.

After the control sections, the module map lists the pseudo-registers established by the compiler. Pseudo-registers are fields in a communications area, the task communications area (TCA), used by PL/I library subroutines and compiled code during execution of a PL/I program. The main storage occupied by the TCA is not allocated until the start of execution of a PL/I program; it does not form part of the load module. The addresses given in the list of pseudo-registers are relative to

Return Code	Meaning
0000	No messages issued; link editing completed without error; successful execution anticipated.
0004	Warning messages only issued; link editing completed; successful execution probable.
0008	Error messages only issued; link editing completed; execution may fail.
0012	Severe error messages issued; link editing may have been completed, but with errors; successful execution improbable.
0016	Unrecoverable error message issued; link editing terminated abnormally; successful execution impossible.

Figure 5-9. Return codes from the linkage editor

the start of the TCA.

At the end of the module map, the linkage editor supplies the following information:

- The total length of the pseudo-registers.
- The relative address of the instruction with which execution of the load module will commence (ENTRY ADDRESS).
- The total length of the load module. For an overlay structure, the length is that of the longest path.

All the addresses and lengths given in the module map and associated information are in hexadecimal.

CROSS-REFERENCE TABLE

The linkage editor listing includes a "Cross-reference Table" only if you specify the option XREF. This option produces a listing that comprises all the information described under "Module Map," above, together with a cross-reference table of external references. The table gives the location of each reference within the load module, the symbol to which the reference refers, and the name of the control section in which the symbol is defined.

For an overlay structure, a cross-reference table is provided for each segment. It includes the number of the segment in which each symbol is defined.

Unresolved symbols are identified in the cross-reference table by the entries $UNRESOLVED or $NEVER-CALL. An unresolved weak external reference (WXTRN) is identified by the entry $UNRESOLVED(W).

RETURN CODE

For every linkage editor job or job step, the linkage editor generates a return code that indicates to the operating system the degree of success or failure it achieved. This code appears in the "end of step" message and is derived by multiplying the highest severity code (see "Diagnostic Messages and Control Statements," earlier in this chapter) by four, as shown in Figure 5-9.

The return code 0004 almost invariably appears after a PL/I program has been link edited because some external references will not have been resolved. (Refer to "Diagnostic Message Directory," earlier in this chapter.)

Additional Processing

Basic processing by the linkage editor produces a single load module from the data that it reads from its primary input, but it has several other facilities that you can call upon by using linkage editor control statements. The use of those statements of particular relevance to a PL/I program is described below. All the linkage editor control statements are fully described in the linkage editor and loader publication.

FORMAT OF CONTROL STATEMENTS

A linkage editor control statement is an 80-byte record that contains two fields. The operation field specifies the operation required of the linkage editor; it must be preceded and followed by at least one blank character. The operand field names the control sections, data sets, or modules that are to be processed, and it may contain symbols to indicate the manner of processing; the field consists of one or more parameters separated by commas. Some control statements may have multiple operand fields separated by commas.

The position of a control statement in the linkage editor input depends on its function.

In the following descriptions of the control statements, items within brackets [] are optional.

MODULE NAME

A load module must have a name so that the linkage editor and the operating system can identify it. A name comprises up to eight characters, the first of which must be alphabetic.

You can name a load module in one of two ways:

1. If you are producing a single load module from a single link-edit job step, it is sufficient to include its name as a member name in the DSNAME parameter of the DD statement with the name SYSLMOD.
2. If you are producing two or more load modules from a single link-edit job step, you will need to use the NAME statement. (The optimizing compiler can supply the NAME statements when you use batch compilation as described in Chapter 4.)

The format of the NAME statement is:

```
NAME name[(R)]
```

|where "name" is any name of up to eight characters; the first character must be alphabetic. The NAME statement serves the following functions:

- It identifies a load module. The name specified will be given to the load module. "(R)", if present, specifies that the load module is to replace an existing load module of the same name in the data set defined by the DD statement with the name SYSLMOD.
- It acts as a delimiter between input for different load modules in one link-edit step.

The NAME statement must appear in the primary input to the linkage editor (the standard data set defined by the DD statement SYSLIN); if it appears elsewhere, the linkage editor ignores it. The statement must follow immediately after the last object module that will form part of the load module it names (or after the INCLUDE control statement that specifies the last object module).

Alternative Names

You can use the ALIAS statement to give a load module an alternative name; a load module can have as many as sixteen aliases in addition to the name given to it in a DD statement with the name SYSLMOD, or by a NAME statement.

The format of the ALIAS statement is:

```
ALIAS name
```

where "name" is any name of up to eight characters; the first character must be alphabetic. You can include more than one name in an ALIAS statement, separating the names by commas, for example:

```
ALIAS FEE,FIE,FOE,FUM
```

An ALIAS statement can be placed before, between, or after object modules and control statements that are being processed to form a load module, but it must precede the NAME statement that specifies the primary name of the load module.

To execute a load module, you can include an alias instead of the primary name in the PGM parameter of an EXEC statement.

Aliases can be used for external entry points in a PL/I procedure. Hence a CALL statement or a function reference to any of the external entry names will cause the linkage editor to include the module containing the alias entry names without the need to use the INCLUDE statement for this module.

ADDITIONAL INPUT SOURCES

The linkage editor can accept input from sources other than the primary input defined in the DD statement with the name SYSLIN. For example, automatic library call enables the linkage editor to include modules from a data set (a library) defined by the DD statement with the name SYSLIB. You can name these additional input sources by means of the INCLUDE statement, and you can direct the automatic library call mechanism to alternative libraries by means of the LIBRARY statement.

INCLUDE Statement

The INCLUDE statement causes the linkage editor to process the module or modules indicated. After the included modules have been processed, the linkage editor continues with the next item in the primary input. If an included sequential data set also contains an INCLUDE statement, that statement is processed as if it were the last item in the data set, as shown in Figure 5-10.

```
Primary Input Sequential            Library
Data Set      Data Set              Member
   ---           ---                  ---
   ---           ---                  ---
   ---           ---                  ---
   end           ---                  ---
INCLUDE          end                  ---
   ---        INCLUDE                 ---
   ---           ---                  ---
   ---           ---    not           ---
   ---           ---    processed     ---
   ---           ---                  ---
   end           end                  end
```

Figure 5-10. Processing of additional data sources

The format of the INCLUDE statement is:

INCLUDE ddname[(membername)]

where "ddname" is the name of a DD statement that defines either a sequential data set or a library that contains the modules and control statements to be processed. If the DD statement defines a library, replace "membername" with the names of the modules to be processed, separated by commas. You can specify more than one ddname, each of which may be followed by any number of member names in a single INCLUDE statement. For example:

INCLUDE D1(MEM1,MEM2),D2(MODA,MODB)

specifies the inclusion of the members MEM1 and MEM2 from the library defined by the DD statement with the name D1, and the members MODA and MODB from the library defined by the DD statement with the name D2.

LIBRARY Statement

The basic function of the LIBRARY statement is to name call libraries in addition to those named in the DD statement SYSLIB. The format of the LIBRARY statement is:

LIBRARY ddname(membername)

where "ddname" is the name of a DD statement that defines the additional call library, and "membername" is the name of the module to be examined by the automatic call mechanism. More than one module can be specified; separate the module names with commas.

OVERLAY STRUCTURES

A load module constructed as an overlay structure can be executed in an area of main storage that is not large enough to contain the entire module at one time. The linkage editor divides the load module into segments that can be loaded and executed in turn. To construct an overlay structure, you must use linkage editor control statements to specify the relationship between the segments. One segment, termed the <u>root segment</u> must remain in main storage throughout the execution of the program.

In an overlay environment the addressing of a static external structure element, array, or string may be incorrect if used in a data-directed I/O statement or CHECK statement. This error will arise if the control section containing the symbol table of the identifier, and the corresponding static internal control section are not in the same overlay segment. This is because the symbol table contains the address of a locator that is in static internal storage. The difficulty can be avoided by ensuring that the procedure in the root segment contains a reference to the identifier in a data-directed I/O or CHECK context. The statement containing the identifier need not be executed; its presence ensures that the symbol table for the identifier addresses the locator in the static internal control section of the root segment.

The descriptor for a controlled external aggregate with fixed extents is stored in the static internal control section of the procedure that allocates it. This prevents references to the external variable being made in other procedures that overlay the segment in which it was allocated. A controlled external variable must be allocated in one of two ways:

```
A: PROC OPTIONS(MAIN);
     .
     CALL B;
     .
     CALL F;
     .
     END A;
```

```
B: PROC;
     .
     CALL C;
     .
     END B;
```

```
C: PROC;
     .
     CALL D;
     .
     CALL E;
     .
     END C;
```

```
D: PROC;
     .
     .
     END D;
```

```
E: PROC;
     .
     .
     END E;
```

```
F: PROC;
     .
     .
     END F;
```

```
                              |
                              |
                              | Procedure A
                              |
                              |
          ----------------------------------
          |                   X            |
          |                                |
Procedure B |                              | Procedure F
          |                                |
         ---                               |
          |
          |
Procedure C |
          |
 -----------------------------
 |            Y              |
 |                           |
 | Procedure D               | Procedure E
 |                           |
 |                           |
```

Figure 5-11. Overlay structure and its tree

1. The variable can be allocated in the root phase. A convenient technique to use would be to have a subroutine, containing the ALLOCATE statement, which could be called from any segment.

2. The variable can be allocated with adjustable extents, so that the descriptor will be copied into the controlled storage area when allocation takes place. Note that this method uses more storage.

<u>Design of the Overlay Structure</u>

Before preparing the linkage editor control statements, you must design the overlay structure for your program. A <u>tree</u> is a graphic representation of an overlay structure that shows which segments occupy main storage at different times. The design of trees is discussed in the linkage editor and loader publication, but for the purposes of this chapter, Figure 5-11 contains a simple example. The program comprises six procedures: A, B, C, D, E,

```
//OPT5#12      JOB
//STEP1        EXEC PLIXCLG,
               PARM.LKED='OVLY'
//PLI.SYSIN    DD *

  (insert here source statements for
  procedure A)

 * PROCESS;

  (insert here source statements for
  procedure B)

 * PROCESS;

  (insert here source statements for
  procedure C)

 * PROCESS;

  (insert here source statements for
  procedure D)

 * PROCESS;

  (insert here source statements for
  procedure E)

 * PROCESS;

  (insert here source statements for
  procedure F)

 /*
 //LKED.SYSIN DD *
    OVERLAY X
    INSERT ******B1,******C1
    OVERLAY Y
    INSERT ******D1
    OVERLAY Y
    INSERT ******E1
    OVERLAY X
    INSERT ******F1
 /*
```

Figure 5-12. Creating and executing the overlay structure of Figure 5-11

and F. Procedure B calls procedure C which, in turn, calls procedures D and E. (Only procedure A requires the option MAIN.)

The main procedure (A) must be in main storage throughout the execution of the program. Since the execution of procedure B will be completed before procedure F is called, the two procedures can occupy the same storage; this is depicted by the lines representing the two procedures in Figure 5-11 starting from the common point (node) X. Procedure B must remain in storage while procedures C, D, and E are executed, but procedures D and E can occupy the same storage; thus the lines representing procedures D and E start from the node X.

The degree of segmentation that can be achieved can be clearly seen from the figure. Since procedure A must always be present, it must be included in the root segment. Procedures F, D and E can usefully be placed in individual segments, as can procedures B and C be placed together; there is nothing to be gained by separating procedures B and C, since they must be present together at some time during execution.

Control Statements

Two linkage editor control statements, OVERLAY and INSERT, control the relationship of the segments in the overlay structure. The OVERLAY statement specifies the start of a segment and the INSERT statement specifies the positions of control sections in a segment. You must include the attribute OVLY in the PARM parameter of the EXEC statement that invokes the linkage editor, otherwise the linkage editor will ignore the control statements.

The format of the OVERLAY statement is:

```
OVERLAY symbol
```

where "symbol" is the node at which the segment starts (for example, X in Figure 5-11). You must specify the start of every segment, except the root segment, in an OVERLAY statement.

The format of the INSERT statement is:

```
INSERT control-section-name
```

where "control-section-name" is the name of the control section (that is, the derivative of the procedure name that is found in the linkage editor map) that is to be placed in the segment. More than one control section can be specified, separate the names with commas. The INSERT statements that name the control sections in the root segment must precede the first OVERLAY statement.

Creating an Overlay Structure

The most efficient method of defining an overlay structure, and the simplest for a PL/I program, is to group all the OVERLAY and INSERT statements together and place them in the linkage editor input (SYSLIN) after the object modules that form the program. The linkage editor initially places all these object modules in the root segment, and then moves those control sections that are referred to in INSERT statements into other segments.

This method has the advantage that you can use batched compilation to process all the procedures in one job step and place the object modules in a temporary data set; this data set must have consecutive organization. You can then place the linkage editor control statements in the input stream, concatenating them with the data set that contains the object modules. (Do not use the NAME compiler option to name the object modules; if you do, the NAME statements inserted by the compiler will cause the linkage editor to attempt to create separate load modules rather than a single overlay structure.)

The use of the IBM-supplied cataloged procedure PLIXCLG to create and execute the overlay structure of Figure 5-11, is shown in Figure 5-12.

An alternative approach instead of batched compilation is to compile the procedures independently and store them as object modules in a private library. You can then use an INCLUDE statement to place them in the input to the linkage editor (SYSLIN).

If an INSERT statement contains the name of an external procedure, the linkage editor will move only the related program control section that has the same name. All other control sections established by the compiler, and all the PL/I library subroutines, will remain in the root segment.

It is important that the PL/I library subroutines be in the root segment, since the optimizing compiler does not support exclusive calls (calls between segments that do not lie in the same path). For example, in Figure 5-11, procedures in the segment containing D could call procedures in the segments containing A, B, C, and D, but not in the segments containing E or F. Procedures in the segments containing B or C could call procedures in the segments containing A, B, C, D, and E, but not in the segment containing F. A procedure in the segment containing B may not call a procedure in the segment containing A if this latter procedure calls a procedure in the segment containing F.

However, certain library subroutines may not be required by all segments, in which case you can move them into a lower segment. To do this, compile the procedures using the compiler option ESD, and examine the resulting external symbol dictionary. For example, if in Figure 5-11 a library subroutine is called only by the segment containing E, you can move it into that segment by placing an INSERT statement, specifying the subroutine name, immediately after the statement INSERT ******E1.

Similarly, you can move control sections from the root segment to lower segments. For example, to move the static internal control section for procedure F into the segment containing F, place the statement INSERT ******F2 after the statement INSERT ******F1. Values assigned to static data items are not retained when a segment is overlaid. Do not move static data from the root segment unless it comprises only:

- Values set by the INITIAL attribute and then unchanged (that is, read-only data).
- Values that need not be retained between different loadings of the segment.

Care must be taken to ensure that the static external control sections for all the PL/I files used in an overlay program are placed in the root segment. If this is not done, failures may occur when the ERROR condition is raised and the PL/I error routines attempt to close the files. In particular, the static external control section for SYSPRINT must always be placed in the root segment.

When using the COUNT option, ensure that all procedures for which count information is required have their static internal control sections in the root segment, or the count information will be rendered invalid.

LINK EDITING FETCHABLE LOAD MODULES

The PL/I FETCH and RELEASE statements permit the dynamic loading of separate load modules which can be subsequently invoked from the PL/I object program.

Fetchable (or dynamically-loaded) modules should be link-edited into a load module library which is subsequently made available for the job step by means of a JOBLIB or STEPLIB DD statement.

The step which link-edits a fetchable load module into a library requires the following linkage editor control statements:

- An ENTRY statement to define the entry-point into the PL/I program.

Control Section	Present in
PLISTART	All programs
IBMBJWT1	Programs that use the WAIT statement
IBMTJWT1	Multitasking programs that use the WAIT statement
IBMBTOC1	Programs that use the COMPLETION builtin function or pseudovariable
IBMTTOC1	Multitasking programs that use the COMPLETION built-in function or pseudovariable.
IBMBTPR1	Programs that use the PRIORITY pseudovariable
IBMTTPR1	Multitasking programs that use the PRIORITY pseudovariable.
IBMBEFL1	Programs compiled with the FLOW or COUNT options.

Figure 5-13. Control sections to be deleted for optimum space-saving

```
//FETCH JOB
//STP EXEC PLIXCL
//PLI.SYSIN DD *
        .
        .
        .
    PL/I source(fetchable)
        .
        .
        .
/*
//LKED.SYSLMOD DD DSN=PRVLIB,...
//LKED.SYSLIN DD DDNAME=SYSIN
//       DD DSN=&&LOADSET,DISP=(OLD,DELETE)
//LKED.SYSIN DD *
  ENTRY   procedure-name
  REPLACE PLISTART
  REPLACE IBMBJWT1
  REPLACE IBMBTOC1
  REPLACE IBMBTPR1
  NAME FETCH1
/*
```

Figure 5-14. Example of link-editing a fetchable load module

- A NAME statement to define the name used for the fetchable load module. This statement is required if the compiler option NAME is not used and if the name is not specified in the DSN parameter in the SYSLMOD DD statement used to define the load module library.
- Optionally, for optimum space saving, REPLACE statements to delete the control sections shown in Figure 5-13, if they are present in the object module.

The name or any alias by which the fetchable load module is identified in the load module library must appear in a FETCH or RELEASE statement within the scope of the invoking procedure.

COBOL or FORTRAN modules cannot be loaded dynamically by the PL/I FETCH statement.

The job control statements and the linkage editor statements to link-edit a fetchable load module into a library called PRVLIB are given in Figure 5-14. The cataloged procedure PLIXCL is used to illustrate these statements by sharing a job that includes both the compilation and the link-editing of the fetchable PL/I module.

Combining PL/I Modules from the Optimizing and Checkout Compilers

When a program is to consist of PL/I modules compiled by the optimizing and checkout compilers, the following points should be considered before link-editing the modules into a single load module:

- The modules compiled by the optimizing compiler should be link-edited to form a load module.
- The linkage editor option NCAL must be specified for this link-editing operation.
- The load module containing the modules compiled by the optimizing compiler can now be link-edited with the link-edit stubs produced by the checkout compiler.

This method ensures that the initialization routine for a program compiled by the optimizing compiler will not be included in the final load module and that the initialization routine for a program compiled by the checkout compiler is used when the program is executed.

Both the space occupied by the final load module and its speed of execution are affected by the SYSLIB data set specified for use by the linkage editor. Two data sets, SYS1.PLICMIX and SYS1.PLIBASE are available. Use SYS1.PLICMIX to obtain a smaller load module at the expense of execution time; use SYS1.PLIBASE to save execution time at the expense of space.

Loader

The loader is an operating system processing program that produces and executes load modules. It always stores the load modules directly in main storage where they are executed immediately.

The input to the loader can include single object modules or load modules, several object modules or load modules, or a mixture of both. The output from the loader always comprises an executable program that is loaded into main storage from where it will be executed.

Unlike the linkage editor you cannot use any control statements with the loader. If any linkage editor control statements are used, they will be ignored, and their presence in the input stream will not be treated as an error. Your job will continue to be processed, a message will be generated and, if you have included a DD statement with the name SYSLOUT, this message and the name of the control statement will be printed on your listing.

The loader compensates for the absence of the facilities provided by control statements by allowing the concatenation of both object and load modules in the data set defined by the DD statement with the name SYSLIN, and by allowing an entry point to be specified by means of the EP option, as described in "Optional Facilities," later in this chapter.

LOADER PROCESSING

A PL/I program cannot be executed until the appropriate PL/I library subroutines have been included. All library subroutines are included during loading. In basic processing, as shown in Figure 5-15, the loader accepts data from its primary input source, a data set defined by the DD statement with the name SYSLIN. For a PL/I program, this data is the object module produced by the compiler. The loader uses the external symbol dictionary in this object module to determine whether the module includes any external references for which there are no corresponding external symbols in the module: it attempts to resolve such references by a method termed automatic library call as described in "Linkage Editor Processing," earlier in this chapter.

The loader locates the subroutines in which the external symbols are defined (if such subroutines exist) and includes them in the load module. If all external references are resolved satisfactorily the load module is executed.

The loader will always search the link-pack area before searching the PL/I resident library, as shown in Figure 5-16. The link-pack area is an area of main storage in which frequently used load modules are stored permanently. If there is more than one copy of an object module in the data set defined by the DD statement with the name SYSLIN, the loader will load the first and ignore the rest.

Main Storage Requirements

The minimum main storage requirements for the loader are shown in Figure 5-17.

This amounts to at least 17K bytes for the loader and its associated routines and data areas plus the main storage required for the program that is to be executed. If the loader program and the data management access routines were stored in the link-pack area, the amount of main storage required would be 3K bytes for the loader data area plus that required by the program that is to be executed.

Job Control Language for the Loader

Although you will probably use cataloged procedures rather than supply all the job control language (JCL) required for a job step that invokes the loader, you should be familiar with these JCL statements so that you can make the best use of the loader and, if necessary, override statements of the cataloged procedures.

The IBM-supplied cataloged procedures that include a loader procedure step are as follows:

- PLIXCG   Compile, load-and-execute
- PLIXG   Load-and-execute

The following paragraphs describe the essential JCL statements for the loader. The IBM-supplied cataloged procedures are described in Chapter 11 and include examples of these statements.

```
         SYSLIN
    (primary input)
r----------------┐
|                |
|PL/I object    A|
|and/or         B|-------┐
|load modules   C|       |
|                |       |
L----------------┘       |         r----------------┐                  r----------------┐
                         |         |                |                  |               A|
                         L-------->|                |                  |               B|
                                   |     loader     |                  |               C|
                                   |                |----------------->| main storage  D|
                         r-------->|                |                  |               E|
        SYSLIB           |         L----------------┘                  |               F|
     (call library)      |                                             |               G|
r----------------┐       |                                             |                |
|                |       |                                             L----------------┘
|PL/I resident  D|       |
|library        E|       |
|(SYS1.PLIBASE) F|-------┘
|               G|
|                |
L----------------┘
```

Figure 5-15. Basic loader processing

```
         SYSLIN
    (primary input)
r----------------┐
|                |                                                           Main
|PL/I object    A|                                                          storage
|and/or load    B|--------┐                                               r-----------┐
|modules        C|        |                                               |           |  A
|                |        |                                               |           |
L----------------┘        |        r----------------┐                     |           |  B--┐
                          |        |                |-------------------->|           |     |
                          L------->|                |                     |           |  C-┐|
                                   |                |                     |           |    ||
                                   |     loader     |   r--------------------------------->H<┘|
                                   |                |   |                 |           |     |
        SYSLIB            r------->|                |   |                 |           |  D<-┘
     (call library)       |        |                |   |                 |           |     |
r----------------┐        |        L----------------┘   |                 |           |  E<-┘
|                |        |                             |                 |           |     |
|PL/I resident  D|        |                             |                 |           |  F<-┘
|library        E|--------┘                             |                 |-----------|     |
|(SYS1.PLIBASE) F|                                      |                 |           |  G<-┘
|               H|--------------------------------------┘                 |link-pack  |
|                |                                                        |   area    |
L----------------┘                                                        L-----------┘
```

Figure 5-16. Loader processing, link-pack area and SYSLIB resolution

Storage required for:	Amount (min) in bytes
Loader program	10K
Data management access routines	4K
Buffers and tables used by loader	3K
PL/I program to be executed	variable

Figure 5-17. Main storage requirements for the loader

EXEC STATEMENT

The name of the loader is IEWLDRGC. It also has the alias LOADER, which is used in the IBM-supplied cataloged procedures, and will be used to refer to the loader program in the rest of this chapter. The basic EXEC statement is:

```
//stepname  EXEC PGM=LOADER
```

By using the PARM parameter of the EXEC statement, you can select one or more of the optional facilities provided by the loader; these are described under "Optional Facilities," later in this chapter.

DD STATEMENTS FOR THE STANDARD DATA SETS

The loader always requires one standard data set; that defined by the DD statement with the name SYSLIN. Three other standard data sets are optional and if you use them you must define them in DD statements with the names SYSLOUT, SYSPRINT, and SYSLIB. The four data sets, their names, and other characteristics of the data sets, are shown in Figure 5-18.

The data sets defined by the DD statements with the names SYSLIN, SYSLIB, and SYSLOUT are those specified at system generation for your installation. Other ddnames may have been specified at your installation; if they have, your JCL statements must use them in place of those given above. In a similar manner the IBM-supplied cataloged procedures PLIXCG and PLIXG use names as shown above; your systems programmer will have to modify these procedures if the names at your installation are different.

Primary Input (SYSLIN)

Primary input to the loader must be a standard data set defined by a DD statement with the name SYSLIN; this data set must have consecutive organization. The input can comprise one or more object modules, one or more load modules, or a mixture of object modules and load modules.

For a PL/I program the primary input is usually a data set containing an object module produced by the compiler. This data set may be on magnetic tape or on a direct-access device, or you can include it in the input job stream. In all cases the input must be in the form of 80-byte F-format records.

The IBM-supplied cataloged procedure

ddname	Contents of Data Set	Possible Device Classes[1]
SYSLIN	Primary input (normally the output from the compiler)	SYSSQ or the input job stream (specified by DD *)
SYSLOUT	Loader messages and module map listing	SYSSQ, SYSDA, or SYSOUT=A
SYSPRINT	PL/I execution-time messages and problem output listing	SYSSQ, SYSDA, or SYSOUT=A
SYSLIB	Automatic call library	SYSDA

[1]SYSSQ   Magnetic tape or direct-access device
SYSDA   Direct-access device
SYSOUT=A   Normal printed output class for system output

Figure 5-18. Loader standard data sets

PLIXCG includes the DD statement:

//SYSLIN DD DSN=&&LOADSET,DISP=(OLD,DELETE)

This statement specifies that the data set &&LOADSET is temporary. If you want to modify this statement you must refer to it by the qualified ddname GO.SYSLIN.

The IBM-supplied cataloged procedure PLIXG does not include a DD statement for the input data set; you must always supply one, specifying the characteristics of your input data set using the qualified ddname GO.SYSLIN.

Automatic Call Library (SYSLIB)

Unless you specify otherwise, the loader will normally attempt to resolve external references by automatic library call. The automatic call library (SYSLIB), and how to specify it, is described in the linkage editor section earlier in this chapter.

Listing (SYSLOUT)

The loader generates a listing that includes a module map (if you have specified the MAP option) and, if errors have been detected during processing, messages referring to these. The information that may appear is described in "Listing Produced by the Loader," later in this chapter.

You must define the data set in which you want this listing to be stored by a DD statement with the name SYSLOUT and it must have consecutive organization. Although the listing is usually printed it can be stored on any magnetic-tape or direct-access device. For printed output the following DD statement will suffice:

//SYSLOUT DD SYSOUT=A

Listing (SYSPRINT)

As well as the information listed in the data set defined by the DD statement with the name SYSLOUT certain information produced by the loader is always stored in the data set defined by the DD statement with the name SYSPRINT. This data set, which must have consecutive organization, holds messages that refer to errors that have occurred during execution of your program, as well as the results produced by your program. The information that may appear is described in "Listing Produced by the Loader," later in this chapter. For printed output the following DD statement will suffice:

//SYSPRINT DD SYSOUT=A

EXAMPLES OF LOADER JCL

A sequence of job control language for the loader is shown in Figure 5-19. A PL/I program has been compiled in a job step with the step name PLI; the resultant object module has been placed in the data set defined by the DD statement with the name SYSLIN. Because this module is to be loaded and executed in the same job as the compile step, this DD statement can use the backward reference, indicated by the asterisk, as shown. If the compile and load-and-go steps were in different jobs, the DD statement would have to specify a permanent data set, cataloged or uncataloged.

The IBM-supplied cataloged procedure PLIXCG includes a DD statement with the name SYSLIN in both the compile and load-and-go procedure steps; you do not need to specify this statement unless you want to modify it. The IBM-supplied cataloged procedure PLIXG does not include a DD statement with the name SYSLIN; you must supply one, using the qualified name GO.SYSLIN.

Typical job control language statements for the loader are shown in Figure 5-20. The example illustrates how to include, in the input stream, both an object module for input to the loader, and data to be used by your program during execution.

The DD statement with the name SYSLIN and the two following unnamed DD statements define three data sets that are to be concatenated into one data set to be used as input to the loader. The first data set is named OBJMOD and contains an object module. This data set could be the output of the optimizing compiler that has just processed your PL/I program. The second data set is named MODLIB(MOD55) containing a load module that has been given the name MOD55 and stored in the library called MODLIB. The third data set is an object module defined by the DD statement with the name IN. This DD statement appears further on and has the asterisk notation that indicates that the data set defined by this statement follows in the input stream.

The DD statement with the name SYSLIB and the unnamed DD statement immediately

```
//LOAD       JOB
              .
              .
              .
//STEP1      EXEC PGM=LOADER
//SYSLIN     DD DSN=*.PLI.SYSLIN,DISP=(OLD,DELETE)
//SYSLIB     DD DSN=SYS1.PLIBASE,DISP=SHR
//SYSLOUT    DD SYSOUT=A
//SYSPRINT   DD SYSOUT=A
```

Figure 5-19. Job control language for load-and-go

```
//LOAD        JCB
               .
               .
               .
//STEP1       EXEC PGM=LOADER
//SYSLIN      DD DSN=OBJECT,UNIT=SYSSQ,VOL=SER=30104,DISP=(OLD,KEEP)
//            CD DSN=MODLIB(MOD55),DISP=SHR
//            DD DDNAME=IN
//SYSLIB      CD DSN=SYS1.PLIBASE,DISP=SHR
//            DD DSN=PRIVLIB,DISP=SHR
//SYSLOUT     CD SYSOUT=A
//SYSPRINT    DD SYSOUT=A
//IN          CD *
               .
               .
               .
    (insert here the object module to be loaded)
               .
               .
               .
/*
//SYSIN       DC *
               .
               .
               .
    (insert here the execution data, if any)
               .
               .
               .
/*
```

Figure 5-20. Object and load modules in load-and-go

following it define two data sets that are to be concatenated so that they can be searched for unresolved external references by automatic library call. The first data set is the PL/I resident library (SYS1.PLILIB) and the second is a private library called PRIVLIB.

Optional Facilities of the Loader

The loader provides a number of optional facilities that are selected by including the appropriate keywords from the following list in the PARM parameter of the EXEC statement that invokes it:

CALL
EP
LET
MAP
PRINT
RES
SIZE

Code the PARM parameter as follows:

PARM = '[optionlist][/pgmparm]'

where "option list" is a list of loader options, and "pgmparm" is a parameter to be passed to the main procedure of the PL/I program to be executed. In the examples given below, the program parameter is referred to as PP.

If both loader options and a program parameter occur in the PARM parameter, the loader options are given first and are separated from the program parameter by a slash. If there are loader options but no program parameter, the slash is omitted, but if there are only program parameters the slash must be coded. If there is more than one option, the option keywords are separated by commas.

The PARM field can have one of three formats:

1. If the special characters / or = are used, the field must be enclosed in single quotes. For example:

```
PARM='MAP,EP=FIRST/PP'
    ='MAP,EP=FIRST'
PARM='/PP'
```

2. If these characters are not included, and there is more than one loader option, the options must be enclosed in parentheses. For example:

```
PARM=(MAP,LET)
```

3. If these characters are not included, and there is only one loader option, neither quotes nor parentheses are required. For example:

```
PARM=MAP
```

To overwrite the PARM parameter options specified in a cataloged procedure, you must refer to the PARM parameter by the qualified name PARM.procstepname. For example: PARM.GO.

The loader options are of two types:

1. Simple pairs of keywords: a positive form (for example, CALL) that requests a facility, and an alternative negative form (for example NOCALL) that rejects that facility. CALL, LET, MAP, PRINT, and RES are of this type.

2. Keywords that permit you to assign a value to a function (for example, SIZE=10K). EP and SIZE are of this type.

The loader options are described in the following sections, in alphabetic order.

CALL Option

The CALL option specifies that the loader will attempt to resolve external references by automatic library call. To preserve compatibility with the linkage editor, the negative form of this option can be specified as NCAL as well as by NOCALL.

EP Option

The EP option specifies the entry point name of the program that is to be executed. The format of the EP option is:

```
EP=name
```

where "name" is an external name. If all input modules are load modules you must specify EP=PLISTART.

LET Option

The LET option specifies that the loader will try to execute the problem program even if a severity 2 error has been found.

MAP Option

The MAP option specifies that the loader is to print a map of the load module giving the relative locations and lengths of control sections in the module. You must specify the data set defined by the DD statement with the name SYSLOUT to have this map printed. The module map is described in "Listing Produced by the Loader," later in this chapter.

PRINT Option

The PRINT option specifies that the data set defined by the DD statement with the name SYSLOUT is to be used for messages, the module map, and other loader information.

RES Option

The RES option specifies that the loader will attempt to resolve external references by a search of the link-pack area of main storage. This search will be made after the primary input to the loader has been processed but before the data set defined by the DD statement with the name SYSLIB is opened.

SIZE Option

The SIZE option specifies the amount of main storage, in bytes, to be allocated to the loader. The format of the SIZE option is:

SIZE=yyyyyy specifies that yyyyyy bytes of main storage are to be allocated to the loader.

SIZE=yyyK specifies that yyyK bytes of main storage are to be allocated to the loader (1K=1024).

The values can be enclosed, optionally, in parentheses.

Listing Produced by the Loader

The loader can provide a listing on the SYSLOUT data set; the SYSPRINT data set is used by the problem program. The contents of each is given in Figure 5-21.

Data set	Contents
SYSLOUT	Loader explanatory messages and diagnostic messages, and optionally, a module map.
SYSPRINT	PL/I execution-time messages, and problem program output.

Figure 5-21. Contents of SYSLOUT and SYSPRINT data sets

The SYSLOUT listing is described here; the SYSPRINT listing is described in Chapter 4.

The items in the SYSLOUT listing appear in the following sequence:

1. Statement identifying the loader.
2. Module map (if specified).
3. Explanatory, error, or warning messages.
4. Diagnostic messages.

MODULE MAP

If the MAP option is specified, a module map is printed in the SYSLOUT listing. The map lists all the control sections in the load module and all the entry point names (other than the first) in each control section. The information for each reference is:

- The control section or entry point name.
- An asterisk, if the control section is included by automatic library call.
- An identifier, as follows:

  SD Section definition: the name of the control section.

  LR Label reference: identifying an entry point in the control section other than the primary entry point.

  CM Common area: an external file, or a non-string element variable declared STATIC EXTERNAL without the INITIAL attribute.

- Absolute address of the control section or entry point.

Each reference is printed left to right across the page and starts at a preset position. This gives the impression that the references are arranged in columns, but the correct way to read the map is line by line, across the page, not down each column.

The module map is followed by a similar listing of the pseudo-registers. The identifier used here is PR, and the address is the offset from the beginning of the pseudo-register vector (PRV). The total length of the PRV is given at the end.

The total length of the module to be executed, and the absolute address of its primary entry point, are given after the explanatory messages and before the diagnostic messages.

EXPLANATORY AND DIAGNOSTIC MESSAGES

The loader generates messages describing errors or conditions, detected during processing by the loader, that may lead to error. The format of these messages is given in "Diagnostic Messages and Control Statements" in the linkage editor section earlier in this chapter.

When the module to be executed has been processed, the loader prints out in full all the messages referred to above. The text of each message, an explanation, and any recommended programmer response, are given in the linkage editor and loader publication.

The warning message IEW1001 almost always appears in the listing. The explanation for this is the same as that for IEW0461, described under "Diagnostic Message Directory," in the linkage editor section earlier in this chapter.

Chapter 6: Data Sets and Files

This chapter describes briefly the nature and organization of data sets, the data management services provided by the operating system, and the record formats acceptable for auxiliary storage devices. The way in which a data set is associated with a PL/I file is fully described in the language reference manual for this compiler. Methods of creating and accessing data sets in PL/I are given in Chapters 7 and 8.

Data Sets

In IBM System/360 Operating System, a <u>data set</u> is any collection of data that can be created by a program and accessed by the same or another program. A data set may be a deck of punched cards; it may be a series of items recorded on magnetic tape or paper tape; or it may be recorded on a direct-access device such as a magnetic disk or drum. A printed listing produced by a program is a data set, but it cannot be accessed by a program.

A data set resides on one or more volumes. A <u>volume</u> is a standard physical unit of auxiliary storage (for example, a reel of magnetic tape or a disk pack) that can be written on or read by an input/output device; a serial number identifies each volume (other than a punched-card or paper-tape volume or a magnetic-tape volume either without labels or with nonstandard labels).

A magnetic-tape or direct-access volume can contain more than one data set; conversely, a single data set can span two or more magnetic-tape or direct-access volumes.

DATA SET NAMES

A data set on a direct-access device must have a name so that the operating system can refer to it. If you do not supply a name, the operating system will supply a temporary one. A data set on a magnetic-tape device must have a name if the tape has standard labels (see "Labels," later in this chapter.) A name consists of up to eight characters, the first of which must be alphabetic. Data sets on punched cards, paper tape, unlabeled magnetic tape, or nonstandard unlabeled magnetic tape do not have names.

You can place the name of a data set, with information identifying the volume on which it resides, in a catalog that exists on the volume containing the operating system. Such a data set is termed a <u>cataloged data set</u>. To catalog a data set use the CATLG subparameter of the DISP parameter of the DD statement. To retrieve a cataloged data set, you do not need to give the volume serial number or identify the type of device; you need only specify the name of the data set and its disposition. The operating system searches the catalog for information associated with the name and uses this information to request the operator to mount the volume containing your data set.

If you have a set of related data sets, you can increase the efficiency of the search for a particular data set by establishing a hierarchy of indexes in the catalog. For example, consider an installation that groups its data sets under four headings: ENGRNG, SCIENCE, ACCNTS, and INVNTRY, as shown in Figure 6-1. In turn, each of these groups is subdivided; for example, the SCIENCE group has subgroups called PHYSICS, CHEM, MATH, and BIOLOGY. The MATH subgroup itself contains three subgroups: ALGEBRA, CALCULUS, and BOOL.

```
                          |
                          |
     ┌-----------------------------------┐
     |        |                 |        |
     |        |                 |        |
  ENGRNG   SCIENCE           ACCNTS   INVNTRY
              |
              |
              |
   ┌--------------------------┐
   |          |       |       |
   |          |       |       |
PHYSICS     CHEM    MATH   BIOLOGY
                      |
                      |
                      |
             ┌---------------------┐
             |          |          |
             |          |          |
          ALGEBRA    CALCULUS    BOOL
```

Figure 6-1. A hierarchy of indexes

To find the data set BOOL, the names of all the indexes of which it is part must be specified, beginning with the largest group SCIENCE, followed by the subgroup name MATH and finally the data set name BOOL. The names are separated by periods. The complete identification needed to find the data set BOOL is

```
SCIENCE.MATH.BOOL
```

Such an identifier is termed a <u>qualified name</u>. The maximum length of a qualified name is 44 characters, including the separating periods; each component name has a maximum length of eight characters. (Do not use names that begin with the letters SYS; if the name is qualified do not use P as the nineteenth character. The names assigned by the operating system to unnamed temporary data sets are of this form, with P as the nineteenth character, and these data sets are deleted when the utility program IEHPROGM is used with a SCRATCH statement that includes the keywords VTOC and SYS.)

Some data sets are updated periodically, or are logically part of a group of data sets, each of which is related to the other in time. You can relate such data sets to each other in what is termed a <u>generation data group</u>. Each data set in a generation data group has the same name qualified by a unique parenthesized generation number (for example, STOCK(0), STOCK(-1), STOCK(-2)). The most recently cataloged data set is generation 0, and the preceding generations are -1, -2, and so on. You specify the number of generations to be saved when you establish the generation data group.

For example, consider a generation data group that contains a series of data sets used for weather reporting and forecasting; the name of the data sets is WEATHER. The generations for the group (assuming that three generations are to be saved) are:

```
WEATHER(0)
WEATHER(-1)
WEATHER(-2)
```

When WEATHER is updated, the new data set is specified to the operating system as WEATHER(+1). When it catalogs the new data set, the operating system changes the name to WEATHER(0), changes the former WEATHER(0) to WEATHER(-1), the former WEATHER(-1) to WEATHER(-2), and deletes the former WEATHER(-2).

To find out how to create a generation data group, refer to the job control language and utilities publications.

BLOCKS AND RECORDS

The items of data in a data set are arranged in blocks separated by interblock gaps (IBG)[1].

A <u>block</u> is the unit of data transmitted to and from a data set. Each block contains one record, part of a record, or several records. A block could also contain a prefix field of up to 99 bytes in length depending on the code (ASCII or EBCDIC) in which the data is recorded. These codes are discussed in "Data Codes," below. Specify the block size in the BLKSIZE parameter of the DD statement or in the BLKSIZE option of the ENVIRONMENT attribute.

A <u>record</u> is the unit of data transmitted to and from a program. When writing a PL/I program, you need consider only the records that you are reading or writing; but when you describe the data sets that your program will create or access, you must be aware of the relationship between blocks and records.

If a block contains two or more records, the records are said to be blocked. Blocking conserves storage space in a volume because it reduces the number of input/output operations required to process a data set. Records are blocked and deblocked automatically by the data management routines.

Specify the record length in the LRECL parameter of the DD statement or in the RECSIZE option of the ENVIRONMENT attribute.

<u>Data Codes</u>: The normal code in which data is recorded in System/360 is the Extended Binary Coded Decimal Interchange Code (EBCDIC) although source input can optionally be coded in BCD (Binary Coded Decimal). However, for magnetic tape only, System/360 will accept data recorded in the American Standard Code for Information Interchange (ASCII). Use the ASCII and BUFOFF options of the ENVIRONMENT attribute if you are reading or writing data sets recorded in ASCII.

A prefix field up to 99 bytes in length may be present at the beginning of each block in an ASCII data set. The use of this field is controlled by the BUFOFF option. For a full description of the options used for ASCII data sets see the language reference manual for this compiler.

---

[1] Although the term "interrecord gap" is widely used in operating system manuals, it is not used here; it has been replaced by the more accurate term "interblock gap."

RECORD FORMATS

The records in a data set must have one of the following formats:

- F fixed length
- V variable length (D- or V-format)
- U undefined length

All formats can be blocked if required, but only fixed-length and variable-length records are deblocked automatically by the system; undefined length records must be deblocked by your program.

Fixed-length Records (F-format Records)

You can specify the following formats for fixed-length records:

F	Fixed-length, unblocked
FB	Fixed-length, blocked
FS	Fixed-length, unblocked, standard
FBS	Fixed-length, blocked, standard

In a data set with fixed-length records, as shown in Figure 6-2, all records have the same length. If the records are blocked, each block contains an equal number of fixed-length records (although the last block may be truncated if there are insufficient records to fill it). If the records are unblocked, each record constitutes a block.

Unblocked records (F-format):

```
┌─────────┐   ┌─────────┐   ┌─────────┐   ┌──
│ Record  │IBG│ Record  │IBG│ Record  │IBG│
└─────────┘   └─────────┘   └─────────┘   └──
```

Blocked records (FB-format):

```
┌────────────Block───────────┐

┌────────────────────────────┐     ┌────────
│  Record    Record    Record│ IBG │ Record
└────────────────────────────┘     └────────
```

Figure 6-2. Fixed-length records

Because it can base blocking and deblocking on a constant record length, the operating system can process fixed-length records faster than variable-length records. The use of "standard" (FS-format and FBS-format) records further optimizes the sequential processing of a data set on a direct-access device. A standard format data set must contain fixed-length records and must have no embedded empty tracks or short blocks (apart from the last block). With a standard format data set, the operating system can predict whether the next block of data will be on a new track and, if necessary, can select a new read/write head in anticipation of the transmission of that block. A PL/I program never places embedded short blocks in a data set with fixed-length records. A data set containing fixed-length records can be processed as a standard data set even if it is not created as such, providing it contains no embedded short blocks or empty tracks.

Variable-length Records (D- or V-format Records)

You can specify the following formats for variable-length records:

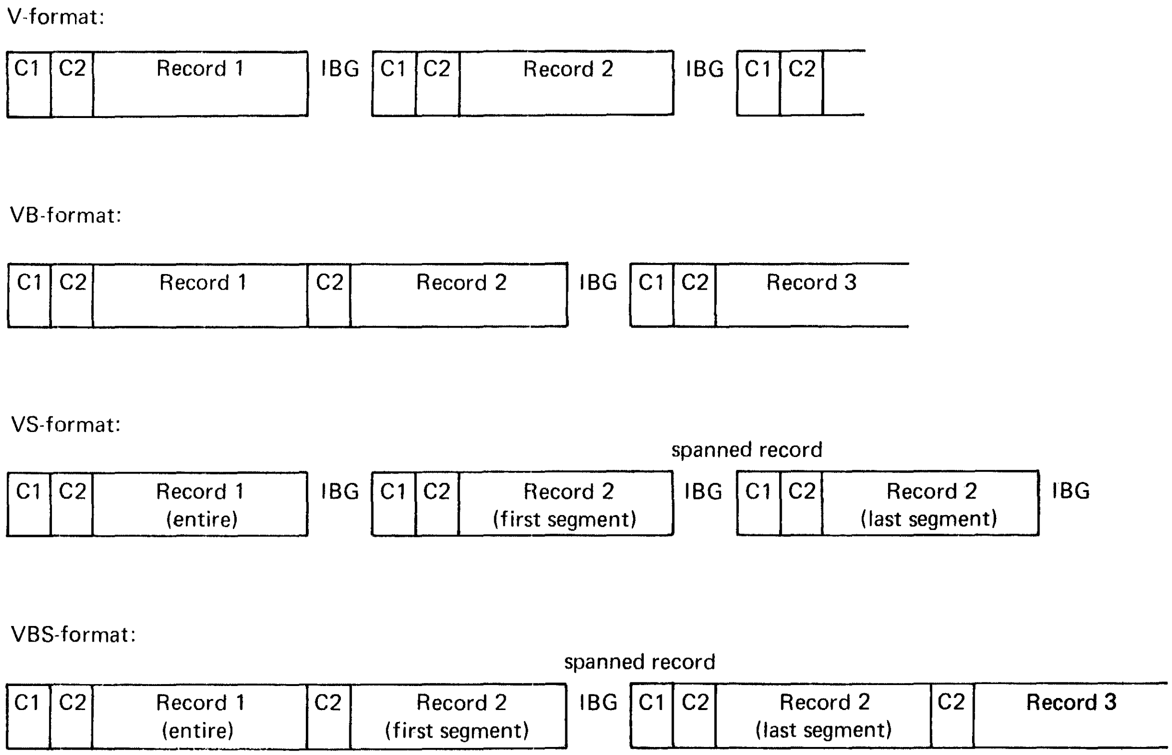
V	Variable-length, unblocked
VB	Variable-length, blocked
VS	Variable-length, unblocked, spanned
VBS	Variable-length, blocked, spanned
D	Variable-length, unblocked, ASCII
DB	Variable-length, blocked, ASCII

V-format permits both variable-length records and variable-length blocks. The first four bytes of each record and of each block contain control information for use by the operating system (including the length in bytes of the record or block). Because of these control fields, variable-length records cannot be read backwards. Illustrations of variable-length records are shown in Figure 6-3.

V-format signifies unblocked variable-length records. Each record is treated as a block containing only one record, the first four bytes of the block contain block control information, and the next four contain record control information.

VB-format signifies blocked variable-length records. Each block contains as many complete records as it can accommodate. The first four bytes of the block contain block control information, and the first four bytes of each record contain record control information.

Spanned Records: A spanned record is a variable-length record in which the length of the record can exceed the size of a block. If this occurs, the record is



C1: Block control information
C2: Record or segment control information

Figure 6-3. Variable-length records

divided into segments and accommodated in two or more consecutive blocks by specifying the record format as either VS or VBS. Segmentation and reassembly are handled automatically. The use of spanned records allows you to select a block size, independently of record length, that will combine optimum use of auxiliary storage with maximum efficiency of transmission.

VS-format is similar to V-format. Each block contains only one record or segment of a record. The first four bytes of the block contain block control information, and the next four contain record or segment control information (including an indication of whether the record is complete or is a first, intermediate, or last segment).

With REGIONAL(3) organization, the use of VS-format removes the limitations on block size imposed by the physical characteristics of the direct-access device. If the record length exceeds the size of a track, or if there is no room left on the current track for the record, the record will be spanned over one or more tracks.

VBS-format differs from VS-format in that each block contains as many complete records or segments as it can accommodate; each block is, therefore, approximately the same size (although there can be a variation of up to four bytes, since each segment must contain at least one byte of data).

ASCII Records: For data sets that are recorded in ASCII use D-format as follows:

D-format records are similar to V-format except that the data they contain is recorded in ASCII.

DB-format records are similar to VB-format except that the data they contain is recorded in ASCII.

Undefined-length Records (U-format Records)

U-format permits the processing of records that do not conform to F- and V-formats. The operating system and the compiler treat each block as a record; your program must perform any required blocking or deblocking.

DATA SET ORGANIZATION

The data management routines of the operating system can handle five types of data set, which differ in the way data is stored within them and in the permitted means of access to the data. The three main types of data set and the corresponding keywords describing their PL/I organization[1] are given in Figure 6-4.

Type of Data Set	PL/I Organization
Sequential	CONSECUTIVE
Indexed sequential	INDEXED
Direct	REGIONAL

Figure 6-4. The three main types of data set

The fourth type, teleprocessing, is recognized by the compiler by the file attribute TRANSIENT.

The fifth type, partitioned, has no corresponding PL/I organization.

In a sequential (or CONSECUTIVE) data set, records are placed in physical sequence. Given one record, the location of the next record is determined by its physical position in the data set. Sequential organization is used for all magnetic tapes, and may be selected for direct-access devices. Paper tape, punched cards, and printed output are sequentially organized.

An indexed sequential (or INDEXED) data set must reside on a direct-access volume. Records are arranged in collating sequence, according to a key that is associated with every record. An index or set of indexes maintained by the operating system gives the location of certain principal records. This permits direct retrieval, replacement, addition, and deletion of records, as well as sequential processing.

----

[1] Do not confuse the terms "sequential" and "direct" with the PL/I file attributes SEQUENTIAL and DIRECT. The attributes refer to how the file is to be processed, and not to the way the corresponding data set is organized.

A direct (or REGIONAL) data set must reside on a direct-access volume. The records within the data set can be organized in three ways: REGIONAL(1), REGIONAL(2), and REGIONAL(3); in each case, the data set is divided into regions, each of which contains one or more records. A key that specifies the region number and, for REGIONAL(2) and REGIONAL(3), identifies the record, permits direct access to any record; sequential processing is also possible.

A teleprocessing data set (associated with a TRANSIENT file in a PL/I program) must reside in main storage. Records are placed in physical sequence; a key embedded in the record provides direct access to any record.

In a partitioned data set, independent groups of sequentially organized data, each called a member, reside on a direct-access volume. The data set includes a directory that lists the location of each member. Partitioned data sets are often called libraries. The compiler includes no special facilities for creating and accessing partitioned data sets; however, this is not necessary since each member can be processed as a CONSECUTIVE data set by a PL/I program, and there is ready access to the operating system facilities for partitioned data sets through job control language. The use of partitioned data sets as libraries is described in Chapter 10.

LABELS

The operating system uses labels to identify magnetic-tape and direct-access volumes and the data sets they contain, and to store data set attributes (for example, record length and block size). The attribute information must originally come from a DD statement or from your program. Once the label is written you need not specify the information again.

Magnetic-tape volumes can have standard or nonstandard labels, or they can be unlabeled. Standard labels have two parts: the initial volume label, and header and trailer labels. The initial volume label identifies a volume and its owner; the header and trailer labels precede and follow each data set on the volume. Header labels contain system information, device-dependent information (for example, recording technique), and data set characteristics. Trailer labels are almost identical with header labels, and are used when magnetic tape is read backwards.

Direct-access volumes have standard

labels. Each volume is identified by a volume label, which is stored at a standard location on the volume. This label contains a volume serial number and the address of a volume table of contents (VTOC). The table of contents, in turn, contains a label, termed a data set control block (DSCB), for each data set stored on the volume.

DATA DEFINITION (DD) STATEMENT

A data definition (DD) statement is a job control statement that defines a data set to the operating system, and is a request to the operating system for the allocation of input/output resources. Each job step must include a DD statement for each data set that is processed by the step.

Chapter 1 describes the format of job control statements. The operand field of the DD statement can contain keyword parameters that describe the location of the data set (for example, volume serial number and identification of the unit on which the volume will be mounted) and the attributes of the data itself (for example, record format).

The DD statement enables you to write PL/I source programs that are independent of the data sets and input/output devices they will use. You can modify the parameters of a data set or process different data sets without recompiling your program; for example, you can cause a program that originally read punched cards to accept input from magnetic tape merely by changing the DD statement.

Name of DD Statement

The name that appears in the name field of the DD statement (ddname) identifies the statement so that other job control statements and the PL/I program can refer to it. A ddname must be unique within a job step; if two DD statements in one job step have the same name, the second statement is ignored. Except when specifying the concatenation of two or more data sets, a DD statement must always have a name.

For input only you can concatenate two or more sequential or partitioned data sets (that is, link them so that they are processed as one continuous data set) by omitting the ddname from all but the first of the DD statements that describe them. For example, the following DD statements cause the data sets LIST1, LIST2, and LIST3 to be treated as a single data set for the duration of the job step in which the statements appear:

```
//GO.LIST DD DSNAME=LIST1,DISP=OLD
//        DD DSNAME=LIST2,DISP=OLD
//        DD DSNAME=LIST3,DISP=OLD
```

When read from a PL/I program the concatenated data sets need not be on the same volume, but the volumes must be on the same type of device, and the data sets must have similar characteristics (for example, block size and record format). You cannot process concatenated data sets backwards.

Parameters of DD Statement

The operand field of the DD statement contains keyword parameters that you can use to give the following information:

- The name of the data set (DSNAME parameter).
- Description of the device and volume that contain the data set (UNIT, VOLUME, SPACE, LABEL, and SYSOUT parameters).
- Disposition of the data set before and after execution of the job step (DISP parameter).
- Data set characteristics (DCB parameter).

The following paragraphs summarize the functions of these groups of parameters. For full details of all the parameters, refer to the job control language publications.

NAMING THE DATA SET

The DSNAME parameter specifies the name of a newly defined data set or refers to the name of an existing data set (for example, DSNAME=ROOTS). You need not specify the DSNAME parameter for a temporary data set (one that exists only for the duration of the job in which it is created); the operating system will give it a temporary name.

DESCRIBING THE DEVICE AND VOLUME

The UNIT parameter specifies the type of input/output device to be allocated for the data set. You can specify the type by giving the actual unit address, the type number of the unit (for example, UNIT=2400 for the 2400 series Nine-track Magnetic Tape Drive), or by naming a group of units established at system generation (for example, UNIT=SYSDA for any direct-access device).

The VOLUME parameter identifies the volume on which the data set resides (for example, VOLUME=SER=12345). It can also include instructions for mounting and demounting volumes.

The SPACE parameter specifies the amount of auxiliary storage required to accommodate a data set on a direct-access device (for example, SPACE=(CYL,10) specifies that 10 cylinders are to be allocated).

The LABEL parameter specifies the type and contents of the data set labels for magnetic tape (for example, LABEL=4 indicates that the data set is the fourth data set on the volume).

The SYSOUT parameter allows you to route an output data set through a system output device (for example, SYSOUT=A). A system output device is any unit (but usually a printer or a card punch) that is used in common by all jobs. The computer operator allocates all the system output devices to specific classes according to device type and function. The usual convention is for class A to refer to a printer and class B to a card punch; the IBM-supplied cataloged procedures assume that this convention is followed. If you use the SYSOUT parameter, the only other information you may have to supply about the data set is the block size, which you can specify either in the DCB parameter of the DD statement or in your PL/I program.

DISPOSITION OF THE DATA SET

The DISP parameter indicates whether a data set exists or is new, and specifies what is to be done with it at the end of the job step (for example, DISP=(NEW,KEEP) specifies that a data set is to be created and that it is to be kept on the volume of the end of the job step). At the end of a job step, you can delete a data set, pass it to the next step in the same job, enter its name in the system catalog or have it removed from the catalog, or you can keep the data set for future use without cataloging it.

The LEAVE and REREAD options of the ENVIRONMENT attribute allow you to use the DISP parameter to control the action taken when the end of a magnetic-tape volume is reached or when a magnetic-tape data set is closed. For a description of these options refer to the language reference manual for this compiler.

Use of the Conditional Subparameters

If you wish use the conditional subparameters of the DISP parameter for data sets processed by PL/I programs, the step abend facility must be used. The step abend facility is obtained as follows:

| 1. The ERROR condition should be raised or signaled whenever the program is to terminate execution after a failure that requires the application of the conditional subparameters.

| 2. The resident library subroutine IBMBEER must be changed to return a non-zero return code. The method of doing this is described in Chapter 12 under the heading "The ABEND Facility".

DATA SET CHARACTERISTICS

The DCB (data control block) parameter of the DD statement allows you to describe the characteristics of the data in a data set, and the way it will be processed, at execution time. Whereas the other parameters of the DD statement deal chiefly with the identity, location, and disposal of the data set, the DCB parameter specifies information required for the processing of the records themselves. The subparameters of the DCB parameter are described in Appendix A. For DCB use, see "Data Control Block," later in this chapter.

The DCB parameter contains subparameters that describe:

- The organization of the data set and how it will be accessed (CYLOFL, DSORG, LIMCT, NCP, NTM, and OPTCD subparameters).
- Device dependent information such as the recording technique for magnetic tape or the line spacing for a printer (CODE, DEN, FUNC, MODE, PRTSP, STACK, and TRTCH subparameters).
- The record format (BLKSIZE, KEYLEN, LRECL, RECFM, and RKP subparameters).

- The number of buffers that are to be used (BUFNC subparameter).

- The printer or card punch control characters (if any) that will be inserted in the first byte of each record (RECFM subparameter).

You can specify BLKSIZE, BUFNO, LRECL, KEYLEN, NCP, RECFM, RKP, and TRKOFL (or their equivalents) in the ENVIRONMENT attribute of a file declaration in your PL/I program instead of in the DCB parameter.

You cannot use the DCB parameter to override information already established for the data set in your PL/I program (by the file attributes declared and the other attributes that are implied by them). DCB subparameters that attempt to change information already supplied are ignored. An example of the DCB parameter is:

```
DCB=(RECFM=FB,BLKSIZE=400,LRECL=40)
```

This parameter specifies that fixed-length records, 40 bytes in length, are to be grouped together in a block 400 bytes long.

Operating System Data Management

An object module produced by the optimizing compiler uses the data management routines of the operating system to control the storage and retrieval of data. The compiler translates each input and output statement in a PL/I program into a set of machine instructions that result in the issuing of assembler language macro instructions that request the data management routines to perform the required input or output operations. (These macro instructions are described in the supervisor and data management macro instructions publication.)

The macro instructions are issued either directly, by compiled code, or by appropriate subroutines from the transient library. In the latter case, the compiled code includes a branch to an interface subroutine in the resident library that initiates the flow of control through other required library subroutines.

The data management routines control the organization of data sets, as well as the storage and retrieval of the records they contain. They create and maintain data set labels, indexes, and catalogs; they transmit data between main storage and auxiliary storage; they use the system catalog to locate data sets; and they request the operator to mount and demount volumes as required.

BUFFERS

The data management routines can provide areas of main storage, termed buffers, in which data can be collected before it is transmitted to auxiliary storage, or into which it can be read before it is made available to a program. The use of buffers permits the blocking and deblocking of records, and may allow the data management routines to increase the efficiency of transmission of data by anticipating the needs of a program. Anticipatory buffering requires at least two buffers: while the program is processing the data in one buffer, the next block of data can be read into another. Anticipatory buffering can only be used for data sets being accessed sequentially.

The operating system can further increase the efficiency of transmission in a program that involves many input/output operations by using chained scheduling. In chained scheduling, a series of read or write operations are chained together and treated as a single operation. For chained scheduling to be effective, at least three buffers are necessary. For more information on chained scheduling see the data management services publication.

The data management routines have two ways of making data that has been read into a buffer available to a program. In the move mode, the data is actually transferred from the buffer into the area of main storage occupied by the program. In the locate mode, the program can process the data while it is still in the buffer; the data management routines pass the address of the buffer to the program to enable it to locate the data. Similarly a program can move output data into the buffer or it can build the data in the buffer itself.

ACCESS METHODS

Data management has two access techniques for transmitting data between main storage and auxiliary storage:

The queued access technique deals with individual records, which it blocks and deblocks automatically. Records are retrieved and written by means of macro instructions. The first time a macro instruction is issued to retrieve a record, the data management routines place a block of records in an input buffer and pass the first record to the program that issued the instruction (that is, they deblock the records); each succeeding retrieval passes another record to the program. When the input buffer is empty, it is automatically refilled with another block. Similarly, another macro instruction places records in an output buffer and, when the buffer is full, writes out the records. Since the queued access technique brings records into main storage before they are requested, it can be used only for records that have been stored sequentially.

The basic access technique uses other macro instructions for input and output. These instructions move blocks, not records. When a macro instruction is issued to retrieve a block, the data management routines pass a block of data to the program that issued the instruction; they do not deblock the records. Similarly, another macro instruction transmits a block to auxiliary storage.

The combination of data set organization, as described earlier in this chapter, and an access technique is termed an access method. The access methods used by the compiler are shown in Figure 6-5.

QSAM:	Queued sequential access method: this combines the queued access technique with sequential organization.
QISAM:	Queued indexed sequential access method: this combines the queued access technique with indexed sequential organization.
BSAM:	Basic sequential access method: this combines the basic access technique with sequential organization.
BISAM:	Basic indexed sequential access method: this combines the basic access technique with sequential organization.
BDAM:	Basic direct access method: this combines the basic access technique with direct organization.
TCAM:	Telecommunications access method: this combines the queued access technique with telecommunications organization.

Figure 6-5. The access methods used by the compiler

The PL/I library subroutines use QSAM for stream-oriented transmission and all of the above methods for record-oriented transmission, as shown in Figure 6-6. They implement PL/I GET and PUT statements by transferring the appropriate number of characters from or to the buffers, and use GET and PUT macro instructions in the locate mode to fill or empty the buffers. (For paper tape, however, the library subroutines use the move mode to permit translation of the transmitted characters before passing them to the PL/I program.)

DATA CONTROL BLOCK

A data control block (DCB) is an area of main storage that contains information about a data set and the volume that contains it. The data management routines refer to this information when they are processing a data set; no data set can be processed unless there exists a corresponding DCB. For a PL/I program, a PL/I library subroutine creates a DCB for the associated data set when a file is opened.

A data control block contains two types of information: data set characteristics and processing requirements. The characteristics include record format, record length, block size, and data set organization. The processing information may specify the number of buffers to be used, and it may include device-dependent information (for example, printer line spacing or magnetic-tape recording density), and special processing options that are available for some data-set organizations.

The information in the DCB comes from three sources:

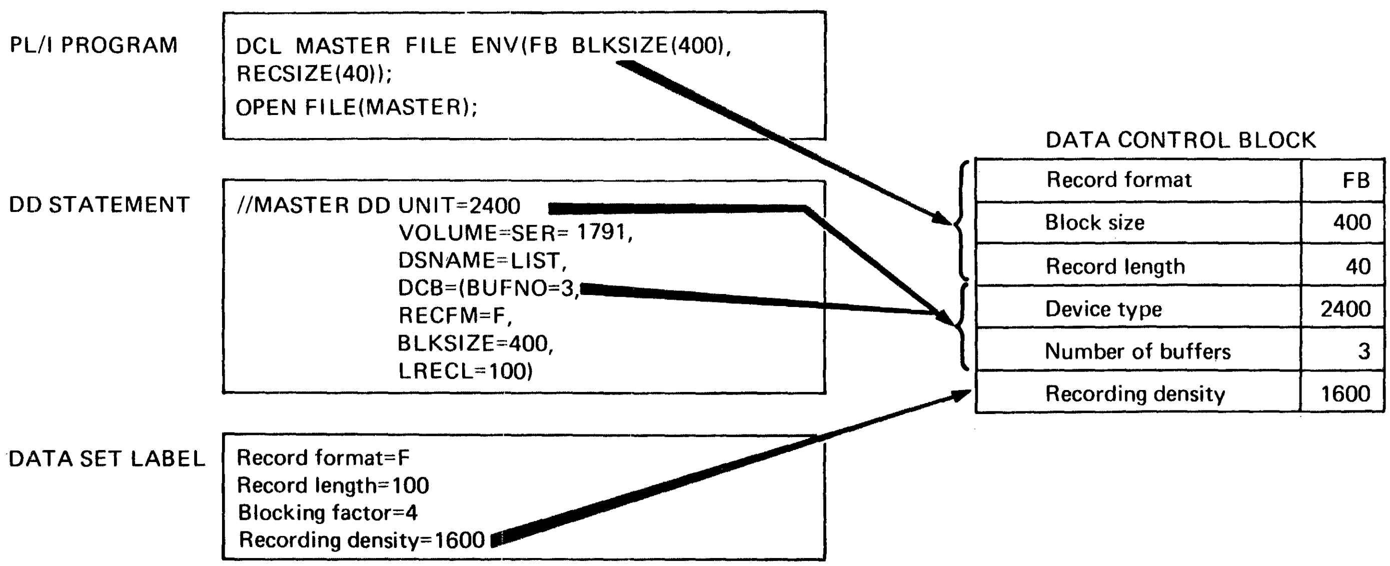
1. The file attributes declared implicitly or explicitly in the PL/I program.
2. The data definition (DD) statement for the data set.
3. If the data set exists, the data set labels.

OPENING A FILE

The execution of a PL/I OPEN statement associates a file with a data set. This requires the merging of the information describing the file and the data set. If any conflict is detected between file

Data Set Organization	File Attributes			Access Methods
CONSECUTIVE	SEQUENTIAL	INPUT OUTPUT UPDATE	BUFFERED	QSAM
			UNBUFFERED	BSAM
INDEXED	SEQUENTIAL	INPUT OUTPUT UPDATE	BUFFERED or UNBUFFERED	QISAM
	DIRECT	INPUT UPDATE	-	BISAM
REGIONAL	SEQUENTIAL	INPUT UPDATE	BUFFERED or UNBUFFERED	BSAM
		OUTPUT		BSAM
	DIRECT	INPUT OUTPUT UPDATE	-	BDAM
TELEPROCESSING	TRANSIENT	INPUT OUTPUT	BUFFERED	TCAM

Figure 6-6. Access methods for record-oriented transmission



Note: Information from the PL/I program overrides that from the DD statement and the data set label.
Information from the DD statement overrides that from the data set label.

Figure 6-7. How the operating system completes the DCB attributes and data set characteristics the UNDEFINEDFILE condition will be raised.

Subroutines of the PL/I library create a skeleton data control block for the data set, and use the file attributes from the DECLARE and OPEN statements, and any attributes implied by the declared attributes, to complete the data control block as far as possible, as shown in Figure 6-7. They then issue an OPEN macro instruction, which calls the data management routines to check that the correct volume is mounted and to complete the data control block. The data management routines examine the data control block to see what information is still needed and then look for this information, first in the DD statement, and finally, if the data set exists and has standard labels, in the data set labels. For new data sets, the data management routines begin to create the labels (if they are required) and to fill them with information from the data control block.

Neither the DD statement nor the data set label can override information provided by the PL/I program; nor can the data set label override information provided by the DD statement.

When the DCB fields have been filled in from these sources, control returns to the PL/I library subroutines. If any fields have still not been filled in, the PL/I OPEN subroutine provides default information for some of them; for example, if LRECL has not been specified, it is now provided from the value given for BLKSIZE.

CLOSING A FILE

The execution of a PL/I CLOSE statement dissociates a file from the data set with which it was associated. The PL/I library subroutines first issue a CLOSE macro instruction and, when control returns from the data management routines, release the data control block that was created when the file was opened. The data management routines complete the writing of labels for new data sets and update the labels of existing data sets.

Auxiliary Storage Devices

The following paragraphs summarize the salient operational features of various types of auxiliary storage devices.

IBM 2520 AND 2540 CARD READER AND PUNCH

Both the card reader and card punch accept F-format, V-format, and U-format records; the control bytes of V-format records are not punched. Any attempt to block records is ignored.

Each punched card corresponds to one record; you should therefore restrict the maximum record length to 80 bytes (EBCDIC mode) or 160 bytes (column-binary mode). To select the mode, use the MODE subparameter of the DCB parameter of the DD statement; if you omit this subparameter, EBCDIC is assumed. (The column-binary mode increases the packing density of information on a card, punching two bytes in each column. Only six bits of each byte are punched; on input, the two high-order bits of each byte are set to zero; on output, the two high-order bits are lost.) The Card Read Punch 2540 has five stackers into which cards are fed after reading or punching. Two stackers accept only cards that have been read, and two others accept only those that have been punched; the fifth (center) stacker can accept either cards that have been read or those that have been punched. The two stackers in each pair are numbered 1 and 2 and the center stacker is numbered 3, as shown in Figure 6-8.

```
                    ┌---------READ----------┐
|         |         |         |         |         |
|         |         |         |         |         |
|         |         |         |         |         |
|    1    |    2    |    3    |    2    |    1    |
└-------------------------------------------------┘

└---------PUNCH---------┘
```

Figure 6-8. Card read punch 2540: stacker numbers

The Card Read Punch 2520 has two stackers, into which cards can be read or punched. The Card Reader 2501 has only one stacker.

Cards are normally fed into the appropriate stacker 1 after reading or punching. You can use the STACK subparameter of the DCB parameter of the DD statement to select an alternative stacker for reading or punching. For punching only, you can select the stacker dynamically by inserting an ANS or System/360 code in the first byte of each record; you must indicate which code you are using in the RECFM subparameter of the DD statement or in the ENVIRONMENT option.

The control character is not punched.

IBM 3505 AND 3525 CARD READER AND PUNCH

The 3505 Card Reader and the 3525 Card Punch are available only to System/370 users. These two devices are functionally separate and operate independently of each other.

The 3505 will read 80-column cards, and provides, in addition to normal card reading, the following facilities:

- Optical mark read (in EBCDIC or column binary mode).
- Read column eliminate (in EBCDIC or column binary mode).
- Stacker selection.

The 3525 is basically an 80-column card punch, and can have the following additional facilities:

- Card reading facilities that optionally include:

  Reading in EBCDIC or column binary mode.

  Read column eliminate.
- Card punching in EBCDIC or column binary mode.
- Card printing facilities that include either:

  Two-line printing.

  or:

  Multiline printing (up to 25 lines).
- Punch interpretation.
- Stacker selection.

The various operations of the 3505 and the 3525 are described in the following sections. In general, the operations to be performed are selected by the FUNC, MODE, and STACK subparameters of the DCB parameter. The formats of these subparameters are described in Appendix A of this manual.

Basic Card Reading and Punching

Card reading or punching on a 3525 is selected by specifying DCB=(FUNC=R) for reading or DCB=(FUNC=P) for punching. If the FUNC subparameter is not specified, the default is FUNC=R for input files and FUNC=P for output files that do not have the PRINT attribute.

Apart from this function selection for the 3525, support for the 3505 as a simple card reader and the 3525 as a card reader or punch is identical to that for the 2540 described earlier in this chapter.

EBCDIC or Column Binary Modes

Cards processed by a 3505 or a 3525 can hold data coded in either EBCDIC or column binary mode. If EBCDIC is used, each card can contain up to 80 characters. If column binary is used, each card can contain up to 160 binary characters, two per card column. EBCDIC and column binary data cannot be intermixed.

In column binary mode, each card column holds two 6-bit characters. The low-order bit appears in row 12 of the card column for the first character, and in row 4 for the second character. The binary values of characters are transmitted to successive bytes in main storage. The two high-order bits of each byte are set to zero (these bits are not represented in the 6-bit code). The characters are transmitted in the order: first (top) character, second (bottom) character, and so on for each column in the card, from column 1 to column 80.

The details of the coding and conversion technique used for column binary data are left to the program designer. The TRANSLATE built-in function may provide a convenient method of converting data to or from column binary form.

Rules for using column binary mode are:

- The MODE subparameter of the DCB parameter must specify column binary (MODE=C).
- The PL/I file must have the RECORD attribute.
- The punch-interpret feature must not be used.
- The file must be either an input file or an output punch file. It cannot be a print file.

- A column binary output file must have a record size of 160 bytes.

Stacker Selection

The stacker selection feature is optionally available on the 3505 and is a standard feature on a 3525. There are two methods of selecting a stacker:

1. The stacker can be selected permanently for all cards in the file. This method involves the STACK subparameter of the DCB parameter.

2. For record-oriented output files on a 3525, the first byte of the record can contain a stacker control character to select the required stacker dynamically. The use of such codes is specified by the CTLASA or CTL360 environment options.

Optical Mark Read

The optical mark read (OMR) feature is available only on the 3505 card reader. This feature enables preprinted or pencil-written marks on a punched card to be read as data. The following rules apply:

- Optical mark read is specified by MODE=EO (EBCDIC mode) or MODE=CO (column binary mode) in the DCB parameter.

- The associated PL/I file must have the RECORD and INPUT attributes, and must not have the TOTAL attribute.

- Records must be F-format with a RECSIZE of 80 (EBCDIC mode) or 160 (column binary mode).

- Up to 40 columns of EBCDIC data or 80 characters of column binary data can be read optically from a single card. Optical and punched data can be read from the same card although there are some restrictions, given below, on how the data is recorded on the card.

- Optical mark data can appear only in alternate card columns and must be separated by blank columns. Optical mark and punched hole columns must also be seperated by at least one blank column. When the record is read in, the data is compressed by removing the blank column following each optical mark column, and the record is padded with blanks.

- The columns containing optically-readable marks must be specified to the program at execution-time by a format descriptor card. This card must be the first card in the deck of cards to be read by the file each time the program is run. Operating procedures for running jobs that use OMR should ensure that this point is not overlooked.

- The OMR descriptor card has the following format:

```
FORMAT (n1,n2),(n3,n4)...
```

where n1 is the first column in a group to be read in OMR mode, n2 is the last column in the group, n3 is the first column in the next group, n4 is the last column in this group, and so on. Remember that only every other column between n1 and n2 or n3 and n4 can be read in OMR mode. A maximum of 40 columns of OMR data can be accomodated on an 80-column card. n1 and n2 (and similarly n3 and n4) must be either both even or both odd, and n3 must be at least 2 greater than n2.

The format descriptor record must begin in column 2 and can continue through column 71. If a continuation is required, punch any character in column 72 and start the continuation in column 16 of the following card.

A blank must follow the keyword FORMAT. Operands must be separated by a comma. Example:

```
FORMAT (1,9),(70,80)
```

This specifies that columns 1 to 10 and 70 to 80 are reserved for OMR use and, of these, columns 1, 3, 5, 7, 9, 70, 72, 74, 76, 78, and 80 will be scanned for optical mark data.

- Note that column 1 of the card always corresponds with the first byte of the data in main storage. Consequently, if an optical mark appears in column 2, column 1 must be blank and byte 1 will also be blank.

- If a marginal mark, weak mark, or poor erasure is detected on a column, the corresponding byte and the last byte of the record are set to X'3F'. The TRANSMIT condition is raised once only for all errors found in a card. The card itself is stacked in the alternative stacker to that normally used by the file.

- When an optical mark read file is closed, the last card is fed and stacked in the same stacker as the previous card. This feed operation resets the device into unformatted mode, ready for the next file opening.

- Optical mark read is not supported on SYSIN. The 3505 must be allocated exclusively to the user's job by specifying the device type of the unit address in the UNIT parameter of the DD statement.

- When a file is opened for optical mark reading, the value of the BUFFERS option (for BUFFERED files) or the NCP option (for UNBUFFERED files) is automatically set to 1.

Read Column Eliminate

The read column eliminate (RCE) feature is optionally available on the 3505 and on a 3525 with card reading facilities. This feature permits the selective reading of card columns. The columns to be ignored when the card is read are specified in a format descriptor card. The ignored columns are replaced by blanks in EBCDIC mode or zeroes in column binary mode before the record is transmitted.

The following rules apply:

- Read column eliminate is specified by MODE=ER (EBCDIC mode) or MODE=CR (column binary mode) in the DCB parameter.

- An RCE format descriptor card must be supplied. This card must be the first card in the deck of cards to be read by the program each time it is executed. Operating procedures for running jobs that use RCE should ensure that this point is not overlooked.

- The RCE descriptor card has the following format:

```
FORMAT (n1,n2),(n3,n4)...
```

  where n1 is the first column in a group of columns to be ignored and n2 is the last column in the group, n3 is the first column in the next group to be ignored, n4 is the last column in this group, and so on.

  The format descriptor card must begin in column 2 and continue through to column 71. If a continuation is required, punch any character in column 72 and start the continuation in column 16 of the following card.

  A blank must follow the keyword FORMAT. Operands must be separated by a comma.

  Example:

```
FORMAT (20,30),(52,76)
```

  This specifies that columns 20 through 30 and columns 52 through 76 are to be ignored when the card is read.

- The PL/I file can have either the STREAM or the RECORD attribute. Records must be F-format.

- When an RCE file is closed, a card feed operation is executed by the reader. If several files are to be read consecutively - either for successive programs in a single batch, or for several files in a single program - a non-data card must separate the files.

- Read column eliminate is not supported on SYSIN. The 3505 or 3525 must be allocated exclusively to the user's job by specifying the device type of the unit address in the UNIT parameter of the DD statement.

Punch Interpret

A single file can be used to punch and interpret cards by specifying DCB=(FUNC=I). Cards are punched normally, and the same data is printed on lines 1 and 3 of the card. The first 64 characters are printed on line 1; the remaining 16 characters are right-justified on line 3.

A punch interpret file may have the STREAM or RECORD and the BUFFERED or UNBUFFERED attributes. Records must be F format, with a record size of 80, or 81 if control characters are being used for stacker selection.

Printing on Cards

The card printing feature of the 3525 is available in two forms:

1. Two-line printing.

2. Multiline printing (up to 25 lines).

Printing can be performed either as the only operation on the card, or as one of a number of operations on the same card. The following rules apply to print-only files. The additional requirements for printing after reading or punching a card are described under "Multiple Operations" later in this chapter.

- The FUNC subparameter of the DCB parameter must specify "W" if the 3525 has the multiline print feature, or "WT" if it has the 2-line print feature. If FUNC is omitted, FUNC=W is defaulted for PL/I PRINT files.

- The PL/I file may have either the RECORD or the STREAM attribute.

- The maximum number of characters that can be printed on each line is 64. The user must ensure that this limit is not exceeded; in particular, on PRINT files, LINESIZE should not exceed 64 or data will be lost.

- If the 3525 has the two-line print feature, and is used by a file with the PRINT attribute or by a file using CTLASA or CTL360 control characters, care should be taken to ensure that no attempt is made to print on any line other than lines 1 and 3. Such an attempt will cause the program to be terminated without raising the PL/I ERROR condition. If a PRINT file is used, and a PAGESIZE of more than 3 is specified, the pagesize is set to 3 when the file is opened.

  If the file is a non-PRINT file, and control characters are not used, records are printed on lines 1 and 3 automatically.

- If a 3525 with the multiple print feature is used, the file should have a maximum pagesize of 25. If a PAGESIZE of greater than 25 is specified on a PRINT file, the pagesize is set to 25 when the file is opened. Whatever the page size, a PUT PAGE statement for a PRINT file will always cause the file to be positioned at line 1 of the next card. Any attempt to print beyond line 25 will cause the program to be terminated without raising the PL/I ERROR condition.

- All the standard ASA control characters can be used, with the exception of "+" (suppress space before printing). The use of the "+" control character, or of SKIP(0) on a PRINT file, will cause the program to be terminated without raising the PL/I ERROR condition.

  Odd numbered lines on a card can be reached using "skip to channel" control characters, channel numbers being defined as follows:

  channel number = (line number + 1)/2

  Only channels 1 through 12 are valid. Other lines can be reached by using "space and print" control characters.

  All lines can be reached by executing sufficient WRITE or PUT operations.

Multiple Operations

Two or three files may be used in association with each other to enable more than one of the operations "read", "punch", and "print" to be performed on a single card during one pass through a 3525. A DD statement is required for each operation that the device is to perform, and the association of these data sets is specified by means of the unit affinity (AFF) parameter, together with the FUNC subparameter of the DCB parameter.

For example, for as set of files that are to perform the operations read-punch-print the association of the data sets and the set of operations are specified as follows:

```
//CARDIN DD UNIT=3525,DCB=(FUNC=RPW)
//PUNCH  DD UNIT=AFF=CARDIN,DCB=(FUNC=RPW)
//PRINT  DD UNIT=AFF=PUNCH,DCB=(FUNC=RPWX)
```

Valid FUNC options are listed in Appendix A of this manual. Note that the FUNC option must specify the complete set of associated operations. "X" must be added to the FUNC option of the print data set. If the 3525 has the two-line print feature, T must also be coded on the FUNC option of the print data set.

The following rules apply to multiple operations:

- All the device-associated files must have the RECORD attribute, and must be all BUFFERED or all UNBUFFERED. None of the files can have the TOTAL option. Records must be F-format.

- If stacker selection is required, it can only be specified on the punch file, if there is one. Either stacker-select control characters or static stacker selection by means of the STACK subparameter can be used.

- An associated data set cannot be allocated to SYSIN or SYSOUT. The 3525 must be allocated exclusively to the user's job by specifying the device type of the unit address in the UNIT parameter of the DD statement.

- Data delimiter cards should not be punched or printed on, or the first card of the following job will be lost.

Details of how to open and close associated files, and of the sequences of operations that can be performed, are given in the Language Reference Manual for this compiler.

Data Protection

To avoid erroneous punching into card columns that already contain data, a "data protection" option can be used on a punch file which is in association with a read file. Data Protection is specified by a "D" in the FUNC option of the DD statement for the punch data set. The user must provide an 80-byte data protection image (DPI) and linkedit it into SYS1.IMAGELIB with a member name of the form FORMxxxx. The DPI contains blanks in columns that are to be protected, and any alphanumeric character in columns that can be punched. An assembler language program is used to link edit the DPI; an example is given in Figure 6-9.

```
|//UP EXEC ASMFCL
|//ASM.SYSIN DD *
FORMDPI  CSECT
         DC   X'40'      (protected column)
         DC   X'40'      (protected column)
         DC   C'3456789A'(punch columns)
         DC   70X'40'    (protected columns)
         END
/*
//LKED.SYSLMOD DD DISP=OLD,
//             DSNAME=SYS1.IMAGELIB(FORMxxxx)
```

Figure 6-9. An example of a program to link edit the DPI

A particular DPI is selected by means of the the FCB parameter of the DD statement for the punch file. For example:

```
//PUNCH  DD  UNIT=AFF=CARDIN,
//           DCB=(FUNC=RPWD),
//           FCB=xxxx
```

Data protection cannot be specified for column binary cards.

PAPER TAPE READER

The paper tape reader accepts F-format and U-format records; each U-format record is followed by an end-of-record character. Use the CODE subparameter of the DCB parameter of the DD statement to request translation of data from one of the six standard paper-tape codes to System/360 internal representation (EBCDIC). Any character found to have a parity error is not transmitted.

PRINTER

The printer accepts F-format, V-format, and U-format records; the control bytes of V-format records are not printed. Each line of print corresponds to one record; you should therefore restrict your record length to the length of one printed line. Any attempt to block records is ignored.

You can use the PRTSP subparameter of the DCB parameter of the DD statement to request the line spacing of your output, or you can control the spacing dynamically by inserting an ANS or System/360 code in the first byte of each record; you must indicate which code you are using in the RECFM subparameter of the DD statement or in the ENVIRONMENT option. The control character is not printed. If you do not specify the line spacing, single spacing (no blanks between lines) is assumed.

MAGNETIC TAPE

Magnetic-tape devices accept D-format, F-format, V-format, and U-format records for both 9-track and 7-track magnetic tape with the one exception that 7-track magnetic tape will not accept V-format records unless the data conversion feature is available. (The data in the control bytes of V-format records is in binary form; in the absence of the data conversion feature, only six of the eight bits in each byte are transmitted to 7-track tape.)

Nine-track magnetic tape is standard in IBM System/360, but some 2400 series magnetic-tape drives incorporate features that facilitate reading and writing 7-track tape. The translation feature changes character data from EBCDIC (the 8-bit code used in System/360) to BCD (the 6-bit code used on 7-track tape) or vice-versa. The data conversion feature treats all data as if it were in the form of a bit string, breaking the string into groups of eight bits for reading into main storage, or into groups of six bits for writing on 7-track tape; the use of this feature precludes reading the tape backwards. To use translation or data conversion, include the TRTCH (tape recording technique) subparameter in the DCB parameter of the DD statement.

The maximum recording density available depends on the model number of the tape drive; single-density tape drive units have a maximum recording density of 800 bytes per inch, and dual-density tape drive units have a maximum of 1600 bytes per inch. For 9-track tapes, a single-density drive offers only the 800 bytes per inch density; the standard density for a dual-density drive is 1600 bytes per inch, but you can use the subparameter DEN (density) of the DD statement to specify 800 bytes per inch. For 7-track tape, the standard recording density for both types of drive unit is 200 bytes per inch; you can use the DEN subparameter of the DCB parameter of the DD statement to select alternatives of 556 or 800 bytes per inch.

Note: When a data check occurs on a magnetic-tape device with short length records (12 bytes on a read and 18 bytes on a write), these records will be treated as noise.

DIRECT-ACCESS DEVICES

Direct-access devices accept F-format, V-format, and U-format records.

The storage space on these devices is divided into conceptual cylinders and tracks. A cylinder is usually the amount of space that can be accessed without movement of the access mechanism, and a track is that part of a cylinder that is accessed by a single read/write head. For example, a 2311 disk pack has ten recording surfaces, each of which has 200 concentric tracks; thus, it contains 200 cylinders, each of which contains ten tracks.

When you create a data set on a direct-access device, you must always indicate to the operating system how much auxiliary storage the data set will require. Use the SPACE parameter of the DD statement to allocate space in terms of blocks, tracks, or cylinders. If you request space in terms of tracks or cylinders, bear in mind that space in a data set on a direct-access device is occupied not only by blocks of data, but by control information inserted by the operating system; if you use small blocks, the control information can result in a considerable space overhead. The following reference cards contain tables that will enable you to determine the amount of space you will require:

- 2301 Drum Storage Unit, Order No. GX20-1717
- 2302 Disk Storage Drive, Order No. GX20-1706
- 2303 Drum Storage Unit, Order No. GX20-1718
- 2311 Disk Storage Drive, Order No. GX20-1705
- 2314 Storage Facility, Order No. GX20-1710
- 2321 Data Cell Drive, Order No. GX20-1704
- 3330 Series Disk Storage, Order No. GX20-1920

Chapter 7: Defining Data Sets for Stream Files

This chapter describes how to define data sets for use with PL/I files that have the STREAM attribute. It explains how to create and access data sets with CONSECUTIVE organization. The essential parameters of the DD statements used in creating and accessing these data sets are summarized in tables, and several examples of PL/I programs (complete with JCL) are included to illustrate the text.

Data sets with the STREAM attribute are processed by stream-oriented transmission, which allows the PL/I program to ignore block and record boundaries and treat a data set as a continuous stream of data items in character form.

For output, the data management subroutines of the PL/I library convert the data items from the program variables into character form if necessary, and build the stream of characters into records for transmission to the data set.

For input, the library subroutines take records from the data set and separate them into the data items requested by the program, converting them into the appropriate form for assignment to the program variables.

Because stream-oriented transmission always treats the data in a data set as a continuous stream, it can be used only to process data sets with CONSECUTIVE organization.

Creating a Data Set

Any data set created using stream-oriented transmission must have CONSECUTIVE organization, but it is not necessary to specify this in the ENVIRONMENT attribute, since it is the default organization.

Your program deals only with data items, and not with records and blocks as they will exist in the data set. Accordingly, you need not concern yourself with the actual structure of the data set beyond specifying a block size (which is always necessary), unless you propose to use record-oriented transmission to access the data set at a later date.

To create a data set, you must give the operating system certain information either in your PL/I program or in the DD statement that defines the data set. The following paragraphs indicate the essential information, and discuss some of the optional information you may supply; the ENVIRONMENT attribute and the LINESIZE option are discussed fully in the language reference manual for this compiler.

ESSENTIAL INFORMATION

You must supply the following information, summarized in Figure 7-1, when creating a data set:

- Device that will write or punch your data set (UNIT, SYSOUT, or VOLUME parameter of DD statement).
- Block size: you can specify the block size either in your PL/I program (ENVIRONMENT attribute or LINESIZE option) or in the DD statement (BLKSIZE subparameter). If you do not specify a record length, unblocked records are assumed and the record length is determined from the block size. If you do not specify a record format, U-format is assumed (except for PRINT files when V-format is assumed: see "PRINT Files," later in this chapter).

If you want to keep a magnetic-tape or direct-access data set (that is, you do not want the operating system to delete it at the end of your job), the DD statement must name the data set and indicate how it is to be disposed of (DSNAME and DISP parameters). The DISP parameter alone will suffice if you want to use the data set in a later step but will not need it after the end of your job.

When creating a data set on a direct-access device, you must specify the amount of space required for it (SPACE parameter of DD statement).

If you want your data set stored on a particular magnetic-tape or direct-access device, you must indicate the volume serial number in the DD statement (SER or REF subparameter of VOLUME parameter). If you do not supply a serial number for a magnetic-tape data set that you want to keep, the operating system will allocate one, inform the operator, and print the number on your program listing.

If your data set is to follow another

Storage Device	Parameters of DD Statement		
	When required	What you must state	Parameters
All	Always	Output device	UNIT= or SYSOUT= or VOLUME=REF=
		Block size[1]	DCB=(BLKSIZE= ...)
Direct access only	Always	Storage space required	SPACE=
Magnetic tape only	Data set not first in volume and for magnetic tapes that do not have standard labels	Sequence number	LABEL=
Direct access and standard labeled magnetic tape	Data set to be used by another job step but is not required after end of job	Disposition	DISP=
	Data set to be kept after end of job	Disposition	DISP=
		Name of data set	DSNAME=
	Data set to be on particular volume	Volume serial number	VOLUME=SER= or VOLUME=REF=

[1]Alternatively, you can specify the block size in your PL/I program by using either the ENVIRONMENT attribute or the LINESIZE option.

Figure 7-1. Creating a data set: essential parameters of DD statement

data set on a magnetic-tape volume, you must use the LABEL parameter of the DD statement to indicate its sequence number on the tape.

EXAMPLE

The use of stream-oriented transmission to create a data set on a 2311 disk drive is shown in Figure 7-2. The data read from the input stream by the standard file SYSIN includes a field VREC that contains five unnamed 7-character subfields; the field NUM defines the number of these subfields that contain information. The output file WORK transmits to the data set the whole of the field FREC and only those subfields of VREC that contain information. The data set has U-format unblocked records with a maximum block size of 400 bytes (defined in the statement that declares the file WORK). All blocks except the last will contain exactly 400 bytes.

Accessing a Data Set

A data set accessed using stream-oriented transmission need not have been created by stream-oriented transmission, but it must have CONSECUTIVE organization, and all the data in it must be in character form. You can open the associated file for input, and read the records the data set contains; or you can open the file for output, and extend the data set by adding records at the end.

To access a data set, you must identify it to the operating system in a DD statement. The following paragraphs, which are summarized in Figure 7-3, indicate the essential information you must include in the DD statement, and discuss some of the optional information you may supply. The discussions do not apply to data sets in the input stream, which are dealt with in Chapter 6.

```
//OPT7#2  JOB
//STEP1 EXEC  PLIXCLG
//PLI.SYSIN  DD  *
 PEOPLE: PROC OPTIONS(MAIN);

         DCL WORK FILE STREAM OUTPUT ENV(U),
             1 REC,
               2 FREC,
                 3 NAME CHAR(19),
                 3 NUM CHAR(1),
                 3 PAD CHAR(25),
               2 VREC CHAR(35),
             IN CHAR(80) DEF REC;

         ON ENDFILE(SYSIN) GO TO FINISH;

         OPEN FILE(WORK) LINESIZE(400);
 MORE:   GET FILE(SYSIN) EDIT(IN)(A(80));
         PUT FILE(WORK) EDIT(IN)(A(45+7*NUM));
         GO TO MORE;
 FINISH: CLOSE FILE(WORK);
         END PEOPLE;
/*
//GO.WORK DD DSN=PEOPLE,UNIT=2311,SPACE=(CYL,(2,1)),DISP=(NEW,KEEP),
//           VOL=SER=D186
//GO.SYSIN DD *
R.C.ANDERSON        0 202848 DOCTOR
B.F.BENNETT         2 771239 PLUMBER         VICTOR HAZEL
R.E.COLE            5 698635 COOK            ELLEN  VICTOR JOAN   ANN    OTTO
J.F.COOPER          5 418915 LAWYER          FRANK  CAROL  DONALD NORMAN BRENDA
A.J.CORNELL         3 237837 BARBER          ALBERT ERIC   JANET
E.F.FERRIS          4 158636 CARPENTER       GERALD ANNA   MARY   HAROLD
/*
```

Figure 7-2. Creating a data set with stream-oriented transmission

ESSENTIAL INFORMATION

If the data set is cataloged, you need supply only the following information in the DD statement:

- The name of the data set (DSNAME parameter). The operating system will locate the information describing the data set in the system catalog, and, if necessary, will request the operator to mount the volume containing it.

- Confirmation that the data set exists (DISP parameter). If you open the data set for output with the intention of extending it by adding records at the end, code DISP=MOD; otherwise, to open the data set for output will result in its being overwritten.

If the data set is not cataloged, you must, in addition, specify the device that will read the data set and, for magnetic-tape and direct-access devices, give the serial number of the volume that contains the data set (UNIT and VOLUME parameters).

If the data set is on paper tape or punched cards, you must specify the block size either in your PL/I program (ENVIRONMENT attribute) or in the DD statement (BLKSIZE subparameter).

If the data set follows another data set on a magnetic-tape volume, you must use the LABEL parameter of the DD statement to indicate its sequence number on the tape.

MAGNETIC TAPE WITHOUT STANDARD LABELS

If a magnetic-tape data set has nonstandard labels or is unlabeled, you must specify the block size either in your PL/I program (ENVIRONMENT attribute) or in the DD statement (BLKSIZE subparameter). The DSNAME parameter is not essential if the data set is not cataloged.

PL/I data management includes no facilities for processing nonstandard labels, which, to the operating system, appear as data sets preceding or following your data set. You can either process the

Parameters of DD Statement			
When required		What you must state	Parameters
Always		Name of data set	DSNAME=
		Disposition of data set	DISP=
If data set not cataloged	All devices	Input device	UNIT= or VOLUME=REF=
	Standard labeled magnetic tape and direct access	Volume serial number	VOLUME=SER=
Magnetic tape: if data set not first in volume or which does not have standard labels		Sequence number	LABEL=
If data set does not have standard labels		Block size[1]	DCB=(BLKSIZE=...)

[1]Alternatively, you can specify the block size in your PL/I program by using either the ENVIRONMENT attribute or the LINESIZE option.

Figure 7-3. Accessing a data set: essential parameters of DD statement

```
//OPT7#4  JOB
//STEP1   EXEC  PLIXCLG
//PLI.SYSIN  DD  *
 PEOPLE: PROC OPTIONS(MAIN);

         DCL WORK FILE STREAM INPUT,
             1 REC,
               2 FREC,
                 3 NAME CHAR(19),
                 3 NUM CHAR(1),
                 3 SERNO CHAR(7),
                 3 PROF CHAR(18),
               2 VREC CHAR(35),
             IN CHAR(80) DEF REC;

         ON ENDFILE(WORK) GO TO FINISH;

         OPEN FILE(WORK);
 MORE:    GET FILE(WORK) EDIT(IN,VREC)(A(45),A(7*NUM));
         PUT FILE(SYSPRINT) SKIP EDIT(IN)(A);
         GO TO MORE;
 FINISH: CLOSE FILE(WORK);
         END PEOPLE;
/*
//GO.WORK DD DSN=PEOPLE,UNIT=2311,VOL=SER=D186,DISP=(OLD,KEEP)
```

Figure 7-4. Accessing a data set with stream-oriented transmission labels as independent data sets or use the LABEL parameter of the DD statement to bypass them; to bypass the labels code LABEL=(2,NL) or LABEL=(,BLP).

RECORD FORMAT

When using stream-oriented transmission to access a data set you do not need to know the record format of the data set (except when you must specify a block size); each GET statement transfers a discrete number of characters to your program from the data stream.

If you do give record format information, it must be compatible with the actual structure of the data set. For example, if a data set is created with F-format records, a record size of 600 bytes, and a block size of 3600 bytes, you can access the records as if they are U-format with a maximum block size of 3600 bytes; but if you specify a block size of 3500 bytes, your data will be truncated.

EXAMPLE

The program in Figure 7-4 reads the data set created by the program in Figure 7-2 and uses the standard file SYSPRINT to list the data it contains. (SYSPRINT is discussed later in this chapter.) Each set of data is read, by the GET statement, into two variables: FREC, which always contains 45 characters; and VREC, which always contains 35 characters. At each execution of the GET statement, VREC consists of the number of characters generated by the expression 7*NUM, together with sufficient blanks to bring the total number of characters to 35. The DISP parameter of the DD statement could read simply DISP=OLD; if the second term is omitted, an existing data set will not be deleted.

Print Files

Both the operating system and the PL/I language include features that facilitate the formatting of printed output. The operating system allows you to use the first byte of each record for a printer control code; the control codes, which are not printed, cause the printer to skip to a new line or page. Tables of printer control codes are given in Figures 8-5 and 8-6. In a PL/I program, the use of a PRINT file provides a convenient means of controlling the layout of printed output in stream-oriented transmission; the compiler automatically inserts printer control codes in response to the PAGE, SKIP, and LINE options and format items.

You can apply the PRINT attribute to any STREAM OUTPUT file, even if you do not intend to print the associated data set directly. When a PRINT file is associated with a magnetic-tape or direct-access data set, the printer control codes have no effect on the layout of the data set, but appear as part of the data in the records.

The compiler reserves the first byte of each record transmitted by a PRINT file for an ANS printer control code, and inserts the appropriate codes automatically. A PRINT file uses only the five printer control codes shown in Figure 7-5.

Code	Action
b (blank)	Space 1 line before printing
0	Space 2 lines before printing
-	Space 3 lines before printing
+	No space before printing
1	Start new page

Figure 7-5. Printer control codes used by a PRINT file

The compiler handles the PAGE, SKIP, and LINE options or format items by padding the remainder of the current record with blanks and inserting the appropriate control code in the next record. If SKIP or LINE specifies more than a three line space, the compiler inserts sufficient blank records with appropriate control codes to accomplish the required spacing. In the absence of a printer control option or format item, when a record is full the compiler inserts a blank code (single line space) in the first byte of the next record.

RECORD FORMAT

You can limit the length of the printed line produced by a PRINT file either by specifying a record length in your PL/I program (ENVIRONMENT attribute), in a DD statement, or by giving a line size in an OPEN statement (LINESIZE option). The record length must include the extra byte for the printer control code, that is, it must be one byte larger than the length of the printed line (five bytes larger for V-format records). The value you specify in the LINESIZE option refers to the number of

```
//OPT7#6  JOB
//STEP1 EXEC  PLIXCLG
//PLI.SYSIN  DD  *
 SINE:    PROC OPTIONS(MAIN);

        DCL TABLE FILE STREAM OUTPUT PRINT,
            TITLE CHAR(13) INIT('NATURAL SINES'),
           HEADINGS CHAR(90) INIT('        0        6        12        18
       24        30        36        42        48        54'),
            PGNO FIXED DEC(2) INIT(1),
            FINISH BIT(1) INIT('0'B),
            VALUES(0:359,0:9)FLOAT DEC(6);

        ON ENDPAGE(TABLE) BEGIN;
         PUT FILE(TABLE) EDIT('PAGE',PGNO)(LINE(55),COL(87),A,F(3));
         IF FINISH='0'B THEN DO;
         PGNO=PGNO+1;
         PUT FILE(TABLE) EDIT(TITLE||' (CONT''D)',HEADINGS)
                             (PAGE,A,SKIP(3),A);
         PUT FILE(TABLE) SKIP(2);
         END;
         END;

        DO I=0 to 359;
         DO J=0 TO 9;
          VALUES(I,J)=SIND(I+J/10);
          END;
         END;
        OPEN FILE(TABLE) PAGESIZE(52) LINESIZE(93);
        PUT FILE(TABLE) EDIT(TITLE,HEADINGS) (PAGE,A,SKIP(3),A);
        DO I=0 TO 71;
          PUT FILE(TABLE) SKIP(2);
          DO J=0 TO 4;
           K=5*I+J;
           PUT FILE(TABLE) EDIT(K,VALUES(K,*))(F(3),10 F(9,4));
           END;
          END;
        FINISH='1'B;
        PUT FILE(TABLE) LINE(54);
        CLOSE FILE(TABLE);
        END SINE;
/*
//GO.TABLE DD DSN=SINES,UNIT=2311,DISP=(NEW,CATLG),VOL=SER=D186,
//        SPACE=(CYL,(1,1))
```

Figure 7-6. Creating a data set using a PRINT file

characters in the printed line; the compiler adds the printer control bytes.

The blocking of records has no effect on the appearance of the output produced by a PRINT file, but it does result in more efficient use of auxiliary storage when the file is associated with a data set on a magnetic-tape or direct-access device. If you use the LINESIZE option, ensure that your line size is compatible with your block size: for F-format records, block size must be an exact multiple of (line size + 1); for V-format records, block size must be at least nine bytes greater than line size.

Although you can vary the line size for a PRINT file during execution by closing the file and opening it again with a new line size, you must do so with caution if you are using the PRINT file to create a data set on a magnetic-tape or direct-access device: you cannot change the record format established for the data set when the file is first opened. If the line size specified in an OPEN statement conflicts with the record format already established, the UNDEFINEDFILE condition will be raised; to prevent this, either specify V-format records with a block size at least nine bytes greater than the maximum line size you intend to use, or ensure that the first OPEN statement specifies the maximum line size. (Output destined for the printer may be stored temporarily on a direct-access device, unless you specify a printer by using UNIT=, even if you intend it to be fed directly to the printer.)

Since PRINT files have a default line size of 120 characters, you need not give any record format information for them. In the absence of other information, the compiler assumes V-format records; the complete default information is:

BLKSIZE=129

LRECL=125

RECFM=VBA

```
IBMSTA1 CSECT
        ENTRY IBMBSTAB
IBMBSTAB EQU  *
        DC    C'IBMBSTAB'
        DC    H'14'   OFFSET OF TAB COUNT
        DC    H'60'   PAGESIZE
        DC    H'120'  LINESIZE
        DC    H'0'    PAGELENGTH
*                     (FOR TERMINALS)
        DC    3H'0'   FILLERS
*                     (RESERVED FOR
*                     FUTURE USE)
*
        DC    H'5'    TAB COUNT
        DC    H'25'   TAB 1
        DC    H'49'   TAB 2
        DC    H'73'   TAB 3
        DC    H'97'   TAB 4
        DC    H'121'  TAB 5
        END
```

Figure 7-7. Tab control library module IBMBSTAB

EXAMPLE

Figure 7-6 illustrates the use of a PRINT file and the printing options of the stream-oriented transmission statements to format a table and write it onto magnetic tape for printing on a later occasion. The table comprises the natural sines of the angles from 0° to 359° 54' in steps of 6'.

The statements in the ENDPAGE on-unit insert a page number at the bottom of each page, and set up the headings for the following page. After the last line of the table has been written, the statement:

PUT FILE(TABLE) LINE(54)

causes the ENDPAGE condition to be raised to ensure that a number appears at the foot of the last page; the preceding statement sets the flag FINISH to prevent a further set of headings from being written.

The DD statement defining the data set created by this program includes no record-format information; the compiler infers the following from the file declaration and the line size specified in the statement that opens the file TABLE:

Record format = VBA (the default for a PRINT file)

Record size = 98 (line size + one byte for printer control character + four bytes for record control field)

| Block size = 102 (record length + four bytes for block control field)

The program in Figure 8-10 uses record-oriented transmission to print the table created by the program in Figure 7-6.

Tab Control Table

Data-directed and list-directed output to a PRINT file is automatically aligned on preset tabulator positions; the tab settings are stored in a table, an assembler language control section, in the transient library module IBMBSTAB (Figure 7-7.)

The standard settings are given in the language reference manual for this compiler. The functions of the fields in the table are as follows:

OFFSET OF TAB COUNT: Halfword binary integer that defines the field that indicates the number of tabs to be used.

PAGESIZE: Halfword binary integer that defines the default page size.

LINESIZE: Halfword binary integer that defines the default line size.

PAGELENGTH: Halfword binary integer that defines the default page length for printing at a terminal. The page length is the number of lines between perforations. It is used for

```
DCL 1 PLITABS STATIC EXT,
    2 (OFFSET INIT(6),
      PAGESIZE INIT(60),
      LINESIZE INIT(120),
      NO_OF_TABS INIT(3),
      TAB1 INIT(30),
      TAB2 INIT(60),
      TAB3 INIT(90)) FIXED BIN(15,0);
```

Figure 7-8. PL/I structure PLITABS for modifying the standard tab settings (alternative method)

output to the terminal in a TSO environment because, unlike a printer, the terminal does not use a control tape to determine page length. The default value is zero which is a special convention to indicate unformatted output. For further information on how the output is formatted at a terminal, refer to the TSO Terminal User's Guide.

FILLERS: Reserved for future use.

Tab count: Number of tab position entries in table (maximum 255). If tab count = 0, any specified tab positions are ignored: each data item is positioned at the start of a new line.

Tab_1-Tab_n Tab positions within the print line, The first position is numbered 1, and the highest position is numbered 255. The value of each tab should be greater than that of the tab preceding it in the table; otherwise, it will be ignored. The first data field in the printed output begins at the next available tab position.

The standard PL/I tab settings in IBMBSTAB can be overriden. If the linkage editor can resolve a reference to PLITABS generated by the compiler, the transient library module IBMBSTAB will not be used. Instead, the stream-oriented input/output routines will refer to the control section PLITABS for the tab settings.

There are two methods of altering the tab settings for a particular program.

One method is to create an assembler-language control section called PLITABS and include it in the link-editing of the program.

The alternative method is to include a PL/I structure in the source program. The organization of the structure is similar to the assembler-language control section for PLITABS given in Figure 7-7. The name of the structure must be PLITABS also and it must be declared STATIC and EXTERNAL. An example of a PL/I structure to create three tab settings in positions 30, 60, and 90, and use the defaults for page size and line size, is given in Figure 7-8.

The equivalent fields for PAGELENGTH and FILLERS are omitted from the structure, and the value given in the offset field is set to 6.

Note that the PAGESIZE field in PLITABS is used by PLIDUMP to define the pagesize for the dump output.

Standard Files

PL/I includes two standard files, SYSIN for input and SYSPRINT for output. If your program includes a GET statement that does not include the FILE option, the compiler inserts the file name SYSIN; if it includes a PUT statement without the FILE option, the compiler inserts the name SYSPRINT.

If you do not declare SYSPRINT, the compiler will give the file the attribute PRINT in addition to the normal default attributes; the complete file declaration will be:

```
SYSPRINT FILE STREAM OUTPUT PRINT EXTERNAL
```

Since SYSPRINT is a PRINT file, the compiler also supplies a default line size of 120 characters and a V-format record. You need give only a minimum of information in the corresponding DD statement; if your installation uses the usual convention that the system output device of class A is a printer, the following is sufficient:

```
//SYSPRINT DD SYSOUT=A
```

If you use one of the IBM-supplied cataloged procedures to execute your program, even this DD statement is not required, since it is included in the GO procedure step.

You can override the attributes given to SYSPRINT by the compiler by explicitly declaring or opening the file. If you do so, bear in mind that this file is also used by the error-handling routines of the compiler, and that any change you make in the format of the output from SYSPRINT will also apply to the format of execution-time error messages. When an error message is printed, eight blanks are inserted at the start of each line except the first. If you specify a line size of less than 72 characters, the messages will not be output to SYSPRINT.

The compiler does not supply any special attributes for the standard input file SYSIN; if you do not declare it, it receives only the normal default attributes. The data set associated with SYSIN is usually in the input stream; if it is not in the input stream, you must supply full DD information.

Chapter 8: Defining Data Sets for Record Files

This chapter describes how to define data sets for use with PL/I files that have the RECORD attribute. It explains how to create and access data sets for the three types of organization: CONSECUTIVE, INDEXED, and REGIONAL recognized by PL/I, and how to create and access data sets for teleprocessing. The essential parameters of the DD statements used in creating and accessing these data sets are summarized in tables, and several examples of PL/I programs (complete with JCL) are included to illustrate the text.

Data sets with the RECORD attribute are processed by record-oriented transmission in which data is transmitted to and from auxiliary storage exactly as it appears in the program variables; no data conversion takes place. A record in a data set corresponds to a variable in the program.

Consecutive Data Sets

A data set with CONSECUTIVE organization can exist on any type of auxiliary storage device. Records are stored sequentially in the order in which you write them.

CREATING A CONSECUTIVE DATA SET

When you create a CONSECUTIVE data set you must specify:

- Device that will write or punch your data set (UNIT, SYSOUT, or VOLUME parameter of DD statement).
- Block size: you can specify the block size either in your PL/I program (ENVIRONMENT attribute) or in the DD statement (BLKSIZE subparameter). If you do not specify a record length, unblocked records are assumed and the record length is determined from the block size. If you do not specify a record format, U-format is assumed.

Storage Device	Parameters of DD Statement		
	When required	What you must state	Parameters
All	Always	Output device	UNIT= or SYSOUT= or VOLUME=REF=
		Block size[1]	DCB=(BLKSIZE=...
Direct access only	Always	Storage space required	SPACE=
Magnetic tape only	Data set not first in volume and for magnetic tapes that do not have standard labels	Sequence number	LABEL=
Direct access and standard labeled magnetic tape	Data set to be used by another job step but not required at end of job	Disposition	DISP=
	Data set to be kept after end of job	Disposition	DISP=
		Name of data set	DSNAME=
	Data set to be on particular device	Volume serial number	VOLUME=SER= or VOLUME=REF=

[1]Alternatively, you can specify the block size in your PL/I program by using the ENVIRONMENT attribute.

Figure 8-1. Creating a CONSECUTIVE data set: essential parameters of DD statement

If you want to keep a magnetic-tape or direct-access data set (that is, you do not want the operating system to delete it at the end of your job), the DD statement must name the data set and indicate how it is to be disposed of (DSNAME and DISP parameters). The DISP parameter alone will suffice if you want to use the data set in a later step but will not need it after the end of your job.

When creating a data set on a direct-access device, you must specify the amount of space required for it (SPACE parameter of DD statement).

If you want your data set stored on a particular magnetic-tape or direct-access device, you must indicate the volume serial number in the DD statement (SER or REF subparameter of VOLUME parameter).

If you do not supply a serial number for a magnetic-tape data set that you want to keep, the operating system will allocate one, inform the operator, and print the number on your program listing.

If your data set is to follow another data set on a magnetic-tape volume, you must use the LABEL parameter of the DD statement to indicate its sequence number on the tape. The essential information for creating a CONSECUTIVE data set is summarized in Figure 8-1.

The DCB subparameters of the DD statement that apply to CONSECUTIVE data sets are listed in Figure 8-2; they are described in Appendix A. You can specify record format (RECFM), block size (BLKSIZE), record size (LRECL), and number of buffers (BUFNO) in the ENVIRONMENT attribute of the DECLARE statement in your PL/I program instead of in a DD statement.

ACCESSING A CONSECUTIVE DATA SET

You can access a CONSECUTIVE data set in three ways. You can open the associated file for input, and read the records the data set contains; you can open the file for output, and extend the data set by adding records at the end; or you can open the file for update, and read and rewrite each record in turn. (The operating system does not permit updating a CONSECUTIVE data set on magnetic tape; you must read the data set and write the updated records into a new data set.)

To access a data set, you must identify it to the operating system in a DD statement. The following paragraphs, which are summarized in Figure 8-3, indicate the essential information you must include in the DD statement, and discuss some of the optional information you may supply. The discussions do not apply to data sets in the input stream, which are dealt with in Chapter 6.

Subparameter	Specifies
BLKSIZE	Maximum number of bytes per block
BUFNO	Number of data management buffers
CODE	Paper tape: code in which the tape is punched
DEN	Magnetic tape: tape recording density
FUNC	Card reader or punch: function to be performed
LRECL	Maximum number of bytes per record
MODE	Card reader or punch: mode or operation (column binary or EBCDIC and read column eliminate or optical mark read
OPTCD	Optional data-management services and data-set attributes
PRTSP	Printer line spacing (0, 1, 2, or 3)
RECFM	Record format and characteristics
STACK	Card reader or punch: stacker selection
TRTCH	Magnetic tape: tape recording technique for 7-track tape

Figure 8-2. DCB subparameters for CONSECUTIVE data sets

Essential Information

If the data set is cataloged, you need supply only the following information in the DD statement:

- The name of the data set (DSNAME parameter). The operating system will locate the information describing the data set in the system catalog, and, if

Parameters of DD Statement			
When required		What you must state	Parameters
Always		Name of data set	DSNAME=
		Disposition of data set	DISP=
If data set not cataloged	All devices	Input device	UNIT= or VOLUME=REF=
	Standard labeled magnetic tape and direct access	Volume serial number	VOLUME=SER=
Magnetic tape: if data set not first in volume or which does not have standard labels		Sequence number	LABEL=
If data set does not have standard labels		Block size[1]	DCB=(BLKSIZE=...)

[1]Alternatively, you can specify the block size in your PL/I program by using either the ENVIRONMENT attribute or the LINESIZE option.

Figure 8-3. Accessing a CONSECUTIVE data set: essential parameters of DD statement

necessary, will request the operator to mount the volume containing it.

- Confirmation that the data set exists (DISP parameter). If you open the data set for output with the intention of extending it by adding records at the end, code DISP=MOD; otherwise, to open the data set for output will result in its being overwritten.

If the data set is not cataloged, you must, in addition, specify the device that will read the data set and, for magnetic-tape and direct-access devices, give the serial number of the volume that contains the data set (UNIT and VOLUME parameters).

If the data set is on paper tape or punched cards, you must specify the block size either in your PL/I program (ENVIRONMENT attribute) or in the DD statement (BLKSIZE subparameter).

If the data set follows another data set on a magnetic-tape volume, you must use the LABEL parameter of the DD statement to indicate its sequence number on the tape.

Magnetic Tape Without Standard Labels

If a magnetic-tape data set has nonstandard labels or is unlabeled, you must specify the block size either in your PL/I program (ENVIRONMENT attribute) or in the DD statement (BLKSIZE subparameter). The DSNAME parameter is not essential if the data set is not cataloged.

PL/I data management includes no facilities for processing nonstandard labels which to the operating system appear as data sets preceding or following your data set. You can either process the labels as independent data sets or use the LABEL parameter of the DD statement to bypass them; to bypass the labels code LABEL=(2,NL) or LABEL=(,BLP).

Record Format

If you give record-format information, it must be compatible with the actual structure of the data set. For example, if a data set is created with F-format records, a record size of 600 bytes, and a block size of 3600 bytes, you can access the records as if they are U-format with a maximum block size of 3600 bytes; but if you specify a block size of 3500 bytes, your data will be truncated.

EXAMPLE OF CONSECUTIVE DATA SETS

Creating and accessing CONSECUTIVE data

```
//OPT8#4  JOB
//STEP1 EXEC  PLIXCLG
//PLI.SYSIN  DD  *
 MERGE: PROC OPTIONS(MAIN);

        DCL  (IN1,IN2,OUT) FILE RECORD SEQUENTIAL,
             (ITEM1 BASED(A),ITEM2 BASED(B)) CHAR(80);

             ON ENDFILE(IN1) BEGIN;
              ON ENDFILE(IN2) GO TO FINISH;
 NEXT2:       WRITE FILE(OUT) FROM(ITEM2);
              READ FILE(IN2) SET(B);
              GO TO NEXT2;
              END;

             ON ENDFILE(IN2) BEGIN;
              ON ENDFILE(IN1) GO TO FINISH;
 NEXT1:       WRITE FILE(OUT) FROM(ITEM1);
              READ FILE(IN1) SET(A);
              GO TO NEXT1;
              END;

             OPEN FILE(IN1) INPUT,
                  FILE(IN2) INPUT,
                  FILE(OUT) OUTPUT;
             READ FILE(IN1) SET(A);
             READ FILE(IN2) SET(B);
 NEXT:       IF ITEM1>ITEM2 THEN DO;
              WRITE FILE(OUT) FROM(ITEM2);
              READ FILE(IN2) SET(B);
              GO TO NEXT;
              END;
             ELSE DO;
              WRITE FILE(OUT) FROM(ITEM1);
              READ FILE(IN1) SET(A);
              GO TO NEXT;
              END;
 FINISH:     CLOSE FILE(IN1),FILE(IN2),FILE(OUT);
             END MERGE;
/*
//GO.OUT DD  DSN=DS3,UNIT=2311,DCB=(RECFM=FB,BLKSIZE=400,LRECL=80),
//           DISP=(NEW,KEEP),VOL=SER=D186,SPACE=(CYL,(1,1))
//GO.IN1 DD  *
          (insert here data to be included in the input stream)
//GO.IN2 DD  *
          (insert here data to be included in the input stream)
/*
```

Figure 8-4. Creating and accessing a CONSECUTIVE data set

sets on magnetic tape are illustrated in the program of Figure 8-4. The program merges the contents of two existing data sets, DS1 and DS2, and writes them onto a new data set, DS3; each of the original data sets contains 15-byte fixed-length records arranged in EBCDIC collating sequence. The two input files, IN1 and IN2, have the default attribute BUFFERED, and locate mode is used to read records from the associated data sets into the respective buffers.

PUNCHING CARDS AND PRINTING

You cannot use a PRINT file for record-oriented transmission, and record-oriented transmission statements cannot include the printing options (PAGE, SKIP, etc). You can still exercise some control over the layout of printed output by including a printer control code as the first byte of each of your output records; you can also use similar control codes to select the stacker to which cards punched by your program are fed.

The operating system recognizes two types of code for printer and card punch commands, ANS code and machine code. You must indicate which code you are using, either in your PL/I program (ENVIRONMENT attribute), or in the DD statement (RECFM subparameter). If you specify one of these codes, but transmit your data to a device other than a printer or a card punch, the operating system will transmit the control bytes as part of your records. If you use an invalid control code, "space 1 line" or "stacker 1" will be assumed.

The ANS control codes, which are listed in Figure 8-5, cause the specified action to occur before the associated record is printed or punched.

The machine control codes differ according to the type of device. The codes for the 1403 Printer are listed in Figure 8.6, and Figure 8-7 gives those for the 2540 Card Read Punch. Control codes for the 3525 card printer are given in Figures 8-8 and 8-9.

Code	Action
b	Space 1 line before printing (blank code)
0	Space 2 lines before printing
-	Space 3 lines before printing
+	Suppress space before printing
1	Skip to channel 1
2	Skip to channel 2
3	Skip to channel 3
4	Skip to channel 4
5	Skip to channel 5
6	Skip to channel 6
7	Skip to channel 7
8	Skip to channel 8
9	Skip to channel 9
A	Skip to channel 10
B	Skip to channel 11
C	Skip to channel 12
V	Select stacker 1
W	Select stacker 2
The channel numbers refer to the printer carriage control tape. (See IBM 1403 Printer Component Description.)	

Figure 8-5. ANS printer and card punch control codes

Print and then act	Action	Act immediately (no printing)
Code byte		Code byte
00000001	Print only (no space)	-
00001001	Space 1 line	00001011
00010001	Space 2 lines	00010011
00011001	Space 3 lines	00011011
10001001	Skip to channel 1	10001011
10010001	Skip to channel 2	10010011
10011001	Skip to channel 3	10011011
10100001	Skip to channel 4	10100011
10101001	Skip to channel 5	10101011
10110001	Skip to channel 6	10110011
10111001	Skip to channel 7	10111011
11000001	Skip to channel 8	11000011
11001001	Skip to channel 9	11001011
11010001	Skip to channel 10	11010011
11011001	Skip to channel 11	11011011
11100001	Skip to channel 12	11100011
The channel numbers refer to the printer carriage control tape. (See IBM 1403 Printer Component Description.)		

Figure 8-6. 1403 printer control codes

Code byte	Action
00000001	Select stacker 1
01000001	Select stacker 2
10000001	Select stacker 3

Figure 8-7. 2540 Card Read Punch control characters

CTLASA code	Action
b	Space 1 line and print
0	Space 2 lines and print
-	Space 3 lines and print
1	Skip to channel 1 and print
2	Skip to channel 2 and print
3	Skip to channel 3 and print
4	Skip to channel 4 and print
5	Skip to channel 5 and print
6	Skip to channel 6 and print
7	Skip to channel 7 and print
8	Skip to channel 8 and print
9	Skip to channel 9 and print
A	Skip to channel 10 and print
B	Skip to channel 11 and print
C	Skip to channel 12 and print

Figure 8-8. 3525 card printer control code (CTLASA)

CTL360 code bytes	Action
00001101	Print on line 1
00010101	Print on line 2
00011101	Print on line 3
00100101	Print on line 4
00101101	Print on line 5
00110101	Print on line 6
00111101	Print on line 7
01000101	Print on line 8
01001101	Print on line 9
01010101	Print on line 10
01011101	Print on line 11
01100101	Print on line 12
01101101	Print on line 13
01110101	Print on line 14
01111101	Print on line 15
10000101	Print on line 16
10001101	Print on line 17
10010101	Print on line 18
10011101	Print on line 19
10100101	Print on line 20
10101101	Print on line 21
10110101	Print on line 22
10111101	Print on line 23
11000101	Print on line 24
11001101	Print on line 25

Figure 8-9. 3525 card printer control codes (CTL360)

```
//OPT8#10      JOB
//STEP1 EXEC   PLIXCLG
//PLI.SYSIN   DD  *
 PRT:     PROC OPTIONS(MAIN);

          DCL TABLE FILE RECORD INPUT SEQUENTIAL,
           PRINTER FILE RECORD OUTPUT SEQL ENV(V BLKSIZE(102) CTLASA),
           LINE CHAR(94) VAR;

          ON ENDFILE(TABLE) GO TO FINISH;

          OPEN FILE(TABLE),FILE(PRINTER);
 NEXT:    READ FILE(TABLE) INTO(LINE);
          WRITE FILE(PRINTER) FROM(LINE);
          GO TO NEXT;
 FINISH:  CLOSE FILE(TABLE),FILE(PRINTER);
          END PRT;
/*
//GO.TABLE DD DSNAME=SINES,DISP=OLD
//GO.PRINTER DD SYSOUT=A
```

Figure 8-10. Printing with record-oriented transmission

There are two types of command for the printer, one causing the action to occur after the record has been transmitted, and the other producing immediate action but transmitting no data (you must include the second type of command in a blank record).

The essential requirements for producing printed output or punched cards are exactly the same as those for creating any other CONSECUTIVE data set (described above). For a printer, if you do not use one of the control codes, all data will be printed sequentially, with no spaces between records; each block will be interpreted as the start of a new line. When you specify a block size for a printer or card punch, and are using one of the control codes, include the control bytes in your block size; for example, if you want to print lines of 100 characters, specify a block size of 101.

Example

The program in Figure 8-10 uses record-oriented transmission to read and print the contents of the data set SINES, created by the PRINT file in Figure 7-6. Since the data set SINES is cataloged, only two parameters are required in the DD statement that defines it. The output file PRINTER is declared with the ENVIRONMENT option CTLASA, specifying that the first byte of each record will be interpreted as an ANS printer control code. The information given in the ENVIRONMENT attribute could alternatively have been given in the DD statement, as follows:

```
DCB=(RECFM=VA,BLKSIZE=102)
```

Indexed Data Sets

A data set with INDEXED organization can exist only on a direct-access device. Each record in the data set is identified by a key that is recorded with the record. A key is a string of not more than 255 characters; all the keys in a data set must have the same length. The records in the data set are arranged according to the collating sequence of their keys. Once an INDEXED data set has been created, the keys facilitate the direct retrieval, addition, and deletion of records.

INDEXES

To provide faster access to the records in the data set, the operating system creates and maintains a system of indexes to the records in the data set. The lowest level of index is the track index. There is a track index for each cylinder in the data set; it occupies the first track (or tracks) of the cylinder, and lists the keys of the last records on each track in the cylinder. A search can then be directed to the first track that has a key that is

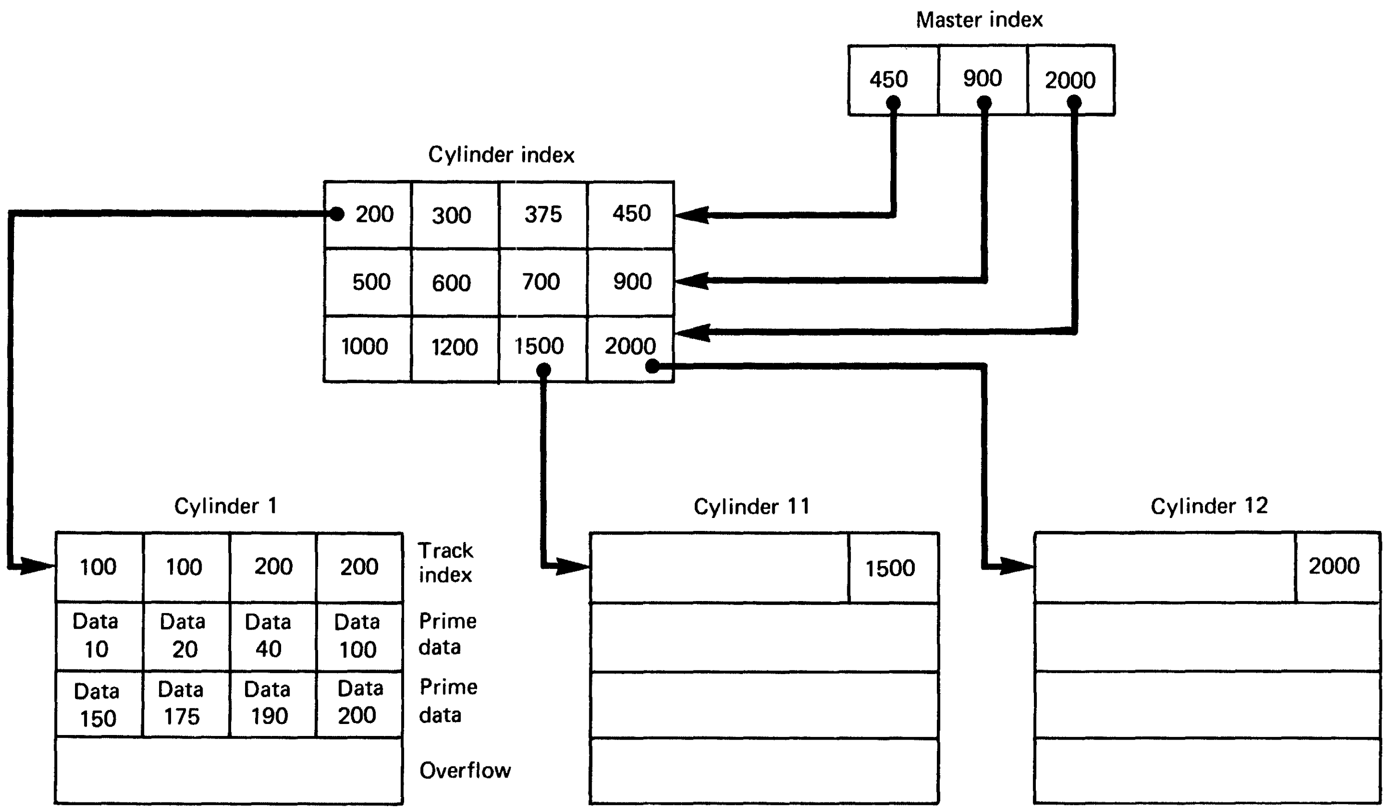


Figure 8-11. Index structure of an INDEXED data set

higher than or equal to the key of the required record.

If the data set occupies more than one cylinder, the operating system develops a higher level index called a cylinder index. Each entry in the cylinder index identifies the key of the last record in the cylinder. To increase the speed of searching the cylinder index, you can request in a DD statement that the operating system develop a master index for a specified number of cylinders; you can have up to three levels of master index; Figure 8-11 illustrates the index structure. The part of the data set that contains the cylinder and master indexes is termed the index area.

When an INDEXED data set is created, all the records are written in what is called the prime data area. If more records are added later, the operating system does not rearrange the entire data set; it inserts each new record in the appropriate position and moves up the other records on the same track. Any records forced off the track by the insertion of a new record are placed in an overflow area. The overflow area can consist either of a number of tracks set aside in each cylinder for the overflow records from that cylinder (cylinder overflow area), or a separate area for all overflow records (independent overflow area). Figure 8-12 shows how records are added to an INDEXED data set.

Each entry in the track index consists of two parts:

1. The normal entry, which points to the last record on the track.

2. The overflow entry, which contains the key of the first record transferred to the overflow area and also points to the last record transferred from the track to the overflow area.

If there are no overflow records from the track, both index entries point to the last record on the track. An additional field is added to each record that is placed in the overflow area. It points to the previous record transferred from the same track; the first record from each track is linked to the corresponding overflow entry in the track index.

CREATING AN INDEXED DATA SET

When you create an INDEXED data set, your program must write the records in the data set sequentially in the order of ascending key values; the associated file must be opened for SEQUENTIAL OUTPUT.

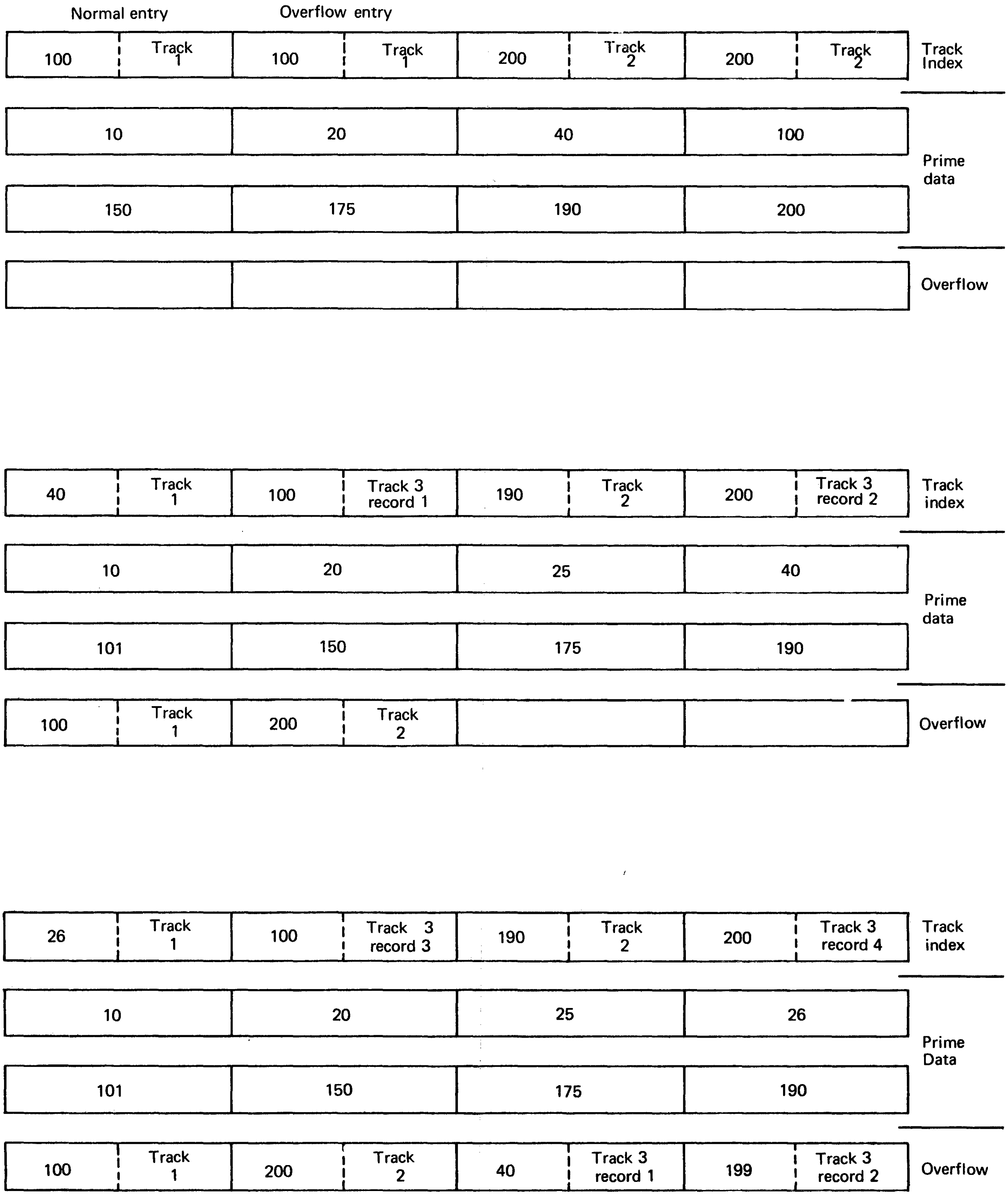


Figure 8-12. Adding records to an INDEXED data set

You can use a single DD statement to define the whole of the data set (index area, prime area, and overflow area), or you can use two or three statements to define the areas independently. If you use two DD statements, you can define either the index area and the prime area together, or the prime area and the overflow area together.

If you want the whole of the data set to be on a single volume, there is no advantage to be gained by using more than one DD statement except to define an independent overflow area (see "Overflow Area," later in this chapter). But, if you use separate DD statements to define the index and/or overflow area on volumes separate from that which contains the prime area, you will increase the speed of direct access to the records in the data set by reducing the number of access mechanism movements required.

When you use two or three DD statements to define an INDEXED data set, the statements must appear in the order: index area; prime area; overflow area. The DD statement must have a name (ddname), but the name fields of a second or third DD statement must be blank. The DD statements for the prime and overflow areas must specify the same type of unit (UNIT parameter). You must include all the DCB information for the data set in the first DD statement; DCB=DSORG=IS will suffice in the other statements.

An INDEXED data set consisting of fixed-length records can be extended by adding records sequentially at the end, until the original space allocated for the prime data is filled. The corresponding file must be opened for sequential output and you must include DISP=MOD in the DD statement.

Essential Information

To create an INDEXED data set, you must give the operating system certain information either in your PL/I program or in the DD statement that defines the data set. The following paragraphs indicate the essential information, and discuss some of the optional information you may supply; the ENVIRONMENT attribute and the LINESIZE option are discussed fully in the language reference manual for this compiler.

You must supply the following information when creating an INDEXED data set:

- Device that will write or punch your data set (UNIT or VOLUME parameter of DD statement).
- Block size: you can specify the block size either in your PL/I program (ENVIRONMENT attribute or LINESIZE option) or in the DD statement (BLKSIZE subparameter). If you do not specify a record length, unblocked records are assumed and the record length is determined from the block size.

If you want to keep a direct-access data set (that is, you do not want the operating system to delete it at the end of your job), the DD statement must name the data set and indicate how it is to be disposed of (DSNAME and DISP parameters). The DISP parameter alone will suffice if you want to use the data set in a later step but will not need it after the end of your job.

If you want your data set stored on a particular direct-access device, you must indicate the volume serial number in the DD statement (SER or REF subparameter of VOLUME parameter). If you do not supply a serial number for a data set that you want to keep, the operating system will allocate one, inform the operator, and print the number on your program listing. All the essential parameters required in a DD statement for the creation of an INDEXED data set are summarized in Figure 8-13, and Figure 8-14 lists the DCB subparameters needed.

Appendix A contains a description of the DCB subparameters.

You cannot place an INDEXED data set on a system output (SYSOUT) device.

You must request space for the prime data area in the SPACE parameter. Your request must be in units of cylinders unless you place the data set in a specific position on the volume (by specifying a track number in the SPACE parameter). In the latter case, the number of tracks you specify must be equivalent to an integral number of cylinders, and the first track must be the first track of a cylinder other than the first cylinder in the volume. You can also use the SPACE parameter to specify the amount of space to be used for the cylinder and master indexes (unless you use a separate DD statement for this purpose). If you do not specify the space for the indexes, the operating system will use part of the independent overflow area; if there is no independent overflow area, it will use part of the prime data area.

In the DCB parameter, you must always specify the data set organization (DSORG=IS), and in the first (or only) DD statement you must also specify the length of the key (KEYLEN).

Parameters of DD Statement		
When required	What you must state	Parameters
Always	Output device	UNIT= or VOLUME=REF=
	Storage space required	SPACE=
	Data control block information: refer to figure 8-14.	DCB=
More than one DD statement	Name of data set and area (index, prime, overflow)	DSNAME=
Data set to be used in another job step but not required after end of job	Disposition	DISP=
Data set to be kept after end of job	Disposition	DISP=
	Name of data set	DSNAME=
Data set to be on particular volume	Volume serial number	VOLUME=SER= or VOLUME=REF=

Figure 8-13. Creating an INDEXED data set: essential parameters of DD statement

Name of Data Set

If you use only one DD statement to define your data set, you need not name the data set unless you intend to access it in another job. But, if you include two or three DD statements, you must specify a data set name, even for a temporary data set.

The DSNAME parameter in a DD statement that defines an INDEXED data set not only gives the data set a name, but it also identifies the area of the data set to which the DD statement refers:

```
DSNAME=name(INDEX)

DSNAME=name(PRIME)

DSNAME=name(OVFLOW)
```

If the data set is temporary, prefix its name with the characters "&&". If you use one DD statement to define the prime and index or prime and overflow area, code DSNAME=name(PRIME); if you use one DD statement, code DSNAME=name(PRIME), or simply DSNAME=name.

Record Format and Keys

An INDEXED data set can contain either fixed-length or variable-length records, blocked or unblocked. You must always specify the record format either in your PL/I program (ENVIRONMENT attribute) or in the DD statement (RECFM subparameter).

The key associated with each record can be contiguous with or embedded within the data in the record; you can save storage space in the data set if you use blocked records with embedded keys.

If the records are unblocked, the key of each record is recorded in the data set in front of the record even if it is also embedded within the record, as shown in (a) and (b) of Figure 8-15. If blocked records do not have embedded keys, the key of each record is recorded within the block in front of the record, and the key of the last record in the block is also recorded in front of the block, as shown in (c) of Figure 8-15. When blocked records have embedded keys, the individual keys are not recorded separately in front of each record in the block; the key of the last record in the block is recorded in front of the block, as shown in (d) of Figure 8-15.

If you use blocked records with non-

DCB Subparameters		
When required	**To specify**	**Subparameters**
These are always required	Record format[1]	RECFM=F, FB, FBS, V, or VB
	Block size[1]	BLKSIZE=
	Data set organization	DSORG=IS
	Key length	KEYLEN=
Include at least one of these if overflow is required	Cylinder overflow area and number of tracks per cylinder for overflow records	OPTCD=Y and CYLOFL=
	Independent overflow area	OPTCD=I
These are optional	Record length[1]	LRECL=
	Embedded key (relative key position)	RKP=
	Master index	OPTCD=M
	Automatic processing of dummy records	OPTCD=L
	Number of data management buffers[1]	BUFNO=
	Number of tracks in cylinder index for each master index entry	NTM=

[1]Alternatively, can be specified in ENVIRONMENT attribute.

Note: Full DCB information must appear in the first, or only, DD statement. Subsequent statements require only DSORG=IS.

Figure 8-14. DCB subparameters for an INDEXED data set

embedded keys, the record size that you specify must include the length of the key, and the block size must be a multiple of this combined length. Otherwise, record length and block size refer only to the data in the record. Record format information is shown in Figure 8-16.

If you use records with embedded keys, you must include the DCB subparameter RKP to indicate the position of the key within the record. For fixed-length records the value specified in the RKP subparameter is one less than the byte number of the first character of the key; that is, if RKP=1, the key starts in the second byte of the record. The value assumed if you omit this subparameter is RKP=0, which specifies that the key is not embedded in the record but is separate from it.

For variable-length records, the value specified in the RKP subparameter must be the relative position of the key within the record plus four. The extra four bytes take into account the 4-byte control field used with variable-length records. For this reason you must never specify RKP less than four. When deleting records you must always specify RKP equal to or greater than five, since the first byte of the data is used to indicate deletion.

For unblocked records, the key, even if embedded, is always recorded in a position preceding the actual data. Consequently, the RKP subparameter need not be specified for unblocked records.

Overflow Area

If you intend to add records to the data set on a future occasion, you must request either a cylinder overflow area or an independent overflow area, or both.

For a cylinder overflow area, include

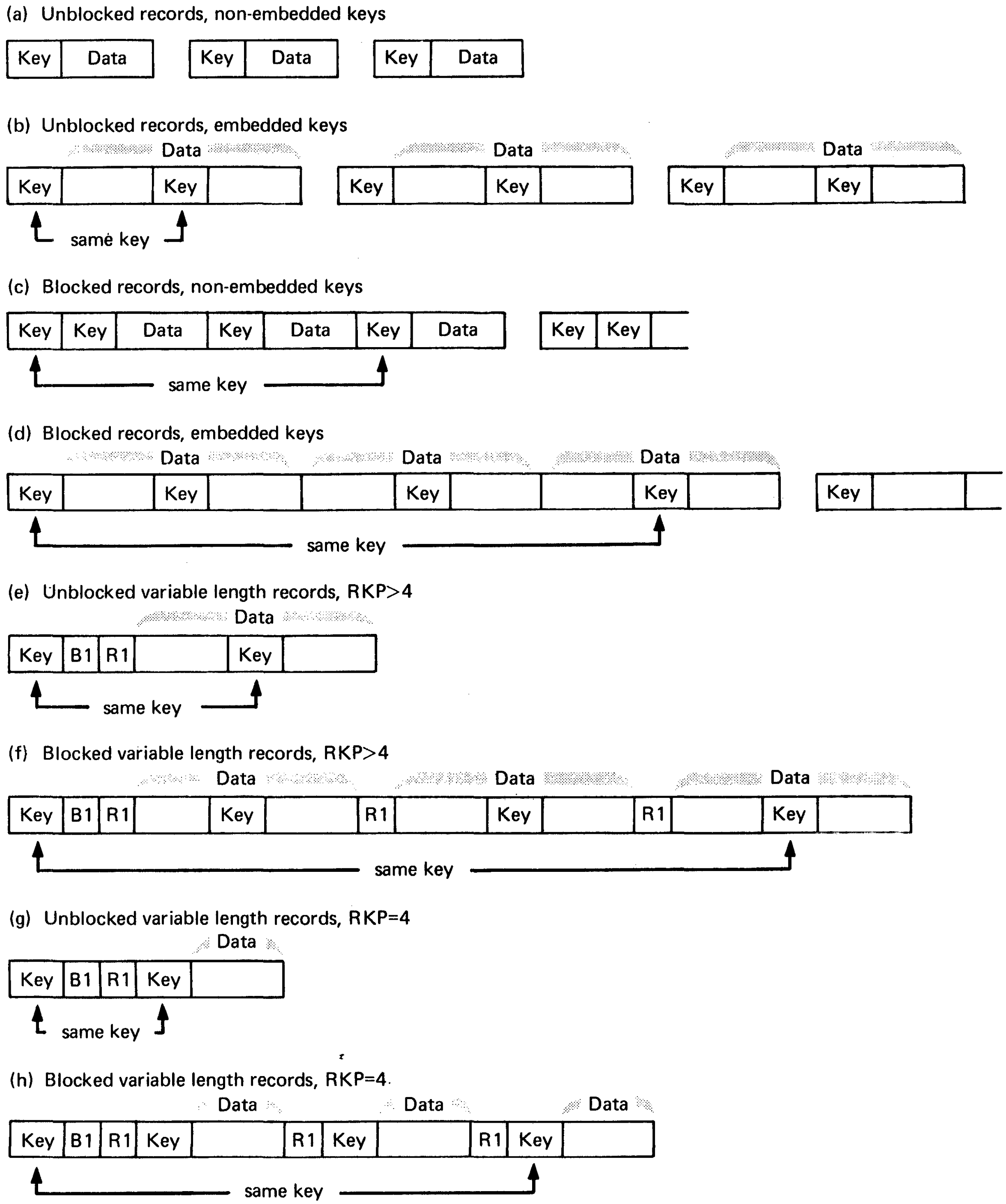


Figure 8-15. Record formats in an INDEXED data set

	RKP	LRECL	BLKSIZE
Blocked records	Not zero	R	R * B
	Zero or omitted	R + K	B*(R+K)
Unblocked records	Not zero	R	R
	Zero or omitted	R	R

R = Size of data in record

K = Length of keys (as specified in KEYLEN subparameter)

B = Blocking factor

Example: For blocked records, non-embedded keys, 100 bytes of data per record, 10 records per block, key length = 20: LRECL=120,BLKSIZE=1200,RECFM=FB

Figure 8-16. Record format information for an INDEXED data set

the DCB subparameter OPTCD=Y and use the subparameter CYLOFL to specify the number of tracks in each cylinder to be reserved for overflow records. A cylinder overflow area has the advantage of a short search time for overflow records, but the amount of space available for overflow records is limited, and much of the space may be unused if the overflow records are not evenly distributed throughout the data set.

For an independent overflow area, use the DCB subparameter OPTCD=I to indicate that overflow records are to be placed in an area reserved for overflow records from all cylinders, and include a separate DD statement to define the overflow area. The use of an independent area has the advantage of reducing the amount of unused space for overflow records, but entails an increased search time for overflow records.

It is good practice to request cylinder overflow areas large enough to contain a reasonable number of additional records and an independent overflow area to be used as the cylinder overflow areas are filled.

If the prime data area is not filled during creation, you cannot use the unused portion for overflow records, nor for any records subsequently added during direct access (although you can fill the unfilled portion of the last track used). You can reserve space for later use within the prime data area by writing "dummy" records during creation: see "Dummy Records," later in this chapter.

Master Index

If you want the operating system to create a master index for you, include the DCB subparameter OPTCD=M, and indicate in the NTM subparameter the number of tracks in the cylinder index you wish to be referred to by each entry in the master index. The operating system will automatically create up to three levels of master index, the first two levels addressing tracks in the next lower level of the master index.

Dummy Records

You cannot change the specification of an INDEXED data set after you have created it. Therefore, you must foresee your future needs where the size and location of the index, prime, and overflow areas are concerned, and you must decide whether you want the operating system to identify and skip dummy (deleted) records.

If you code OPTCD=L, the operating system will identify any record that is named in a DELETE statement by placing the bit string (8)'1'B in the first byte. Subsequently, during SEQUENTIAL processing of the data set, such records will be ignored; if they are forced off a track when the data set is being updated, they will not be placed in the overflow area. Do not specify OPTCD=L when using blocked or variable-length records with non-embedded keys; if you do, the string (8)'1'B will overwrite the key of the "deleted" record.

You can include a dummy record in an INDEXED data set by setting the first byte of data to (8)'1'B and writing the record in the usual way.

ACCESSING AN INDEXED DATA SET

You can open an INDEXED data set for sequential or direct access, and for input or update in each case. Sequential input allows you to read the records in ascending key sequence, and in sequential update you can read and rewrite each record in turn; during sequential access, if OPTCD=L is specified when the data set is created, dummy records are ignored. Using direct

Parameters of DD Statement		
When required	What you must state	Parameters
Always	Name of data set	DSNAME=
	Disposition of data set	DISP=
	Data control block information	DCB=
If data set not cataloged	Input device	UNIT= or VOLUME=REF=
	Volume serial number	VOLUME=SER=

Figure 8-17. Accessing an INDEXED data set: essential parameters of DD statement

input, you can read records using the READ statement, and in direct update you can read or delete existing records or add new ones.

To access an INDEXED data set, you must define it in one, two or three DD statements; the DD statements must correspond with those used when the data set is created. The following paragraphs indicate the essential information you must include in each DD statement, and Figure 8-17 summarizes this information.

If the data set is cataloged, you need supply only the following information in each DD statement:

- The name of the data set (DSNAME parameter). The operating system will locate the information that describes the data set in the system catalog and, if necessary, will request the operator to mount the volume that contains it.

- Confirmation that the data set exists (DISP parameter).

- Full DCB information for the first, or only, DD statement. Subsequent statements require only DSORG=IS to be coded.

If the data set is not cataloged, you must, in addition, specify the device that will process the data set and give the serial number of the volume that contains it (UNIT and VOLUME parameters).

REORGANIZING AN INDEXED DATA SET

It is necessary to reorganize an INDEXED data set periodically because the addition of records to the data set results in an increasing number of records in the overflow area. Therefore, even if the overflow area does not eventually become full, the average time required for the direct retrieval of a record will increase. The frequency of reorganization depends on how often the data set is updated, on how much storage is available in the data set, and on your timing requirements.

Reorganizing the data set also eliminates records that are marked as "deleted," but are still present within the data set.

There are two ways to reorganize an INDEXED data set:

1. Read the data set into an area of main storage or onto a temporary CONSECUTIVE data set, and then recreate it in the original area of auxiliary storage.

2. Read the data set sequentially and write it into a new area of auxiliary storage; you can then release the original auxiliary storage.

EXAMPLES OF INDEXED DATA SETS

The creation of a simple INDEXED data set is illustrated in Figure 8-18. The data set contains a telephone directory, using the subscribers' names as keys to the telephone numbers.

The program in Figure 8-19 updates this data set and prints out its new contents. The input data includes the following codes to indicate the operations required:

```
//OPT8#18   JOB
//STEP1 EXEC  PLIXCLG
//PLI.SYSIN  DD  *
 TELNOS: PROC OPTIONS(MAIN);

         DCL DIREC FILE RECORD SEQUENTIAL KEYED ENV(INDEXED),
             CARD CHAR(80),
             NAME CHAR(20) DEF CARD POS(1),
             NUMBER CHAR(3) DEF CARD POS(21),
             IOFIELD CHAR(3);

         ON ENDFILE(SYSIN) GO TO FINISH;

         OPEN FILE(DIREC) OUTPUT;
 NEXTIN: GET FILE(SYSIN) EDIT(CARD)(A(80));
         IOFIELD=NUMBER;
         WRITE FILE(DIREC) FROM(IOFIELD) KEYFROM(NAME);
         GO TO NEXTIN;
 FINISH: CLOSE FILE(DIREC);
         END TELNOS;
/*
//GO.DIREC DD DSNAME=TELNO(INDEX),UNIT=2311,SPACE=(CYL,1),
//      DCB=(RECFM=F,BLKSIZE=3,DSORG=IS,KEYLEN=20,OPTCD=LIY,CYLOFL=2),
//      DISP=(NEW,KEEP),VOLUME=SER=D186
//      DD DSNAME=TELNO(PRIME),UNIT=2311,SPACE=(CYL,4),DCB=DSORG=IS,
//      DISP=(NEW,KEEP),VOLUME=SER=D186
//      DD DSNAME=TELNO(OVFLOW),UNIT=2311,SPACE=(CYL,4),
//      DCB=DSORG=IS,DISP=(NEW,KEEP),VOL=SER=D186
//GO.SYSIN DD *
ACTION,G.           162
BAKER,R.            152
BRAMLEY,O.H.        248
CHEESEMAN,D.        141
CORY,G.             336
ELLIOTT,D.          875
FIGGINS,S.          413
HARVEY,C.D.W.       205
HASTINGS,G.M.       391
KENDALL,J.G.        294
LANCASTER,W.R.      624
MILES,R.            233
NEWMAN,M.W.         450
PITT,W.H.           515
ROLF,D.E.           114
SHEERS,C.D.         241
SUTCLIFFE,M.        472
TAYLOR,G.C.         407
WILTON,L.W.         404
WINSTONE,E.M.       307
/*
```

Figure 8-18. Creating an INDEXED data set

A: Add a new record
C: Change an existing record
D: Delete an existing record

Regional Data Sets

A data set with REGIONAL organization can exist only on a direct-access device. A REGIONAL data set is divided into regions that are numbered consecutively from zero. The following paragraphs briefly describe the three types of REGIONAL organization.

REGIONAL(1): In this organization a region is a record. Each record in the data set is identified by its region number, an unsigned decimal integer not exceeding 16777215. Region numbers start from 0 at the beginning of the data set.

```
//OPT8#19  JOB
//STEP1 EXEC  PLIXCLG
//PLI.SYSIN  DD  *
 DIRUPDT:PROC OPTIONS(MAIN);

         DCL DIREC FILE RECORD KEYED ENV(INDEXED),
             ONCODE BUILTIN,
             NUMBER CHAR(3),
             NAME CHAR(20),
             CODE CHAR(2);

         ON ENDFILE(SYSIN) GO TO PRINT;

         ON KEY(DIREC) BEGIN;
          IF ONCODE=51 THEN PUT FILE(SYSPRINT) SKIP EDIT
                              ('NOT FOUND:',NAME)(A(15),A);
          IF ONCODE=52 THEN PUT FILE(SYSPRINT) SKIP EDIT
                             ('DUPLICATE:',NAME)(A(15),A);
          END;

         OPEN FILE(DIREC) DIRECT UPDATE;
 NEXT: GET FILE(SYSIN) EDIT(NAME,NUMBER,CODE)(A(20),A(3),X(56),A(1));
         IF CODE='A' THEN WRITE FILE(DIREC) FROM(NUMBER) KEYFROM(NAME);
         ELSE IF CODE='C' THEN REWRITE FILE(DIREC) FROM(NUMBER)
                                                         KEY(NAME);
         ELSE IF CODE='D' THEN DELETE FILE(DIREC) KEY(NAME);
         ELSE PUT FILE(SYSPRINT) SKIP EDIT('INVALID CODE:',NAME)
                                              (A(15),A);
         GO TO NEXT;
 PRINT:  CLOSE FILE(DIREC);
         PUT FILE(SYSPRINT) PAGE;
         OPEN FILE(DIREC) SEQUENTIAL INPUT;

         ON ENDFILE(DIREC) GO TO FINISH;

 NEXTIN: READ FILE(DIREC) INTO(NUMBER) KEYTO(NAME);
         PUT FILE(SYSPRINT) SKIP EDIT(NAME,NUMBER)(A);
         GO TO NEXTIN;
 FINISH: CLOSE FILE(DIREC);
         END DIRUPDT;
/*
//GO.DIREC DD DSN=TELNO(INDEX),UNIT=2311,VOL=SER=D186,DISP=(OLD,KEEP)
//          DD DSN=TELNO(PRIME),UNIT=2311,VOL=SER=D186,DISP=(OLD,KEEP)
//          DD DSN=TELNO(OVFLOW),UNIT=2311,VOL=SER=D186,DISP=(OLD,KEEP)
//GO.SYSIN DD *
NEWMAN,M.W.         516                                                  C
GOODFELLOW,D.T.     889                                                  A
MILES,R.                                                                 D
HARVEY,C.D.W.       209                                                  A
BARTLETT,S.G.       183                                                  A
CORY,G.                                                                  D
READ,K.M.           001                                                  A
PITT,W.H.
ROLF,D.F.                                                                D
ELLIOTT,D.          291                                                  C
HASTINGS,G.M.                                                            D
BRAMLEY,O.H.        439                                                  C
/*
```

Figure 8-19. Updating an INDEXED data set

REGIONAL(1) data sets have no recorded keys. Note, however, that PL/I REGIONAL(1) DIRECT INPUT or UPDATE files can be used to process data sets that do have recorded keys. In particular, REGIONAL(2) and REGIONAL(3) data sets can be acessed by a file declared as ENV(REGIONAL(1)).

REGIONAL(2): This organization is similar to REGIONAL(1), but differs, in that a key is recorded with each record. The recorded key is a string of not more than 255 characters. For files with the DIRECT attribute, a record is written in the first vacant space on the track that contains the region number specified in the WRITE statement; for retrieval, the search for a record begins on the track that contains the region number specified in the READ statement, and may continue through the data set until the record has been found. For files that are created sequentially, the record is written in the region specified.

REGIONAL(3): This organization is similar to REGIONAL(2), but differs in that each region corresponds to one track of the direct-access device and is not a record position. Depending on the record length, a region can contain one or more records.

The major advantage of REGIONAL organization over other types of data set organization is that it allows you to control the relative placement of records; by judicious programming, you can optimize record access in terms of device capabilities and the requirements of particular applications. REGIONAL(1) organization is most suited to applications where there will be no duplicate region numbers, and where most of the regions will be filled (reducing wasted space in the data set). REGIONAL(2) and REGIONAL(3) are more appropriate where records are identified by numbers that are thinly distributed over a wide range. You can include in your program an algorithm that derives the region number from the number that identifies a record in such a manner as to optimize the use of space within the data set; duplicate region numbers may occur but, unless they are on the same track, their only effect might be to lengthen the search time for records with duplicate region numbers.

REGIONAL(1) and REGIONAL(2) data sets can contain only F-format unblocked records, but a REGIONAL(3) data set can have unblocked records of all three formats, F, V, and U. The examples at the end of this section illustrate typical applications of all three types of REGIONAL organization.

CREATING A REGIONAL DATA SET

You can use either sequential or direct-access to create a REGIONAL data set.

In sequential creation, you must present records in order of ascending region numbers; for REGIONAL(1) and REGIONAL(2) the region number for each record must exceed that of the preceding record since each region can contain only one record. In all cases, dummy records (identified by (8)'1'B in the first byte) are placed automatically in regions whose numbers are skipped. The data set can have up to 15 extents, which may be on more than one volume.

For direct creation, one of the PL/I library subroutines formats the whole of the data set when you open the corresponding file. For REGIONAL(1) and (2), and for REGIONAL(3) with F-format records, formatting involves filling the data set with dummy records; for REGIONAL(3) with U-format or V-format records, a record, called the <u>capacity record</u> is written at the start of each track to indicate an empty track. During creation, you can present records in any order. The data set can have only one extent, and can therefore reside on only one volume.

Essential Information

To create a REGIONAL data set, you must give the operating system certain information either in your PL/I program or in the DD statement that defines the data set. The following paragraphs indicate the essential information, and discuss some of the optional information you may supply; the ENVIRONMENT attribute and the LINESIZE option are discussed fully in the language reference manual for this compiler.

You must supply the following information when creating a REGIONAL data set:

- Device that will write or punch your data set (UNIT or VOLUME parameter of DD statement).
- Block size: you can specify the block size either in your PL/I program (ENVIRONMENT attribute or LINESIZE option) or in the DD statement (BLKSIZE subparameter). If you do not specify a record length, unblocked records are assumed and the record length is determined from the block size.

Parameters of DD Statement		
When required	**What you must state**	**Parameters**
Always	Output device	UNIT= or VOLUME=REF=
	Storage space required	SPACE=
	Data control block information: refer to figure 8-21	DCB=
Data set to be used in another job step but not required in another job	Disposition	DISP=
Data set to be kept after end of job	Disposition	DISP=
	Name of data set	DSNAME=
Data set to be on particular volume	Volume serial number	VOLUME=SER= or VOLUME=REF=

Figure 8-20. Creating a REGIONAL data set: essential parameters of DD statement

DCB Subparameters		
When required	**To specify**	**Subparameters**
These are always required	Record format[1]	RECFM=F or RECFM=V[2] REGIONAL(3) only or RECFM=U REGIONAL(3) only
	Block size[1]	BLKSIZE=
	Data set organization	DSORG=DA
	Key length (REGIONAL(2) and (3) only)	KEYLEN=
These are optional	Limited search for a record or space to add a record (REGIONAL(2) and (3) only)	LIMCT=
	Number of data management buffers[1]	BUFNO=

[1] Alternatively, can be specified in ENVIRONMENT attribute.
[2] RECFM=VS must be specified in the ENVIRONMENT attribute for sequential input or update.

Figure 8-21. DCB subparameters for a REGIONAL data set

If you want to keep a data set (that is, you do not want the operating system to delete it at the end of your job), the DD statement must name the data set and indicate how it is to be disposed of (DSNAME and DISP parameters). The DISP parameter alone will suffice if you want to use the data set in a later step but will not need it after the end of your job.

If you want your data set stored on a particular direct-access device, you must indicate the volume serial number in the DD statement (SER or REF subparameter of VOLUME parameter). If you do not supply a serial number for a data set that you want to keep, the operating system will allocate one, inform the operator, and print the number on your program listing. All the essential parameters required in a DD statement for the creation of a REGIONAL data set are summarized in Figure 8-20, and Figure 8-21 lists the DCB subparameters needed. Appendix A contains a description of the DCB subparameters.

You cannot place a REGIONAL data set on a system output (SYSOUT) device.

In the DCB parameter, you must always specify the data set organization as direct by coding DSORG=DA. For REGIONAL(2) and REGIONAL(3), you must also specify the length of the recorded key (KEYLEN): refer to the language reference manual for this compiler for a description of how the recorded key is derived from the source key supplied in the KEYFROM option.

For REGIONAL(2) and REGIONAL(3), if you want to restrict the search for space to add a new record, or the search for an existing record, to a limited number of tracks beyond the track that contains the specified region, use the LIMCT subparameter of the DCB parameter. If you omit this parameter, the search will continue to the end of the data set, and then from the beginning of the data set back to the starting point in the data set.

ACCESSING A REGIONAL DATA SET

You can open an existing REGIONAL data set for sequential or direct access, and for input or update in each case. Using sequential input with a REGIONAL(1) data set you can read all the records in ascending region number sequence, and in sequential update you can read and may rewrite each record in turn. Sequential access of a REGIONAL(2) or REGIONAL(3) data set will give you the records in the order in which they appear in the data set, which is not necessarily region number order. Using direct input, you can read any record by supplying its region number and, for REGIONAL(2) and REGIONAL(3), its recorded key; in direct update, you can read or delete existing records or add new ones. The operating system ignores dummy records in a REGIONAL(2) or REGIONAL(3) data set; but a program that processes a REGIONAL(1) data set must be prepared to recognize dummy records.

To access a REGIONAL data set, you must identify it to the operating system in a DD statement. The following paragraphs indicate the minimum information you must include in the DD statement; this information is summarized in Figure 8-22.

If the data set is cataloged, you need supply only the following information in your DD statement:

- The name of the data set (DSNAME parameter). The operating system will locate the information that describes the data set in the system catalog and, if necessary, will request the operator to mount the volume that contains it.

- Confirmation that the data set exists (DISP parameter).

If the data set is not cataloged, you must, in addition, specify the device that will read the data set and give the serial number of the volume that contains the data set (UNIT and VOLUME parameters).

EXAMPLES OF REGIONAL DATA SETS

REGIONAL(1) Data Sets

Creating a REGIONAL(1) data set is illustrated in Figure 8-23.

The program uses the same data as that in Figure 8-18, but interprets it in a different way: the data set is effectively a list of telephone numbers with the names of the subscribers to whom they are allocated. The telephone numbers correspond with the region numbers in the data set, the data in each occupied region being a subscriber's name. The SPACE parameter of the DD statement requests space for 1000 twenty-byte records (that is, for 1000 regions); since space is never allocated in units of less than one track and one 2311 track can accommodate 45 twenty-byte records, there will in fact be 1035 regions. Note that the data set has no recorded keys because it is created using a DIRECT OUTPUT file.

Parameters of DD Statement		
When required	What you must state	Parameters
Always	Name of data set	DSNAME=
	Disposition of data set	DISP=
If data set not cataloged	Input device	UNIT= or VOLUME=REF=
	Volume serial number	VOLUME=SER=

Figure 8-22. Accessing a REGIONAL data set: essential parameters of DD statement

Updating a REGIONAL(1) data set is illustrated in Figure 8-24. The data read by the program is identical with that used in Figure 8-19, and the codes are interpreted in the same way. Like the program in Figure 8-19, this program updates the data set and lists its contents. Before each new or updated record is written the existing record in the region is tested to ensure that it is a dummy; this is necessary because a WRITE statement can overwrite an existing record in a REGIONAL(1) data set even if it is not a dummy. Similarly, during the sequential reading and printing of the contents of the data set, each record is tested and dummy records are not printed.

REGIONAL(2) Data Sets

The use of REGIONAL(2) data sets is illustrated in Figure 8-25, Figure 8-26, and Figure 8-27. The programs in these figures perform the same functions as those given for REGIONAL(3), with which they can usefully be compared.

The programs depict a library processing scheme, in which loans of books are recorded and reminders are issued for overdue books. Two data sets, STOCK2 and LOANS2, are involved. STOCK2 contains descriptions of the books in the library, and uses the 4-digit book reference numbers as recorded keys; a simple algorithm is used to derive the region numbers from the reference numbers. (It is assumed that there are about 1000 books, each with a number in the range 1000-9999.) LOANS2 contains records of books that are on loan; each record comprises two dates, the date of issue and the date of the last reminder. Each reader is identified by a 3-digit reference number, which is used as a region number in LOANS2; the reader and book numbers are concatenated to form the recorded keys.

In Figure 8-25, the data sets STOCK2 and LOANS2 are created. The file LOANS, which is used to create the data set LOANS2 is opened for direct output merely tc fcrmat the data set; the file is closed immediately without any reccrds being written onto the data set. It is assumed that the number of books on loan will not exceed 100; therefore the SPACE parameter in the DD statement that defines LOANS2 requests 100 blocks of 19 bytes (12 bytes of data and a 7-byte key: see Figure 8-26). Direct creation is alsc used for the data set STOCK2 because, even if the input data is presented in ascending reference number order, identical region numbers might be derived from successive reference numbers.

Updating of the data set LOAN2 is illustrated in Figure 8-26. Each item of input data, read from a punched card, comprises a book number, a reader number, and a code to indicate whether it refers to a new issue (I), a returned book (R), or a renewal (A). The position cf the reader number on the card allows the 8-character region number to be derived directly by overlay defining. The DATE built-in function is used to obtain the current date. This date is written in both the issue date and reminder date porticns of a new record or an updated record.

The program in Figure 8-27 uses a sequential update file (LOANS) to process the records in the data set LOANS2, and a direct input file (STOCK) tc obtain the book description from the data set STOCK2 for use in a reminder note. Each record from LOAN2 is tested to see whether the last reminder was issued more than a month ago; if necessary, a reminder note is issued and the current date is written in the reminder date field of the reccrd.

```
//OPT8#23  JOB
//STEP1 EXEC  PLIXCLG
//PLI.SYSIN  DD  *
 CRR1:    PROC OPTIONS(MAIN);

          DCL NOS FILE RECORD OUTPUT DIRECT KEYED ENV(REGIONAL(1)),
              CARD CHAR(80),
              NAME CHAR(20) DEF CARD POS(1),
              NUMBER CHAR(3) DEF CARD POS(21),
              IOFIELD CHAR(20);

          ON ENDFILE (SYSIN) GO TO FINISH;

          OPEN FILE(NOS);
 NEXT:    GET FILE(SYSIN) EDIT(CARD)(A(80));
          IOFIELD=NAME;
          WRITE FILE(NOS) FROM(IOFIELD) KEYFROM(NUMBER);
          GO TO NEXT;
 FINISH: CLOSE FILE(NOS);
          END CRR1;
/*
//GO.NOS DD DSN=NOSA,UNIT=2311,SPACE=(TRK,(23,3)),DCB=(RECFM=F,
//            BLKSIZE=20,DSORG=DA),DISP=(NEW,KEEP),VOL=SER=D186
//GO.SYSIN DD *
ACTION,G.           162
BAKER,R.            152
BRAMLEY,O.H.        248
CHEESEMAN,L.        141
CORY,G.             336
ELLIOTT,D.          875
FIGGINS,E.S.        413
HARVEY,C.D.W.       205
HASTINGS,G.M.       391
KENDALL,J.G.        294
LANCASTER,W.R.      624
MILES,R.            233
NEWMAN,M.W.         450
PITT,W.H.           515
ROLF.D.E.           114
SHEERS,C.D.         241
SUTCLIFFE,M.        472
TAYLOR,G.C.         407
WILTON,L.W.         404
WINSTONE,E.M.       307
/*
```

Figure 8-23. Creating a REGIONAL(1) data set

REGIONAL(3) Data Sets

The use of REGIONAL(3) data sets, illustrated in Figure 8-28, Figure 8-29, and Figure 8-30, is similar to the REGIONAL(2) figures, above; only the important differences are discussed here.

To conserve space in the data set STOCK3, U-format records are used. In each record, the author's name and the title of the book are concatenated in a single character string, and the lengths of the two parts of the string are written as part of the record. The average record (including the recorded key) is assumed to be 60 bytes; therefore the average number of records per track (that is, per region) is 25, and there will be 40 regions.

In Figure 8-28, the data set STOCK3 is created sequentially; duplicate region numbers are acceptable, because each region can contain more than one record.

In Figure 8-29, the region number for the data set LOANS3 is obtained simply by testing the reader number; there are only three regions, because a 2311 track can hold 36 nineteen-byte records.

The only notable difference between Figure 8-30 and the corresponding

```
//OPT8#24  JOB
//STEP1    EXEC  PLIXCLG
//PLI.SYSIN  DD  *
 ACR1:        PROC OPTIONS(MAIN);

        DCL NOS FILE RECORD KEYED ENV(REGIONAL(1)),
            NAME CHAR(20),
            (NEWNO,OLDNO) CHAR(3),
            CODE CHAR(1),
            IOFIELD CHAR(20),
            BYTE1     CHAR(1) DEF IOFIELD POS(1);

        ON ENDFILE(SYSIN) GO TO PRINT;

        OPEN FILE(NOS) DIRECT UPDATE;
 NEXT:      GET FILE(SYSIN) EDIT(NAME,NEWNO,OLDNO,CODE)
            (A(20),2 A(3),X(53),A(1));
        IF CODE='A' THEN GO TO RITE;
            ELSE IF CODE='C' THEN DO;
            DELETE FILE(NOS) KEY(OLDNO);
            GO TO RITE;
            END;
        ELSE IF CODE='D' THEN DELETE FILE(NOS) KEY(OLDNO);
              ELSE PUT FILE(SYSPRINT) SKIP
                       EDIT('INVALID CODE:',NAME)(A(15),A);
        GO TO NEXT;
 RITE:      READ FILE(NOS) KEY(NEWNO) INTO(IOFIELD);
        IF UNSPEC(BYTE1)=(8)'1'B THEN WRITE FILE(NOS) KEYFROM(NEWNO)
                                           FROM(NAME);
        ELSE PUT FILE(SYSPRINT) SKIP EDIT('DUPLICATE:',NAME)(A(15),A);
        GO TO NEXT;
 PRINT: CLOSE FILE(NOS);
        PUT FILE(SYSPRINT) PAGE;
        OPEN FILE(NOS) SEQUENTIAL INPUT;

        ON ENDFILE(NOS) GO TO FINISH;

 NEXTIN: READ FILE(NOS) INTO(IOFIELD) KEYTO(NEWNO);
        IF UNSPEC(BYTE1)=(8)'1'B THEN GO TO NEXTIN;
        ELSE PUT FILE(SYSPRINT) SKIP EDIT(NEWNO,IOFIELD)(A(5),A);
        GO TO NEXTIN;
 FINISH: CLOSE FILE(NOS);
        END ACR1;
/*
//GO.NOS DD DSN=NOSA,UNIT=2311,VOL=SER=D186,DISP=(OLD,KEEP)
//GO.SYSIN DD *
NEWMAN,M.W          516450                                                     C
GOODFELLOW,D.T.     889                                                        A
MILES,R.               233                                                     D
HARVEY,C.D.W.       209                                                        A
BARTLETT,S.G.       183                                                        A
CORY,G.                336                                                     D
READ,K.M.           001                                                        A
PITT,W.H.              515
ROLF,D.F.              114                                                     D
ELLIOTT,D.          472875                                                     C
HASTINGS,G.M.          391                                                     D
BRAMLEY,O.H.        439248                                                     C
/*
```

Figure 8-24. Updating a REGIONAL(1) data set

```
//OPT8#25  JOB
//STEP1 EXEC  PLIXCLG
//PLI.SYSIN  DD  *
 CRR2:    PROC OPTIONS(MAIN);

          DCL STOCK FILE RECORD KEYED ENV(REGIONAL(2)),
              LOANS FILE RECORD KEYED ENV(REGIONAL(2)),
              NUMBER CHAR(4),
              1 BOOK,
                2 AUTHOR CHAR(25),
                2 TITLE CHAR(50),
                2 QTY FIXED DEC(3),
              INTER FIXED DEC(5),
              REGION CHAR(8);

          OPEN FILE(LOANS) DIRECT OUTPUT;
          CLOSE FILE(LOANS);

          ON ENDFILE(SYSIN) GO TO FINISH;

          OPEN FILE(STOCK) DIRECT OUTPUT;
 NEXT:    GET FILE(SYSIN) LIST(NUMBER,BOOK);
          INTER=(NUMBER-1000)/9;  /* INTERMEDIATE FIXED DECIMAL ITEM */
          REGION=INTER;   /* USED TO ENSURE CORRECT PRECISION  */
          WRITE FILE(STOCK) FROM(BOOK) KEYFROM(NUMBER||REGION);
          GO TO NEXT;
 FINISH: CLOSE FILE(STOCK);
          END CRR2;
/*
|//GO.LOANS DD DSN=LOANS2,UNIT=2311,SPACE=(19,100),DCB=(RECFM=F,
|//              BLKSIZE=19,DSORG=DA,KEYLEN=7),DISP=(NEW,CATLG),
//              VOLUME=SER=D186
//GO.STOCK DD DSN=STOCK2,UNIT=2311,SPACE=(19,100),DCB=(RECFM=F,
//              BLKSIZE=19,DSORG=DA,KEYLEN=7),DISP=(NEW,CATLG),
//              VOLUME=SER=D186
//GO.SYSIN DD *
'1015' 'W.SHAKESPEARE' 'MUCH ADO ABOUT NOTHING'  1
'1214' 'L.CARROLL' 'THE HUNTING OF THE SNARK'  1
'3079' 'G.FLAUBERT' 'MADAME BOVARY'  1
'3083' 'V.M.HUGO' 'LES MISERABLES'  2
'3085' 'J.K.JEROME' 'THREE MEN IN A BOAT'  2
'4295' 'W.LANGLAND' 'THE BOOK CONCERNING PIERS THE PLOWMAN'  1
'5999' 'O.KHAYYAM' 'THE RUBAIYAT OF OMAR KHAYYAM'  3
'6591' 'F.RABELAIS' 'THE HEROIC DEEDS OF GARGANTUA AND PANTAGRUEL'  1
'8362' 'H.D.THOREAU' 'WALDEN, OR LIFE IN THE WOODS'  1
'9765' 'H.G.WELLS' 'THE TIME MACHINE'  3
/*
```

Figure 8-25. Creating a REGIONAL(2) data set

REGIONAL(2) figure is in the additional processing required for the anlysis of the records read from the data set STOCK3. The records are read into a varying-length character string and a based structure is overlaid on the string so that the data in the record can be extracted.

TELEPROCESSING

Teleprocessing in PL/I is provided by an extension of record-oriented transmission with the addition of the TRANSIENT file attribute and of the PENDING condition. The compiler provides a link between PL/I message processing programs (MPPs) and the Telecommunications Access Method (TCAM) of the operating system.

A TCAM message control program (MCP) handles messages originating from and destined for a number of remote terminals, each of which is identified by a terminal name carried with the message. These messages are transmitted to and from your PL/I message processing program by means of queues in main storage. (These queues are

```
//OPT8#26   JOB
//STEP1 EXEC  PLIXCLG
//PLI.SYSIN  DD  *
 DUR2:   PROC OPTIONS(MAIN);
         DCL 1 RECORD,
               2 (ISSUE,REMINDER) CHAR(6),
             SYSIN FILE RECORD INPUT SEQUENTIAL,
             LOANS FILE RECORD UPDATE DIRECT KEYED ENV(REGIONAL(2)),
             CARD CHAR(80),
             DATE BUILTIN,
             BOOK CHAR(4) DEF CARD POS(1),
             READER CHAR(3) DEF CARD POS(10),
             CODE CHAR(1) DEF CARD POS(20),
             REGION CHAR(8) DEF CARD POS(5);

         ON ENDFILE(SYSIN) GO TO FINISH;

         OPEN FILE(SYSIN),FILE(LOANS);
         ISSUE,REMINDER=DATE;
 NEXT:   READ FILE(SYSIN) INTO(CARD);
         IF CODE='I' THEN WRITE FILE(LOANS) FROM(RECORD)
                      KEYFROM(READER||BOOK||REGION);
         ELSE IF CODE='R' THEN DELETE FILE(LOANS)
                      KEY(READER||BOOK||REGION);
         ELSE IF CODE='A' THEN REWRITE FILE(LOANS) FROM(RECORD)
                      KEY(READER||BOOK||REGION);
         ELSE PUT FILE(SYSPRINT) SKIP LIST
                      ('INVALID CODE:',BOOK,READER);
         GO TO NEXT;
 FINISH: CLOSE FILE(SYSIN),FILE(LOANS);
         END DUR2;
/*
//GO.LOANS DD DSN=LOANS2,DISP=OLD
//GO.SYSIN DD *
3085     095      X
5999     003      A
3083     091      R
3083     049      I
/*
```

Figure 8-26. Updating a REGIONAL(2) data set directly

supported by corresponding queues on a direct-access device in auxiliary storage. Your PL/I program has access only to the main storage queues by means of a single buffer for each file.)

The exact message format (specified to the compiler by means of the ENVIRONMENT attribute) depends on the MPP. A message may be a complete unit, or may consist of a number of records so that it can be split up for processing. You must have this message format information to enable you to write the message processing program. Full information on how to write an MPP is given in the language reference manual for this compiler. A full account of TCAM procedure is given in the OS: TCAM Message Processing Program Services and OS: TCAM Message Control Program publications.

MESSAGE PROCESSING PROGRAM (MPP)

This program receives the terminal message as input and produces output according to the data in the message. You can code this program in PL/I.

An MPP is not mandatory at teleprocessing installations, as for example, an MCP is. If the messages you transmit do not require processing, because they are only switched between terminals, an MPP is not required. However, you can pass data to a problem program and you can receive the output with a minimum of delay, and most installations are likely to have a set of processing programs available for these purposes. These programs are stored as load modules, either in main storage or in a library in auxiliary storage.

```
//OPT8#27  JOB
//STEP1 EXEC  PLIXCLG
//PLI.SYSIN  DD  *
 SUR2:    PROC OPTIONS(MAIN);

          DCL LOANS FILE RECORD SEQUENTIAL UPDATE KEYED ENV(REGIONAL(2)),
              STOCK FILE RECORD DIRECT INPUT KEYED ENV(REGIONAL(2)),
              (TODAY,LASMTH) CHAR(6),
              YEAR PIC '99' DEF LASMTH,
              MONTH PIC '99' DEF LASMTH POS(3),
              1 RECORD,
                2 (ISSUE,REMINDER) CHAR(6),
              DATE BUILTIN,
              LOANKEY CHAR(7),
              READER CHAR(3) DEF LOANKEY POS(1),
              BKNO CHAR(4) DEF LOANKEY POS(4),
              INTER FIXED DEC(5),
              REGION CHAR(8),
              1 BOOK,
                2 AUTHOR CHAR(25),
                2 TITLE CHAR(50),
                2 QTY FIXED DEC(3);

          TODAY,LASMTH=DATE;
          IF MONTH='01' THEN DO;
            MONTH='12';
            YEAR=YEAR-1;
            END;
          ELSE MONTH=MONTH-1;
          OPEN FILE(LOANS),FILE(STOCK);

          ON ENDFILE(LOANS) GO TO FINISH;

 NEXT:    READ FILE(LOANS) INTO(RECORD) KEYTO(LOANKEY);
          IF REMINDER<LASMTH THEN DO;
            REMINDER=TODAY;
            REWRITE FILE(LOANS) FROM(RECORD);
            INTER=(BKNO-1000)/9;  /* INTERMEDIATE FIXED DECIMAL ITEM */
            REGION=INTER;   /* USED TO ENSURE CORRECT PRECISION  */
            READ FILE(STOCK) INTO(BOOK) KEY(BKNO||REGION);
            PUT FILE(SYSPRINT) SKIP(4) EDIT(READER,AUTHOR,TITLE)
            (A,SKIP(2));
            END;
          GO TO NEXT;
 FINISH: CLOSE FILE(LOANS),FILE(STOCK);
          END SUR2;
/*
//GO.LOANS DD DSN=LOADS2,DISP=OLD
//GO.STOCK DD DSN=STOCK2,DISP=OLD
```

Figure 8-27. Updating a REGIONAL(2) data set sequentially

HOW TO RUN AN MPP

An example of an MPP and the job control language required to create it is shown in Figure 8-31. The EXEC statement invokes the cataloged procedure PLIXCL to compile and link edit the PL/I message processing program. The appropriate TCAM modules are included in the program by the linkage editor. The load module produced is stored in the partitioned data set SYS1.MSGLIB under the member name MPPROC.

MPP is declared as a teleprocessing file that can process messages up to 100 bytes long. Similarly OUTMSG is declared as a teleprocessing file that can receive messages up to 500 bytes long.

The READ statement gets a record (that is, a message) from the queue. The terminal identifier is inserted into the KEYTO character string. The record is placed in the INDATA variable for processing. The appropriate READ SET statement could also have been used here.

```
//OPT8#28  JOB
//STEP1 EXEC  PLIXCLG
//PLI.SYSIN  DD  *
 CRR3:    PROC OPTIONS(MAIN);

          DCL STOCK FILE RECORD KEYED ENV(REGIONAL(3)),
              1 CARD,
                2 NUMBER CHAR(4),
                2 AUTHOR CHAR(25) VAR,
                2 TITLE CHAR(50) VAR,
                2 QTY1 FIXED DEC(3),
              (L1,L2,X) FIXED DEC(3),
              1 BOOK CTL,
                2 (L3,L4) FIXED DEC(3),
                2 QTY2 FIXED DEC(3),
                2 DESCN CHAR(X) VAR,
              INTER FIXED DEC(5),
              REGION CHAR(8);

          ON ENDFILE(SYSIN) GO TO FINISH;

          OPEN FILE(STOCK) SEQUENTIAL OUTPUT;
 NEXT:    GET FILE(SYSIN) LIST(CARD);
          L1=LENGTH(AUTHOR);
          L2=LENGTH(TITLE);
          X=L1+L2;
          ALLOCATE BOOK;
          L3=L1;
          L4=L2;
          QTY2=QTY1;
          DESCN=AUTHOR||TITLE;
          INTER=(NUMBER-1000)/225;      /* INTERMEDIATE FIXED DECIMAL */
          REGION=INTER;                 /* ITEM USED TO ENSURE CORRECT PRECISION     */
          WRITE FILE(STOCK) FROM(BOOK) KEYFROM(NUMBER||REGION);
          FREE BOOK;
          GO TO NEXT;
 FINISH: CLOSE FILE(STOCK);
          END CRR3;
/*
//GO.STOCK DD DSN=STOCK3,UNIT=2311,SPACE=(TRK,(40,5)),DCB=(RECFM=U,
//        BLKSIZE=110,DSORG=DA,KEYLEN=4),DISP=(,CATLG),VOL=SER=D186
//GO.SYSIN DD *
'1015' 'W.SHAKESPEARE' 'MUCH ADO ABOUT NOTHING'  1
'1214' 'L.CARROLL' 'THE HUNTING OF THE SNARK'  1
'3079' 'G.FLAUBERT' 'MADAME BOVARY'  1
'3083' 'V.M.HUGO' 'LES MISERABLES'  2
'3085' 'J.K.JEROME' 'THREE MEN IN A BOAT'  2
'4295' 'W.LANGLAND' 'THE BOOK CONCERNING PIERS THE PLOWMAN'  1
'5999' 'O.KHAYYAM' 'THE RUBAIYAT OF OMAR KHAYYAM'  3
'6591' 'F.RABELAIS' 'THE HEROIC DEEDS OF GARGANTUA AND PANTAGRUEL'  1
'8362' 'H.D.THOREAU' 'WALDEN, OR LIFE IN THE WOODS'  1
'9765' 'H.G.WELLS' 'THE TIME MACHINE'  3
/*
```

Figure 8-28. Creating a REGIONAL(3) data set

```
//OPT8#29  JOB
//STEP1 EXEC  PLIXCLG
//PLI.SYSIN  DD  *
 DUR3:    PROC OPTIONS(MAIN);

          DCL 1 RECORD,
                2 (ISSUE,REMINDER) CHAR(6),
              SYSIN FILE RECORD INPUT SEQUENTIAL,
              LOANS FILE RECORD UPDATE DIRECT KEYED ENV(REGIONAL(3)),
              CARD CHAR(80),
              BOOK CHAR(4) DEF CARD POS(1),
              READER CHAR(3) DEF CARD POS(10),
              CODE CHAR(1) DEF CARD POS(20),
              DATE BUILTIN,
              REGION CHAR(8);

          ON ENDFILE(SYSIN) GO TO FINISH;

          OPEN FILE(SYSIN),FILE(LOANS);
          ISSUE,REMINDER=DATE;
 NEXT:    READ FILE(SYSIN) INTO(CARD);
          IF READER<'034' THEN REGION='00000000';
          ELSE IF READER<'067' THEN REGION='00000001';
               ELSE REGION='00000002';
          IF CODE='I' THEN WRITE FILE(LOANS) FROM(RECORD)
                                KEYFROM(READER||BOOK||REGION);
          ELSE IF CODE='R' THEN DELETE FILE(LOANS)
                                KEY(READER||BOOK||REGION);
               ELSE IF CODE='A' THEN REWRITE FILE(LOANS) FROM(RECORD)
                                KEY(READER||BOOK||REGION);
                    ELSE PUT FILE(SYSPRINT) SKIP LIST
                                ('INVALID CODE',BOOK,READER);
          GO TO NEXT;
 FINISH:  CLOSE FILE(SYSIN),FILE(LOANS);
          END DUR3;
/*
//GO.LOANS DD DSN=LOANS3,DISP=OLD
//GO.SYSIN DD *
3085      095       X
5999      003       A
3083      091       R
3083      049       I
/*
```

Figure 8-29. Updating a REGIONAL(3) data set directly

```
//OPT8#30  JOB
//STEP1 EXEC  PLIXCLG
//PLI.SYSIN  DD  *
 SUR3:    PROC OPTIONS(MAIN);

      DCL LOANS FILE RECORD SEQUENTIAL UPDATE KEYED ENV(REGIONAL(3)),
              STOCK FILE RECORD DIRECT INPUT KEYED ENV(REGIONAL(3)),
              (TODAY,LASMTH) CHAR(6),
              YEAR PIC '99' DEF LASMTH,
              MONTH PIC '99' DEF LASMTH POS(3),
              1 RECORD,
                2(ISSUE,REMINDER) CHAR(6),
              LOANKEY CHAR(7),
              READER CHAR(3) DEF LOANKEY POS(1),
              BKNO CHAR(4) DEF LOANKEY POS(4),
              INTER FIXED DEC(5),
              DATE BUILTIN,
              REGION CHAR(8),
              1 BOOK,
                2 (L1,L2) FIXED DEC(3),
                2 QTY FIXED DEC(3),
                2 DESCN CHAR(75)VAR,
              AUTHOR CHAR(25) VAR,
              TITLE CHAR(50) VAR;

          TODAY,LASMTH=DATE;
          IF MONTH='01' THEN DO;
              MONTH='12';
              YEAR=YEAR-1;
              END;
          ELSE MONTH=MONTH-1;
          OPEN FILE(LOANS),FILE(STOCK);

          ON ENDFILE(LOANS) GO TO FINISH;

 NEXT:    READ FILE(LOANS) INTO(RECORD) KEYTO(LOANKEY);
          IF REMINDER<LASMTH THEN DO;
           REMINDER=TODAY;
           REWRITE FILE(LOANS) FROM(RECORD);
           INTER=(BKNO-1000)/225;     /* INTERMEDIATE FIXED DECIMAL   */
          REGION=INTER;     /*ITEM USED TO ENSURE CORRECT PRECISION   */
           READ FILE(STOCK) INTO(BOOK) KEY(BKNO||REGION);
           AUTHOR=SUBSTR(DESCN,1,L1);
           TITLE=SUBSTR(DESCN,L1+1,L2);
           PUT FILE(SYSPRINT) SKIP(4) EDIT(READER,AUTHOR,TITLE)
                          (A,SKIP(2));
           END;
          GO TO NEXT;
 FINISH:  CLOSE FILE(LOANS),FILE(STOCK);
          END SUR3;
/*
//GO.LOANS DD DSN=LOANS3,DISP=OLD
//GO.STOCK DD DSN=STOCK3,DISP=OLD
```

Figure 8-30. Updating a REGIONAL(3) data set sequentially

```
//          JOB
//          EXEC PLIXCL
//PLI.SYSIN DD *
| MPPROC: PROC OPTIONS(MAIN);
        DCL MPP FILE RECORD KEYED TRANSIENT ENV(TP(M)RECSIZE(100)),
        OUTMSG FILE RECORD KEYED TRANSIENT ENV(TP(M)RECSIZE(500)),
        INDATA CHAR(100),
        OUTDATA CHAR(500),
        TKEY CHAR(6);
          .
          .
          .
        OPEN FILE(MPP) INPUT,FILE(OUTMSG) OUTPUT;
          .
          .
          .
        READ FILE(MPP) KEYTO(TKEY) INTO(INDATA);
          .
          .
          .
|       WRITE FILE(OUTMSG) KEYFROM(TKEY) FROM(OUTDATA);
          .
          .
          .
 ENDTP: CLOSE FILE(MPP),FILE(OUTMSG);
        END MPPROC;
|/*
|//LKED.SYSLMOD DD DSNAME=SYS1.MSGLIB(MPPROC),...
```

Figure 8-31. PL/I message processing program

The WRITE statement puts the data in OUTDATA into the destination queue; the terminal identifier is taken from the character string in TKEY. An appropriate LOCATE statement could also have been used.

Once the load module has been stored on a direct-access device it can be restored for execution at any time. The job control statements to perform this might be:

```
//        JOB
//JOBLIB DD DSNAME=SYS1.MSGLIB,DISP=SHR
//        EXEC PGM=MPPROC
|//MPP    DD QNAME=...
|//OUTMSG DD QNAME=...
//SYSPRINT  DD  SYSOUT=A
```

The JOBLIB DD statement is required to make SYS1.MSGLIB available sc that the operating system can find the program MPPROC. The DD statement with the name DD1 associates the PL/I file with the main storage queue name (MPP).

Chapter 9: Virtual Storage Access Method(VSAM)

The Virtual Storage Access Method (VSAM) is both an access method and a form of data set organization. VSAM is available only to System/370 users. A virtual storage (or relocate) version of the operating system is required.

VSAM data sets can reside only on the following direct access storage devices:

IBM 2305
IBM 2314
IBM 2319
IBM 3330
| IBM 3340

VSAM Data Sets

There are two types of VSAM data sets: entry sequenced data sets (ESDS) and key sequenced data sets (KSDS). Key sequenced data sets have an associated index; a KSDS together with its index is referred to as an indexed VSAM data set. An entry sequenced data set has no associated index.

All VSAM data sets are cataloged, either in a master catalog or in a user catalog. The catalog entry is made when the data set is "defined", and remains until the data set is "deleted".

DATA FORMAT

The unit of data that is transmitted between a PL/I program and a VSAM data set is called a logical record. Logical records have no defined record format; VSAM will accept records of any length up to a maximum value that is specified when the data set is defined.

Logical records are grouped together in control intervals, and control intervals in turn are grouped in control areas. The sizes of control intervals and control areas are selected by the system to make optimum use of the particular storage device that is being used.

KEY SEQUENCED DATA SETS

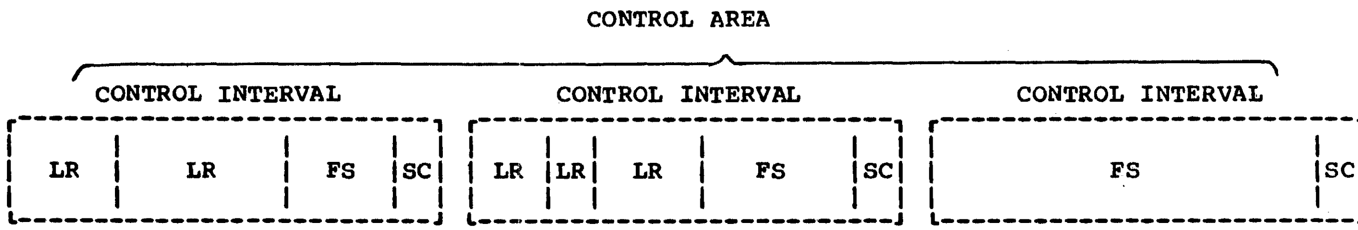
Figure 9-1 illustrates the structure of a key sequenced data set. Each control interval contains system control information, one or more logical records, and some free space to allow for the later addition of records. The amount of free space in a control interval can be specified as a percentage of the total space when the data set is defined (see "Creating VSAM Data Sets" later in this chapter). Similarly, the user can specify how many empty control intervals are to be left in each control area to allow for future additions.

Logical records in a KSDS are ordered in the collating sequence of an embedded key. The order is maintained when records are inserted into an existing data set, and when existing records are increased or decreased in length. Deleted records are physically deleted from the data set. The free space specification facility improves the performance of update operations by minimizing the moving of records and the splitting of control intervals and areas when records are added or increased in length.

Associated with each KSDS is an index data set. The index is in the form of a tree structure that gives rapid access to a specified key value. The lowest level of the index data set is known as the "sequence set", and the remaining levels are known as the "index set". For direct access, a logical record with a particular key is located by means of a search through successive levels of the index data set. This process is illustrated in Figure 9-2. For sequential access, only the sequence set is used.

ENTRY SEQUENCED DATA SETS

The structure of an entry sequenced data set is similar to that of a key sequenced data set in that it contains logical records within control intervals within control areas. However, the logical records are stored in the order in which they are submitted when the data set is created, and records cannot be subsequently added (except at the end of the data set), deleted, or changed in length. Any unused space which exists in a control interval is thus wasted space.



LR = logical record
FS = free space
SC = system control information

Figure 9-1. Structure of Key Sequenced Data Set

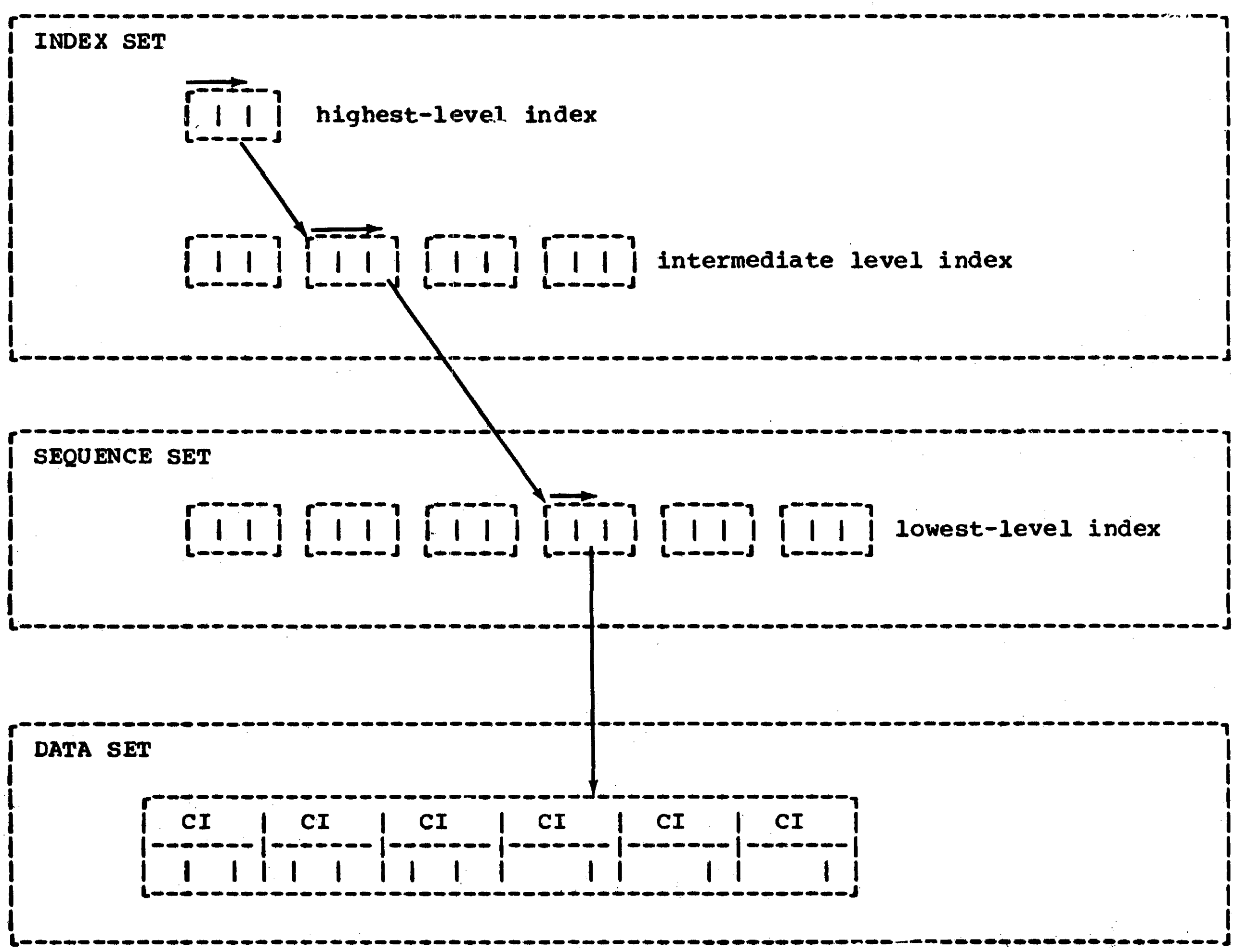


Figure 9-2. Indexed VSAM Data Set

Operations on VSAM Data Sets

ACCESS METHOD SERVICES

Access Method Services is a utility program that enables various operations to be performed on VSAM data sets. It is used to define VSAM data sets, to delete them, to print out their contents, and so on. A full description of the use and syntax of access method services is given in OS/VS Access Method Services, Order No. GC35-0009. The principal functions are listed in Figure 9-3.

DEFINE	To create VSAM catalogs and data set entries within the VSAM catalogs.
ALTER	To change VSAM catalog entries.
DELETE	To remove entries from the VSAM catalog.
LISTCAT	To list entries within VSAM catalogs.
REPRO	To copy the contents of data sets into other data sets.
PRINT	To print the contents of data sets.
EXPORT	To produce backup or portable copies of VSAM data sets.
IMPORT	To accept backup or portable copies of VSAM data sets.
VERIFY	To check the end-of-file information in a catalog for correspondence to the physical end of the data set.

Figure 9-3. The principal Access Method Services functions

CREATING VSAM DATA SETS

Before a VSAM data set can be created, VSAM data space must be available on a suitable direct access storage device. Space can be obtained by using the DEFINE command of Access Method Services; this space is then owned by VSAM and is used as a space pool for the creation of VSAM data sets.

When VSAM data space is available, the characteristics of the VSAM data set that is to be created are defined by means of a further DEFINE command. This causes an entry for the VSAM data set to be made in the VSAM master catalog, and the space requested for the data set to be obtained from the available VSAM space and formatted. The data set can then be "loaded" with data by the application program.

The use of the DEFINE command for these purposes is illustrated in the examples later in this chapter.

Note: The DEFINE command for the data set may specify either SUBALLOCATION or UNIQUE. SUBALLOCATION, which is the standard default, specifies that the space for the data set is to be a suballocation of VSAM space on a specified volume. If UNIQUE is specified, the allocation is made directly on a specified volume, and it is not necessary to obtain VSAM space as described in the preceeding paragraphs. In the rest of this chapter it is assumed that SUBALLOCATION is in effect.

Creating a Key Sequenced Data Set

The example in Figure 9-4 illustrates the creation of a key sequenced data set. This example is similar to that shown in Chapter 8 for the creation of an INDEXED data set; the only changes in the PL/I program are the replacement of INDEXED by VSAM in the ENVIRONMENT option of the output file declaration, and a modification to the output record structure so that the records contain embedded keys.

The first job step invokes Access Method Services (PGM=IDCAMS) to obtain space for the data set and to enter its characteristics in the VSAM catalog. The first DEFINE command obtains VSAM data space on volume HUR137. Note that the FILE parameter in this DEFINE statement refers to the DD statement with the ddname DD1. This DEFINE command and the corresponding DD statement may be omitted if sufficient VSAM space is already available on the required volume.

The second DEFINE statement defines the VSAM "cluster" that contains the data set and its associated index data set. It specifies that the data set and its index are to be placed on volume HUR137 and that the name of the data set (the dsname) is TELNO. The definition of the data set includes the information that the embedded key is 20 characters long and is at the front of the logical records, that both the average and the maximum lengths of logical records are 23 bytes, that 20% of the space in each control interval is to be left

```
//OPT9#4  JOB
//   EXEC  PGM=IDCAMS
//SYSPRINT  DD  SYSOUT=A
//DD1       DD  UNIT=2314,VOL=SER=HUR137,DISP=OLD
//SYSIN     DD  *
   DEFINE SPACE(VOL(HUR137) FILE(DD1) CYL(10,10))
   DEFINE CLUSTER(NAME(TELNO) VOL(HUR137))  -
          DATA(CYL(4,1) KEYS(20,0) RECSZ(23,23)  -
               FREESPACE(20,30))  -
          INDEX(CYL(1,1))
/*
//   EXEC  TL1LOCLG
//PLI.SYSIN DD *
 TELNOS:PROC OPTIONS(MAIN);

        DCL DIREC FILE RECORD SEQUENTIAL KEYED ENV(VSAM),
            CARD CHAR(80),
            NAME CHAR(20) DEF CARD POS(1),
            NUMBER CHAR(3) DEF CARD POS(21),
            OUTREC CHAR(23) DEF CARD POS(1);

        ON ENDFILE(SYSIN) GOTO FINISH;

        OPEN FILE(DIREC) OUTPUT;

 NEXTIN:GET FILE(SYSIN) EDIT(CARD)(A(80));
        WRITE FILE(DIREC) FROM(OUTREC) KEYFROM(NAME);
        GOTO NEXTIN;

 FINISH:CLOSE FILE(DIREC);

        END TELNOS;
//GO.DIREC  DD  DSNAME=TELNO,DISP=OLD
//GO.SYSIN  DD  *
ACTION,G.           162
BAKER,R.            152
BRAMLEY,O.H.        248
CHEESEMAN,D.        141
CORY,G.             336
ELLIOTT,D.          875
FIGGINS,S.          413
HARVEY,C.D.W.       205
HASTINGS,G.M.       391
KENDALL,J.G.        294
LANCASTER,W.R.      624
MILES,R.            233
NEWMAN,M.W.         450
PITT,W.H.           515
ROLF,D.E.           114
SHEERS,C.D.         241
SUTCLIFFE,M.        472
TAYLOR,G.C.         407
WILTON,L.W.         404
WINSTONE,E.M.       307
/*
```

Figure 9-4. Creating and Initializing a Key Sequenced Data Set

```
//OPT9#5  JOB
//STEP1 EXEC  TL1LOCLG
//PLI.SYSIN  DD  *
 DIRUPDT:PROC OPTIONS(MAIN);

         DCL DIREC FILE RECORD KEYED ENV(VSAM),
             ONCODE BUILTIN,
             OUTREC CHAR(23),
             NUMBER CHAR(3) DEF OUTREC POS(21),
             NAME CHAR(20) DEF OUTREC,
             CODE CHAR(2);

         ON ENDFILE(SYSIN) GO TO PRINT;

         ON KEY(DIREC) BEGIN;
          IF ONCODE=51 THEN PUT FILE(SYSPRINT) SKIP EDIT
                             ('NOT FOUND:',NAME)(A(15),A);
          IF ONCODE=52 THEN PUT FILE(SYSPRINT) SKIP EDIT
                            ('DUPLICATE:',NAME)(A(15),A);
         END;

         OPEN FILE(DIREC) DIRECT UPDATE;

 NEXT: GET FILE(SYSIN) EDIT(NAME,NUMBER,CODE)(A(20),A(3),X(56),A(1));
         IF CODE='A' THEN WRITE FILE(DIREC) FROM(OUTREC) KEYFROM(NAME);
         ELSE IF CODE='C' THEN REWRITE FILE(DIREC) FROM(OUTREC)
                                                         KEY(NAME);
         ELSE IF CODE='D' THEN DELETE FILE(DIREC) KEY(NAME);
         ELSE PUT FILE(SYSPRINT) SKIP EDIT('INVALID CODE:',NAME)
                                              (A(15),A);
         GO TO NEXT;

 PRINT:  CLOSE FILE(DIREC);
         PUT FILE(SYSPRINT) PAGE;
         OPEN FILE(DIREC) SEQUENTIAL INPUT;

         ON ENDFILE(DIREC) GO TO FINISH;

 NEXTIN: READ FILE(DIREC) INTO(OUTREC);
         PUT FILE(SYSPRINT) SKIP EDIT(OUTREC)(A);
         GO TO NEXTIN;
 FINISH: CLOSE FILE(DIREC);
         END DIRUPDT;
/*
//GO.DIREC DD DSNAME=TELNO,DISP=OLD
//GO.SYSIN DD *
NEWMAN,M.W.         516                                                            C
GOODFELLOW,D.T.     889                                                            A
MILES,R.                                                                           D
HARVEY,C.D.W.       209                                                            A
BARTLETT,S.G.       183                                                            A
CORY,G.                                                                            D
READ,K.M.           001                                                            A
PITT,W.H.
ROLF,D.F.                                                                          D
ELLIOTT,D.          291                                                            C
HASTINGS,G.M.                                                                      D
BRAMLEY,O.H.        439                                                            C
/*
```

Figure 9-5. Updating a Key Sequenced Data Set

```
//OPT9#6  JOB
//    EXEC   PGM=IDCAMS
//SYSPRINT  DD  SYSOUT=A
//SYSIN     DD  *
   DEFINE CLUSTER(NAME(DS3) VOL(HUR137) CYL(1,1) RECSZ(80,80)  -
                  NONINDEXED)
/*
//STEP1 EXEC  TL1LOCLG
//PLI.SYSIN  DD  *
 MERGE: PROC  OPTIONS(MAIN);
        DCL   (IN1,IN2) FILE RECORD SEQUENTIAL,
               OUT FILE RECORD SEQUENTIAL ENV(VSAM),
              (ITEM1 BASED(A),ITEM2 BASED(B)) CHAR(80);
              ON ENDFILE(IN1) BEGIN;
               ON ENDFILE(IN2) GO TO FINISH;
 NEXT2:        WRITE FILE(OUT) FROM(ITEM2);
               READ FILE(IN2) SET(B);
               GO TO NEXT2;
              END;
              ON ENDFILE(IN2) BEGIN;
               ON ENDFILE(IN1) GO TO FINISH;
 NEXT1:        WRITE FILE(OUT) FROM(ITEM1);
               READ FILE(IN1) SET(A);
               GO TO NEXT1;
              END;
              OPEN FILE(IN1) INPUT,
                   FILE(IN2) INPUT,
                   FILE(OUT) OUTPUT;
              READ FILE(IN1) SET(A);
              READ FILE(IN2) SET(B);
 NEXT:        IF ITEM1>ITEM2 THEN DO;
               WRITE FILE(OUT) FROM(ITEM2);
               READ FILE(IN2) SET(B);
               GO TO NEXT;
              END;
              ELSE DO;
               WRITE FILE(OUT) FROM(ITEM1);
               READ FILE(IN1) SET(A);
               GO TO NEXT;
              END;
 FINISH:      CLOSE FILE(IN1),FILE(IN2),FILE(OUT);
              END MERGE;
/*
//GO.OUT DD  DSNAME=DS3,DISP=OLD
//GO.IN1 DD  *
 (insert here data to be included in the input stream)
//GO.IN2 DD  *
 (insert here data to be included in the input stream)
/*
```

Figure 9-6. Creating an Entry Sequenced Data Set

free, and that 30% of the control intervals in each control area are also to be left free.

The following job steps compile, link-edit, and execute the PL/I program that loads the initial information into the data set. Note that the only information that need be supplied in the DD statement for the data set is the data set name that was defined in the DEFINE statement, together with the data set disposition (DISP=).

Accessing a Key Sequenced Data Set

The program in Figure 9-5 updates the data set that was created in Figure 9-4 and prints out its new contents. This example is similar to that shown in Chapter 8 for updating an INDEXED data set.

Creating and Accessing an Entry Sequenced Data Set

The example in Figure 9-6 illustrates the creation of an entry sequenced data set. The example is similar to that given in Chapter 8 for the creation of a CONSECUTIVE data set.

The first job step in the example invokes Access Method Services to define and catalog the data set. It is assumed in this example that VSAM already "owns" data space on the specified volume. Note that the VSAM "cluster" in this case contains only the ESDS. NONINDEXED must be specified in the DEFINE statement, to indicate that the records contain no keys and that an ESDS is required.

The PL/I program in this example merges the contents of two existing data sets, DS1 and DS2, and writes them onto the VSAM data set defined in the previous job step. Each of the original data sets contains 80-byte fixed length records arranged in EBCDIC collating sequence.

DD Statements for VSAM Data Sets

This section describes the minimum information that must appear in DD statements for VSAM data sets. The additional facilities that are available through the job control language are also listed; further information on these facilities is given in OS/VS VSAM Programmer's Guide, Order No. GC26-3806.

If a DEFINE command is used to obtain VSAM data space on a particular volume, a DD statement must be provided to define the volume. The ddname of this DD statement must appear in the FILE parameter of the DEFINE command. The DD statement must contain the UNIT, VOLUME, and DISP parameters. For example, if the DEFINE command is:

```
DEFINE  SPACE(.... FILE(DDN).....)
```

the corresponding DD statement must have the form:

```
//DDN DD UNIT=xxxx,VOL=SER=yyyy,DISP=OLD
```

Once a data set has been defined using the DEFINE command, it can be accessed by specifying the dsname and a disposition of OLD. Additional parameters can, however, be specified. For VSAM data sets, the DCB parameter is invalid; its place is taken by the AMP parameter. The AMP parameter has the following format:

```
AMP='subparameter,subparameter,...'
```

The valid subparameters of the AMP parameter are:

BUFSP=number	specifies the amount of storage to be set aside for VSAM buffers.
BUFND=number	specifies the number of data buffers required.
BUFNI=number	specifies the number of index buffers required.
RECFM=format	specifies record format. The use of this subparameter is described under the heading "The Compatibility Interface" later in this chapter.
STRNO=number	specifies how many concurrent data-set positioning requests VSAM must be prepared to handle. For convenience, the PL/I programmer can make STRNO equal to the number of PL/I files that will be open on the data set at the same time.
TRACE	specifies that a trace of Access Method Control Blocks (ACBs) is required during processing.
AMORG	must be specified if VOL=SER information is used to define a catalog or a subset mount of a multivolume data set.
|OPTCD={L|IL}	specifies how deleted records are to be handled when the compatibility interface is being used (see "The Compatibility Interface" later in this chapter.)

The Compatibility Interface

PL/I programs that are written to create and access ISAM data sets (ENV(INDEXED)) can be used to access VSAM key sequenced data sets without alteration. Two types of access are possible: "native" access, in which the data set is accessed exactly as though the file had been declared with ENV(VSAM), and access via the ISAM/VSAM compatibility interface.

The fact that the data set being

accessed is a VSAM data set is detected by the PL/I library routines when the file is opened, and the required support is provided. This support will normally be native VSAM support; in order to force use of the compatibility interface, the user must code either RECFM=F|FB|V|VB or OPTCD=L in the AMP parameter of the DD statement for the data set. Use of the compatibility interface must be forced if any of the following situations exists:

- The PL/I program uses records with non-embedded keys.
- The user requires the lengths of records being read or written to be checked against the record length specified for the data set; the RECORD condition is to be raised if an incorrect-length record is encountered.
- Deleted records are to be retained in the data set (ISAM deletion). If deleted records are to be deleted from the data set (VSAM deletion), but the compatibility interface must be used for some other reason, the programmer must specify OPTCD=IL.
- The number of channel programs specified (NCP) is greater than one. Note, however, that the compatibility interface is obtained automatically in this case if a file declared with ENV(INDEXED) is opened on a VSAM KSDS.

If the compatibility interface is used, and RECFM is not specified either in the program or in the AMP parameter, the default is RECFM=V.

If a PL/I file declared with ENV(INDEXED) is used to load a VSAM KSDS with F-format records, and the key is not embedded, the record size specified on the DEFINE command for the VSAM data set must be equal to the length of the user record plus the length of the key.

Password Protection of VSAM Data Sets

VSAM provides a password protection option that enables VSAM data sets to be protected against unauthorized access or deletion. Passwords are specified as a parameter of the DEFINE command when a VSAM data set is defined. In order to gain access to a password-protected data set, the PL/I programmer must specify the correct password in the the ENVIRONMENT attribute of the PL/I file.

There are three levels of password protection of interest to the PL/I programmer:

1. Master Password - Specifying this password allows the user to perform any operation on a data set or on the index and catalog records associated with it.
2. Update Password - Specifying this password allows the user to retrieve, update, delete, or insert records in a data set.
3. Read-Only Password - Specifying this password allows the user to retrieve records form a data set, but not to update, delete, or insert records.

Note that password protection is effective only if the catalog that contains the data set is itself password protected.

Sharing VSAM Data Sets

SHARING BETWEEN JOBS

Independent jobs running in the same system may share VSAM data sets provided that both jobs specify DISP=SHR in their DD statements for the data set. The type of sharing that is to be allowed on any particular data set can be specifed in the DEFINE command when the data set is defined. The following four types of sharing are possible:

1. The data set may be used by one job for output <u>or</u> by any number of jobs for input.
2. The data set may be used by one job for output <u>and</u> by any number of jobs for input.
3. The data set may be fully shared, the user being completely responsible for read and write integrity.
4. As (3) above, but VSAM will refresh the buffers for each request.

SHARING BETWEEN SUBTASKS IN A JOB

Subtasks can share VSAM data sets either through separate DD statements or through the same DD statement.

If separate DD statements are used, the rules are the same as those for sharing between jobs.

If a single DD statement is used, the data set can be fully shared. The value of STRNO specified in the AMP parameter of the DD statement should be equal to the number of files that will be open on the data set concurrently.

Chapter 10: Libraries of Data Sets

Within the IBM operating system, the terms "partitioned data set" and "library" are used synonymously to signify a type of data set that can be used for the storage of other data sets (usually programs in the form of source, object or load modules). A library must be stored on direct-access storage and be wholly contained in one volume. It contains independent, consecutively-organized, data sets, called members. Each member has a unique name, not more than eight characters long, which is stored in a directory that is part of the library. All the members of one library must have the same data characteristics because only one data set label is maintained.

Members can be created individually until there is insufficient space left for a new entry in the directory, or until there is insufficient space for the member itself. Members can be accessed individually by specifying the member name.

DD statements or ALLOCATE commands are used to create and access members.

Members can be deleted by means of the IBM utility program IEHPROGM. This deletes the member name from the directory so that the member can no longer be accessed; but the space occupied by the member itself cannot be used again unless the library is recreated using, for example, the IBM utility program IEBCOPY. An attempt to delete a member by using the DISP parameter of a DD statement will cause the whole data set to be deleted.

Types of Library

The following types of library may be used with a PL/I program:

- The system program library SYS1.LINKLIB. This can contain all system processing programs such as compilers and the linkage editor.

- Private program libraries. These usually contain user-written programs. It is often convenient to create a temporary private library to store the load module output from the linkage editor until it is executed by a later job step in the same job. The library will be deleted at the end of the job. Private libraries are also used for automatic library call by the linkage editor and the loader.

- The system procedure library, SYS1.PROCLIB. This contains the job control procedures that have been cataloged for your installation.

How to Use a Library

The ways in which the libraries described above can be used are described in the following sections.

BY THE LINKAGE EDITOR OR LOADER

The output from the linkage editor is usually placed on a private program library.

The automatic call library used as input to the linkage editor or loader (see Chapter 5) can be SYS1.LINKLIB, a private program library, or a subroutine library.

In each case, the processing of directory entries is performed by the operating system.

When you are adding a member to a library, you must specify the member name as follows:

- When a single module is produced as output from the linkage editor, the member name can be specified as part of the data set name (see later in this chapter).

- When more than one module is produced as output from the linkage editor, the member name for the first module can be specified as part of the data set name or in the NAME option or NAME control statement. The member names for the subsequent modules must be specified in the NAME option or the NAME control statement.

BY THE OPERATING SYSTEM

When you request the execution of a load module in an EXEC statement or CALL command, the operating system must be able to retrieve the load module from a library. For a CALL command, this library is specified explicitly or implicitly in the command. For an EXEC statement, the following rules apply.

The operating system will assume the load module is a member of SYS1.LINKLIB, and will search in the directory for that library for the name you have specified, unless you have also specified that the load module is in a private library, in one of the following ways.

If the load module has been added to the private library in a previous step of the job (usually a link-edit step) and the member name was specified as part of the data set name, then you can refer, in the EXEC statement, to the DD statement defining the library instead of specifying the load module name. The library must have been given the disposition PASS.

If the load module exists on the private library before the job starts, then you have several ways of defining the library.

You can define the library in a DD statement, with the ddname JOBLIB, immediately after the JOB statement. This library will be used in place of SYS1.LINKLIB for all the steps of the job. If any load module is not found on the private library, the system will then look for it on SYS1.LINKLIB.

You can define the library in a DD statement with the ddname STEPLIB, at any point in the job control procedure. The private library will be used in place of SYS1.LINKLIB, or any library specified in a JOBLIB DD statement, for the job step in which it appears (though it can also be "passed" to subsequent job steps in the normal way). If any load module is not found on the private library, the system will look for it on the library specified in the JOBLIB DD statement (if used) or on SYS1.LINKLIB. The STEPLIB DD statement can be used in a cataloged procedure.

Alternatively, if you specify SYS1.LINKLIB in the JOBLIB or STEPLIB DD statements, and then concatenate the private library to it, the private library will be used only if a load module cannot be first found on SYS1.LINKLIB.

BY YOUR PROGRAM

Libraries can be used directly by a PL/I program.

If you are adding a new member to a library, its directory entry will be made by the operating system when the associated file is closed, using the member name specified as part of the data set name.

If you are accessing a member of a library, its directory entry can be found by the operating system from the member name that you specify as part of the data set name.

More than one member of the same library can be processed by the same PL/I program, but only one such output file can be open at any one time. Different members are accessed by giving the member name in a DD statement.

Creating a Library

To create a library include in your job step a DD statement containing the information given in Figure 10-1. The information required is similar to that for a consecutively-organized data set (see Chapter 8) except for the SPACE parameter.

Information Required	Parameter of DD statement
Type of device that will process the library	UNIT=
Serial number of the volume that will contain the library	VOLUME=SER
Name of the library	DSNAME=
Amount of space required for the library	SPACE=
Disposition of the library	DISP=

Figure 10-1. Information required when creating a library

SPACE PARAMETER

The SPACE parameter in a DD statement that defines a library must always be of the form:

```
SPACE=(units,(quantity,
      increment,directory))
```

Although you can omit the third term (increment), indicating its absence by a comma, the last term, specifying the number of directory blocks to be allocated, must always be present.

The amount of auxiliary storage required for a library depends on the number and sizes of the members to be stored in it and on how often members will be added or replaced. (Space occupied by deleted members is not released.) The number of directory blocks required depends on the number of members and the number of aliases. Although you can specify an incremental quantity in the SPACE parameter that will allow the operating system to obtain more space for the data set if necessary, both at the time of creation and when new members are added, the number of directory blocks is fixed at the time of creation and cannot be increased.

If the data set is likely to be large or you expect to do a lot of updating, it might be best to allocate a full volume. Otherwise, make your estimate as accurate as possible to avoid wasting space or time recreating the data set.

The number of directory entries that a 256-byte directory block can contain depends on the amount of user data included in the entries. The maximum length of an entry is 74 bytes, but the entries produced by the linkage editor vary in length between 34 bytes and 52 bytes, which is equivalent to between four and seven entries per block.

For example, the DD statement:

```
//PDS DD UNIT=2311,VOLUME=SER=3412,
//    DSNAME=ALIB,
//    SPACE=(CYL,(50,,10)),
//    DISP=(,CATLG)
```

requests the job scheduler to allocate 50 cylinders of the 2311 disk pack with serial number 3412 for a new partitioned data set named ALIB, and to enter this name in the system catalog. The last term of the SPACE parameter requests that part of the space allocated to the data set be reserved for ten directory blocks.

Creating a Library Member

The members of a library must have identical characteristics otherwise you may subsequently have difficulty retrieving them. This is necessary because the volume table of contents (VTOC) will contain only one data set control block (DSCB) for the library and not one for each member. When using a PL/I program to create a member, the operating system creates the directory entry; you cannot place information in the user data field.

When creating a library and a member at the same time, the DD statement must include all the parameters listed under the heading "Creating a Library," earlier in this chapter (although you can omit the DISP parameter if the data set is to be temporary). The DSNAME parameter must include the member name in parentheses. For example, DSNAME=ALIB(MEM1) names the member MEM1 in the data set ALIB. If the member is placed in the library by the linkage editor, you can use the linkage editor NAME statement or the NAME compiler option instead of including the member name in the DSNAME parameter. You must also describe the characteristics of the member (record format, etc.) either in the DCB parameter or in your PL/I program; these characteristics will also apply to other members added to the data set.

When creating a member to be added to an existing library, you will not need the SPACE parameter; the original space allocation applies to the whole of the library and not to an individual member. Furthermore, you will not need to describe the characteristics of the member, since these are already recorded in the DSCB for the library.

To add two or more members to a library in one job step, you must include a DD statement for each member, and you must close one file that refers to the library before you open another.

Examples

The use of the cataloged procedure PLIXC to compile a simple PL/I program and place the object module in a new library named EXLIB is shown in Figure 10-2. The DD statement that defines the new library and names the object module overrides the DD statement SYSLIN in the cataloged procedure. (The PL/I program is a function procedure that, given two values in the form of the character string produced by the TIME built-in function, returns the difference in milliseconds.)

The use of the cataloged procedure PLIXCL to compile and link edit a PL/I program and place the load module in the existing library "PUBPGM" is shown in Figure 10-3. (The PL/I program lists the names of the members of a library.)

To use a PL/I program to add or delete one or more records within a member of a library, you must rewrite the entire member in another part of the library; this is

```
//OPT10#2     JOB
//STEP1  EXEC  PLIXC
//PLI.SYSLIN  DD  DSNAME=EXLIB(ELAPSE),UNIT=2311,VOL=SER=D186,
//       SPACE=(CYL,(10,,2)),DISP=(NEW,KEEP)
//PLI.SYSIN  DD  *
   ELAPSE:  PROC(TIME1,TIME2);

     DCL (TIME1,TIME2) CHAR(9),
         H1 PIC '99' DEF TIME1,
         M1 PIC '99' DEF TIME1 POS(3),
         MS1 PIC '99999' DEF TIME1 POS(5),
         H2 PIC '99' DEF TIME2,
         M2 PIC '99' DEF TIME2 POS(3),
         MS2 PIC '99999' DEF TIME2 POS(5),
         ETIME FIXED DEC(7);

     IF H2<H1 THEN H2=H2+24;
     ETIME=((H2*60+M2)*600000+MS2)-((H1*60+M1)*600000+MS1);
     RETURN(ETIME);
     END ELAPSE;
/*
```

Figure 10-2. Creating new libraries for compiled object modules

```
//OPT10#3     JOB
//STEP1  EXEC  PLIXCL
//PLI.SYSIN DD  *
   MNAME:  PROC  OPTIONS(MAIN);

     DCL LINK FILE RECORD SEQUENTIAL INPUT,
         1 DIRBLK,
        2 COUNT BIT(16),
        2 ENTRIES(254) CHAR(1),
         1 ENTRY BASED(A),
        2 NAME CHAR(8),
        2 TTR CHAR(3),
        2 INDIC,
   3 ALIAS BIT(1),
   3 TTRS BIT(2),
   3 USERCT BIT(5),
         (LEN,PTR) FIXED BIN(31);

     ON ENDFILE(LINK) GO TO FINISH;

     OPEN FILE(LINK);
       NEXTBLK: READ FILE(LINK) INTO(DIRBLK);
     LEN=COUNT;
     PTR=1;
       NEXTENT: A=ADDR(ENTRIES(PTR));
     PUT FILE(SYSPRINT) SKIP LIST(NAME);
     PTR=PTR+12+2*USERCT;
     IF PTR+2>LEN THEN GO TO NEXTBLK;
     GO TO NEXTENT;
       FINISH: CLOSE FILE(LINK);
     END MNAME;
/*
//LKED.SYSLMOD  DD  DSN=PUBPGM(DIRLIST),DISP=OLD,VOL=SER=D186,UNIT=2311
```

Figure 10-3. Placing a load module in an existing library

```
//OPT10#4      JOB
//STEP1  EXEC  PLIXCLG
//PLI.SYSIN  DD  *
  NMEM:  PROC OPTIONS(MAIN);

      DCL OUT FILE RECORD SEQUENTIAL OUTPUT,
          IOFIELD CHAR(80) BASED(A);

      ON ENDFILE(IN) GO TO FINISH;

  NEXT: READ FILE(IN) SET(A);
      WRITE FILE(OUT) FROM(IOFIELD);
      GO TO NEXT;
  FINISH: END NMEM;
/*
//GO.OUT   DD  DSN=ALIB(NMEM),UNIT=2311,VOL=SER=D186,
//      DISP=(NEW,CATLG),SPACE=(CYL,(10,1,1)),
//      DCB=(RECFM=FB,BLKSIZE=400,LRECL=80)
//GO.IN  DD  *
 (insert here data to be included in the input stream)
/*
```

Figure 10-4. Creating a library member in a PL/I program

```
//OPT10#5      JOB
//STEP1  EXEC  PLIXCLG
//PLI.SYSIN  DD  *
  UPDTM: PROC OPTIONS(MAIN);

      DCL (OLD,NEW) FILE RECORD SEQUENTIAL,
          DATA CHAR(80);

      ON ENDFILE(OLD)  GO TO FINISH;

      OPEN FILE(OLD) INPUT,FILE(NEW) OUTPUT TITLE('OLD');
 NEXT: READ FILE(OLD) INTO(DATA);
      IF DATA=' ' THEN GO TO NEXT;
      WRITE FILE(NEW) FROM(DATA);
      PUT FILE(SYSPRINT) SKIP LIST(DATA);
      GO TO NEXT;
 FINISH: CLOSE FILE(OLD),FILE(NEW);
      END UPDTM;
/*
//GO.OLD  DD  DSNAME=ALIB(NMEM),DISP=OLD
```

Figure 10-5. Updating a library member

rarely an economic proposition, since the space originally occupied by the member cannot be used again. You must use two files in your PL/I program, but both can be associated with the same DD statement. The program shown in Figure 10-5 updates the member created by the program in Figure 10-4; it copies all the records of the original member except those that contain only blanks.

Library Structure

The structure of a library is illustrated in Figure 10-6. The directory of a library is a series of records (entries) at the beginning of the data set; there is at least one directory entry for each member. Each entry contains a member name, the relative address of the member within the library, and a variable amount of user data. The entries are arranged in ascending alphameric order of member names.

A directory entry can contain up to 62 bytes of user data (information inserted by the program that created the member). An entry that refers to a member (load module)

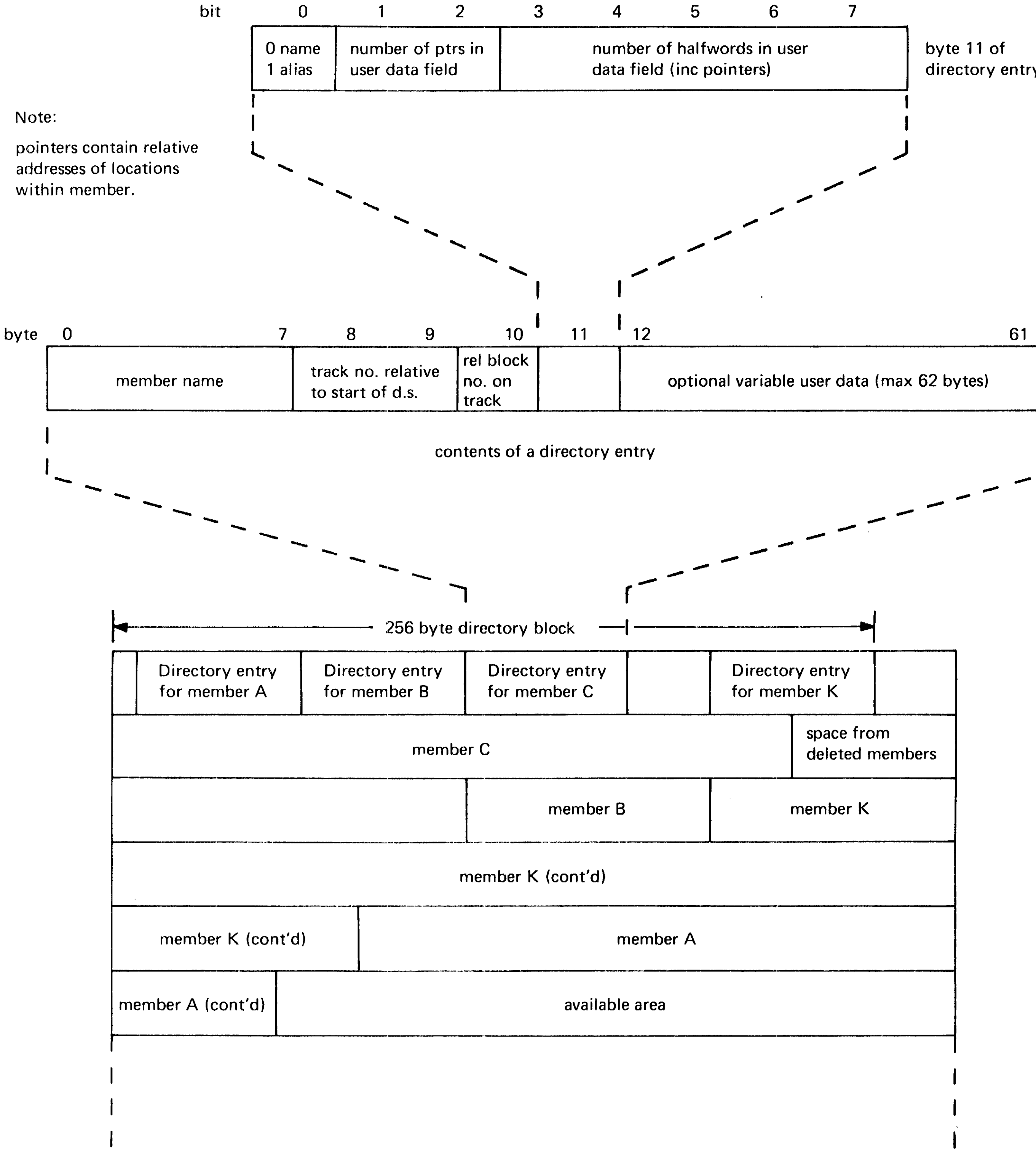


Figure 10-6. Structure of a library

written by the linkage editor includes user data in a standard format, described in the manual System Control Blocks.

If you use a PL/I program to create a member, the operating system creates the directory entry for you and you cannot write any user data. However, you can use assembler language macro instructions to create a member and write your own user data; the method is described in the manual Supervisor and Data Management Services.

Directory entries are stored in fixed-length blocks of 256 bytes, each containing a 2-byte count field specifying the number of active bytes in a block, and as many complete entries as will fit into the remaining 254 bytes. The directory is in effect a sequential data set that contains fixed-length unblocked records, and can be read as such.

The program illustrated in Figure 10-3 demonstrates a method of extracting information from directory entries. The program lists the names of all the members of a library; the library must be defined, when the program is executed, in a DD statement with the name LINK.

Chapter 11: Cataloged Procedures

This chapter describes the standard cataloged procedures supplied by IBM for use with the OS PL/I Optimizing Compiler, explains how to invoke them, and how to make temporary or permanent modifications to them.

A cataloged procedure is a set of job control statements stored in a system library, the procedure library (SYS1.PROCLIB). It comprises one or more EXEC statements, each of which may be followed by one or more DD statements. You can retrieve the statements by naming the cataloged procedure in the PROC parameter of an EXEC statement in the input stream. When the operating system processes this EXEC statement, it replaces it in the input stream with the statements of the cataloged procedure.

The use of cataloged procedures saves time and reduces errors in coding frequently used sets of job control statements. If the statements in a cataloged procedure do not match your requirements exactly, you can easily modify them or add new statements for the duration of a job. It is recommended that each installation review these procedures and modify them to obtain the most efficient use of the facilities available and to allow for installation conventions; refer to "Permanent Modification," later in this chapter.

Invoking a Cataloged Procedure

To invoke a cataloged procedure, specify its name in the PROC parameter of an EXEC statement. For example, to use the cataloged procedure PLIXC, you could include the following statement in the appropriate position among your other job control statements in the input stream:

```
//stepname EXEC PROC=PLIXC
```

You need not code the keyword PROC; if the first operand in the EXEC statement does not begin PGM= or PROC=, the job scheduler interprets it as the name of a cataloged procedure. The following statement is equivalent to that given above:

```
//stepname EXEC PLIXC
```

When the operating system meets the name of a cataloged procedure in an EXEC statement, it extracts the statements of the cataloged procedure from the procedure library and substitutes them for the EXEC statement in the input job stream. If you include the parameter MSGLEVEL=1 in your JOB statement, the operating system will include the original EXEC statement in its listing, and will add the statements of the cataloged procedure. In the listing, cataloged procedure statements are identified by XX or X/ as the first two characters; X/ signifies a statement that has been modified for the current invocation of the cataloged procedure.

An EXEC statement identifies a job step, which can require either the execution of a program or the invocation of a cataloged procedure. A cataloged procedure includes one or more EXEC statements, which identify procedure steps. However, an EXEC statement in a cataloged procedure cannot invoke another cataloged procedure; it must request the execution of a program.

It may be necessary for you to modify the statements of a cataloged procedure for the duration of the job step in which it is invoked, either by adding DD statements or by overriding one or more parameters in the EXEC or DD statements. For example, cataloged procedures that invoke the compiler require the addition of a DD statement with the name SYSIN to define the data set containing the source statements. Also, whenever you use more than one standard link-edit procedure step in a job, you must modify all but the first cataloged procedure that you invoke if you want to execute more than one of the load modules.

Multiple Invocation of Cataloged Procedures

You can invoke different cataloged procedures, or invoke the same cataloged procedure several times, in the same job. No special problems are likely to arise unless more than one of these cataloged procedures involves a link-edit procedure step, in which case you must take the following precautions to ensure that all your load modules can be executed.

The linkage editor always places a load module that it creates in the standard data set defined by the DD statement with the name SYSLMOD. In the absence of a linkage editor NAME statement (or the NAME compiler option), it uses the member name specified in the DSNAME parameter as the name of the module. In the standard cataloged procedures, the DD statement with the name SYSLMOD always specifies a temporary library named &&GOSET, and gives the load module the member name GO.

Consider what will happen if, for example, you use the cataloged procedure PLIXCLG twice in a job to compile, link edit, and execute two PL/I programs, and do not name each of the two load modules that will be created by the linkage editor. The linkage editor will name the first load module GO, as specified in the first DD statement with the name SYSLMOD. It will not be able to use the same name for the second load module since the first load module still exists in the library &&GOSET; it will allocate a temporary name to the second load module (a name that is not available to your program). Step GO of the cataloged procedure requests the operating system to initiate execution of the load module named in the first DD statement with the name SYSLMOD in the step LKED, that is, to execute the module named GO from the library &&GOSET. Consequently, the first load module will be executed twice and the second not at all.

To prevent this, use one of the following methods:

- Delete the library &&GOSET at the end of the step GO of the first invocation of the cataloged procedure by adding a DD statement of the form:

  ```
  //GO.SYSLMOD DD DSN=&&GOSET,
       DISP=(OLD,DELETE)
  ```

- Modify the DD statement with the name SYSLMOD in the second and subsequent invocations of the cataloged procedure so as to vary the names of the load modules. For example:

  ```
  //LKED.SYSLMOD DD DSN=&&GOSET(GO1)
  ```

  and so on.

- Use the NAME compiler option to give a different name to each load module and change your job control statements to specify the execution of the load modules with these names.

Dedicated Data Sets

Many of the processing programs in the operating system, including the optimizing compiler and the linkage editor, use temporary workfiles. To avoid allocating data sets for these workfiles each time they are required, an installation using the MVT operating system can dedicate one or more data sets for temporary workfiles, and these remain permanently allocated.

The standard cataloged procedures allow you to assign dedicated data sets to the optimizing compiler and linkage editor. The DD statements for workfiles have the ddname SYSUT1. In these DD statements, the DSNAME parameter is coded:

```
DSNAME=&&ddname
```

where "ddname" is the ddname of that DD statement. Your installation must have assigned these names to the dedicated data sets, otherwise you must override the DD statement in the cataloged procedure in order to specify the names used by your installation.

If the system cannot assign the dedicated data set to your job step, it creates a temporary data set instead. For full details of dedicated data sets see the OS System Programmer's Guide.

Multitasking Using Cataloged Procedures

When you use a cataloged procedure to link edit a multitasking program, you must ensure that the load module includes the multitasking versions of the PL/I resident library subroutines. To enable you to select the appropriate library, the cataloged procedures that invoke the linkage editor and the loader include a symbolic parameter (&LKLBDSN) in the DSNAME parameter of the DD statement SYSLIB, which defines the data set to be used as the automatic call library. This data set is described in Chapter 5. The default value of this symbolic parameter is SYS1.PLIBASE, which is the name of the non-multitasking ("base") library.

To ensure that the multitasking library (SYS1.PLITASK) is searched before the base library, include the parameter LKLBDSN='SYS1.PLITASK' in the EXEC statement that invokes the cataloged procedure; for example:

```
//STEPA EXEC PLIXCLG,LKLBDSN='SYS1.PLITASK'
```

The DD statement SYSLIB is always followed in the standard cataloged procedures by another, unnamed, DD statement that includes the parameter DSNAME=SYS1.PLIBASE. The effect of this statement is to concatenate the base library with the multitasking library, if the latter is used; the base library can then be searched for any subroutine common to multitasking and non-multitasking and therefore not included in the multitasking library. When the non-multitasking library is selected, the second DD statement has no effect.

The use of the symbolic parameter &LKLBDSN means that for non-multitasking programs, SYS1.PLIBASE is concatenated with itself. This has no effect other than a very small increase in job scheduling time, but does avoid the need for different cataloged procedures for link editing multitasking and non-multitasking programs.

Modifying Cataloged Procedures

You can modify a cataloged procedure temporarily by including parameters in the EXEC statement that invokes the cataloged procedure or by placing additional DD statements after the EXEC statement. Temporary modifications apply only for the duration of the procedure step in which the procedure is invoked and only to that procedure step; they do not affect the master copy of the cataloged procedure stored in the procedure library.

Alternatively, you can modify a cataloged procedure permanently by rewriting the job control statements that are stored in the procedure library. Permanent modification should be made only by system programmers responsible for maintaining the procedure library. Some of the considerations that may influence their decisions to modify the standard cataloged procedures are discussed below.

TEMPORARY MODIFICATION

Temporary modifications can apply to EXEC or DD statements in a cataloged procedure. To change a parameter of an EXEC statement, you must include a corresponding parameter in the EXEC statement that invokes the cataloged procedure; to change one or more parameters of a DD statement, you must include a corresponding DD statement after the EXEC statement that invokes the cataloged procedure. Although you may not add a new EXEC statement to a cataloged procedure, you can always include additional DD statements.

EXEC Statement

If a parameter of an EXEC statement that invokes a cataloged procedure has an unqualified name, the parameter applies to all the EXEC statements in the cataloged procedure. The effect on the cataloged procedure depends on the parameters, as follows:

- PARM applies to the first procedure step and nullifies any other PARM parameters.
- COND and ACCT apply to all the procedure steps.
- TIME and REGION apply to all the procedure steps and override existing values.

For example, the statement:

```
//stepname EXEC PLIXCLG,PARM='SIZE(MAX)',
     REGION=144K
```

invokes the cataloged procedure PLIXCLG, substitutes the option SIZE(MAX) for OBJECT and NODECK in the EXEC statement for procedure step PLI, and nullifies the PARM parameter in the EXEC statement for procedure step LKED; it also specifies a region size of 144K for all three procedure steps.

To change the value of a parameter in only one EXEC statement of a cataloged procedure, or to add a new parameter to one EXEC statement, you must identify the EXEC statement by qualifying the name of the parameter with the name of the procedure step. For example, to alter the region size for procedure step PLI only in the preceding example, code:

```
//stepname EXEC PROC=PLIXCLG,
     PARM='SIZE(MAX)',REGION.PLI=144K
```

A new parameter specified in the invoking EXEC statement overrides completely the corresponding parameter in the procedure EXEC statement.

You can nullify all the options specified by a parameter by coding the keyword and equal sign without a value. For example, to suppress the bulk of the linkage editor listing when invoking the cataloged procedure PLIXCLG, code:

```
//stepname EXEC PLIXCLG,PARM.LKED=
```

DD Statement

To add a DD statement to a cataloged

procedure, or to modify one or more parameters of an existing DD statement, you must include, in the appropriate position in the input stream, a DD statement with a name of the form "procstepname.ddname". If "ddname" is the name of a DD statement already present in the procedure step identified by "procstepname," the parameters in the new DD statement override the corresponding parameters in the existing DD statement; otherwise, the new DD statement is added to the procedure step. For example, the statement:

```
//PLI.SYSIN DD *
```

adds a DD statement to the procedure step PLI of cataloged procedure PLIXC and the effect of the statement:

```
//PLI.SYSPRINT DD SYSOUT=C
```

is to modify the existing DD statement SYSPRINT (causing the compiler listing to be transmitted to the system output device of class C).

Overriding DD statements must follow the EXEC statement that invokes the cataloged procedure in the same order as the corresponding DD statements of the cataloged procedure. DD statements that are being added must follow the overriding DD statements for the procedure step in which they are to appear.

To override a parameter of a DD statement, code either a revised form of the parameter or a replacement parameter that performs a similar function (for example, SPLIT for SPACE). To nullify a parameter, code the keyword and equal sign without a value. You can override DCB subparameters by coding only those you wish to modify; that is, the DCB parameter in an overriding DD statement does not necessarily override the entire DCB parameter of the corresponding statement in the cataloged procedures.

PERMANENT MODIFICATION

To make permanent modifications to a cataloged procedure, or to add a new cataloged procedure, use the system utility program IEBUPDTE, which is described in the utilities publication. The following paragraphs discuss some of the factors you should have in mind when considering whether to modify the standard cataloged procedures for your installation. For further information on writing installation cataloged procedures see the system programmer's guide.

In general, installation conventions will dictate the options that you include in the PARM, UNIT, and SPACE parameters of the cataloged procedures, and also the blocking factors for output data sets.

If your installation uses the MVT control program of the operating system, you may need to modify some or all of the REGION parameters.

The minimum region size for compilation should be at least 8K bytes larger than the largest value that will be specified in the SIZE compiler option, excluding SIZE(MAX).

In cataloged procedures that invoke the linkage editor, a region size of 100K is specified for the link-edit procedure step.

You can reduce this region size if you are using the 44K F-level linkage editor. In general, the region size should be at least 8K bytes larger than the design size for the particular version of the linkage editor being used. You must alter the region size if you are using the 128K F-level linkage editor.

Under MVT, the operating system requires up to 52K bytes of main storage within a region when initiating or terminating a job step. If you specify a region size of less than 52K bytes, completion of a job may be held up until 52K bytes are available.

The minimum region size used by MVT is dependent on the installation, and is defined at system generation. There is nothing to be gained in reducing the region size below this value.

If your installation uses MFT only, you can delete the REGION parameter from all cataloged procedures, otherwise it will be ignored.

IBM-Supplied Cataloged Procedures

The standard PL/I cataloged procedures supplied for use with the optimizing compiler are:

- PLIXC Compile only
- PLIXCL Compile and link edit
- PLIXCLG Compile, link edit, and execute
- PLIXLG Link edit and execute
- PLIXCG Compile, load-and-execute
- PLIXG Load-and-execute

The individual statements of the cataloged procedures are not fully described, since all the parameters are discussed elsewhere in this publication. These cataloged procedures do not include a DD statement for the input data set; you must always provide one. The example shown in Figure 11-1 illustrates the JCL statements you might use to invoke the cataloged procedure PLIXCLG to compile, link edit, and execute, a PL/I program.

```
//COLEGO    JOB
//STEP1     EXEC PLIXCLG
//PLI.SYSIN DD *
                 .
                 .
                 .
   (insert here PL/I program to be
   compiled)
                 .
                 .
                 .
/*
```

Figure 11-1. Invoking a cataloged procedure

No IBM-supplied cataloged procedure is provided to produce an object module on punched cards. You can temporarily modify any of the cataloged procedures that have a compile step to produce a punched card output; an example is shown in Figure 11-2.

```
//stepname      EXEC PLIXCLG,
//              PARM.PLI='OBJECT,DECK'
//PLI.SYSPUNCH DD SYSOUT=B
//PLI.SYSIN     DD ...
              .
              .
              .
```

Figure 11-2. Modifying a cataloged procedure to produce a punched card output

Compile Only (PLIXC)

This cataloged procedure, shown in Figure 11-3, comprises only one procedure step, in which the options specified for the compilation are OBJECT and NODECK. (IEL0AA is the symbolic name of the compiler.) In common with the other cataloged procedures that include a compilation procedure step, PLIXC does not include a DD statement for the input data set; you must always supply an appropriate statement with the qualified ddname PLI.SYSIN.

The OBJECT option causes the compiler to place the object module, in a form suitable for input to the linkage editor, in the standard data set defined by the DD statement with the name SYSLIN. This statement defines a temporary data set named &&LOADSET on a magnetic-tape or direct-access device; if you want to retain the object module after the end of your job, you must substitute a permanent name for &&LOADSET (that is, a name that does not commence &&) and specify KEEP in the appropriate DISP parameter for the last procedure step in which the data set is used.

The term MOD in the DISP parameter allows the compiler to place more than one object module in the data set, and PASS ensures that the data set will be available to a later procedure step providing a corresponding DD statement is included there.

The SPACE parameter allows an initial allocation of 250 eighty-byte records and, if necessary, 15 further allocations of 100 records (a total of 1750 records, which should suffice for most applications).

Compile and Link-edit (PLIXCL)

This cataloged procedure, shown in Figure 11-4, comprises two procedure steps: PLI, which is identical with cataloged procedure PLIXC, and LKED, which invokes the linkage editor (symbolic name IEWL) to link edit the object module produced in the first procedure step.

Input data for the compilation procedure step requires the qualified ddname PLI.SYSIN. The COND parameter in the EXEC statement LKED specifies that this procedure step should be bypassed if the return code produced by the compiler is greater than 9 (that is, if a severe or unrecoverable error occurs during compilation).

The DD statement with the name SYSLIB specifies the PL/I resident library, from which the linkage editor will obtain appropriate modules for inclusion in the load module. The linkage editor always places the load modules it creates in the standard data set defined by the DD statement with the name SYSLMOD. This statement in the cataloged procedure specifies a new temporary library &&GOSET, in which the load module will be placed and given the member name GO (unless you specify the NAME compiler option for the

```
//PLIXC       PROC
//PLI         EXEC PGM=IEL0AA,PARM='OBJECT,NODECK',REGION=100K
//SYSPRINT    DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=125,BLKSIZE=629)
//SYSLIN      DD DSN=&&LOADSET,DISP=(MOD,PASS),UNIT=SYSSQ,
//               SPACE=(80,(250,100))
//SYSUT1      DD DSN=&&SYSUT1,UNIT=SYSDA,SPACE=(1024,(60,60),,CONTIG),
//               DCB=BLKSIZE=1024
```

Figure 11-3. Cataloged procedure PLIXC

```
//PLIXCL      PROC LKLBDSN='SYS1.PLIBASE'
//PLI         EXEC PGM=IEL0AA,PARM='OBJECT,NODECK',REGION=100K
//SYSPRINT    DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=125,BLKSIZE=629)
//SYSLIN      DD DSN=&&LOADSET,DISP=(MOD,PASS),UNIT=SYSSQ,
//               SPACE=(80,(250,100))
//SYSUT1      DD DSN=&&SYSUT1,UNIT=SYSDA,SPACE=(1024,(60,60),,CONTIG),
//               DCB=BLKSIZE=1024
//LKED        EXEC PGM=IEWL,PARM='XREF,LIST',COND=(9,LT,PLI),REGION=100K
//SYSLIB      DD DSN=&LKLBDSN,DISP=SHR
//            DD DSN=SYS1.PLIBASE,DISP=SHR
//SYSLMOD     DD DSN=&&GOSET(GO),DISP=(MOD,PASS),UNIT=SYSDA,
//               SPACE=(1024,(50,20,1),RLSE)
//SYSUT1      DD DSN=&&SYSUT1,UNIT=SYSDA,SPACE=(1024,(200,20)),
//               DCB=BLKSIZE=1024
//SYSPRINT    DD SYSOUT=A
//SYSLIN      DD DSN=&&LOADSET,DISP=(OLD,DELETE)
//            DD DDNAME=SYSIN
```

Figure 11-4. Cataloged procedure PLIXCL

```
//PLIXCLG     PROC LKLBDSN='SYS1.PLIBASE'
//PLI         EXEC PGM=IEL0AA,PARM='OBJECT,NODECK',REGION=100K
//SYSPRINT    DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=125,BLKSIZE=629)
//SYSLIN      DD DSN=&&LOADSET,DISP=(MOD,PASS),UNIT=SYSSQ,
//               SPACE=(80,(250,100))
//SYSUT1      DD DSN=&&SYSUT1,UNIT=SYSDA,SPACE=(1024,(300,60),,CONTIG),
//               DCB=BLKSIZE=1024
//LKED        EXEC PGM=IEWL,PARM='XREF,LIST',COND=(9,LT,PLI),REGION=100K
//SYSLIB      DD DSN=&LKLBDSN,DISP=SHR
//            DD DSN=SYS1.PLIBASE,DISP=SHR
//SYSLMOD     DD DSN=&&GOSET(GO),DISP=(MOD,PASS),UNIT=SYSDA,
//               SPACE=(1024,(50,20,1),RLSE)
//SYSUT1      DD DSN=&&SYSUT1,UNIT=SYSDA,SPACE=(1024,(200,20)),
//               DCB=BLKSIZE=1024
//SYSPRINT    DD SYSOUT=A
//SYSLIN      DD DSN=&&LOADSET,DISP=(OLD,DELETE)
//            DD DDNAME=SYSIN
//GO          EXEC PGM=*.LKED.SYSLMOD,COND=((9,LT,PLI),(9,LT,LKED)),
//               REGION=100K
//SYSPRINT    DD SYSOUT=A
```

Figure 11-5. Cataloged procedure PLIXCLG

```
//PLIXLG      PROC LKLBDSN='SYS1.PLIBASE'
//LKED        EXEC PGM=IEWL,PARM='XREF,LIST',REGION=100K
//SYSLIB      DD DSN=&LKLBDSN,DISP=SHR
//            DD DSN=SYS1.PLIBASE,DISP=SHR
//SYSLMOD     DD DSN=&&GOSET(GO),DISP=(MOD,PASS),UNIT=SYSSQ,
//               SPACE=(1024,(50,20,1),RLSE)
//SYSUT1      DD DSN=&&SYSUT1,UNIT=SYSDA,SPACE=(1024,(200,20)),
//               DCB=BLKSIZE=1024
//SYSPRINT    DD SYSOUT=A
//SYSLIN      DD DNAME=SYSIN
//GO          EXEC PGM=*.LKED.SYSLMOD,COND=(9,LT,LKED),REGION=100K
//SYSPRINT    DD SYSOUT=A
```

Figure 11-6. Cataloged procedure PLIXLG

compiler procedure step). In specifying a temporary library, the cataloged procedure assumes that you will execute the load module in the same job; if you want to retain the module, you must substitute your own statement for the DD statement with the name SYSLMOD.

The last statement, DDNAME=SYSIN, illustrates how to concatenate a data set defined by a DD statement with the name SYSIN with the primary input (SYSLIN) to the linkage editor. You could place linkage editor control statements in the input stream by this means, as described in Chapter 5.

Compile, Link-edit, and Execute (PLIXCLG)

This cataloged procedure, shown in Figure 11-5, comprises three procedure steps, PLI and LKED, which are identical with the two procedure steps of PLIXCL, and GO, in which the load module created in the step LKED is executed. The third procedure step will be executed only if no severe or unrecoverable errors occur in the preceding procedure steps.

Input data for the compilation procedure step should be specified in a DD statement with the name PLI.SYSIN, and for the execution procedure step in a DD statement with the name GO.SYSIN.

Link-edit and Execute (PLIXLG)

This cataloged procedure, shown in Figure 11-6, comprises two procedure steps, LKED and GO, which are similar to the procedure steps of the same names in PLIXCLG.

In the procedure step LKED, the DD statement with the name SYSLIN does not define a data set, but merely refers the operating system to the DD statement SYSIN, which you must supply with the qualified ddname LKED.SYSIN. This DD statement defines the data set from which the linkage editor will obtain its primary input. Execution of the procedure step GO is conditional on successful execution of the procedure step LKED only.

Compile, Load, and Execute (PLIXCG)

This cataloged procedure, shown in Figure 11-7, achieves the same results as PLIXCLG but uses the loader instead of the linkage editor. However, instead of using three procedure steps (compile, link edit, and execute), it has only two (compile, and load-and-execute). In the second procedure step, the loader program is executed; this program processes the object module produced by the compiler and executes the resultant executable program immediately. Input data for the compilation procedure step requires the qualified ddname PLI.SYSIN.

The REGION parameter of the EXEC statement GO specifies 100K bytes. Since the loader requires about 17K bytes of main storage, there are about 83K bytes for your program; if this is likely to be insufficient, you must modify the REGION parameter. The use of the loader imposes certain restrictions on your PL/I program; before using this cataloged procedure, refer to Chapter 5, which explains how to use the loader.

Load and Execute (PLIXG)

This cataloged procedure, shown in Figure 11-8, achieves the same results as PLIXLG

```
//PLIXCG     PROC LKLBDSN='SYS1.PLIBASE'
//PLI        EXEC PGM=IEL0AA,PARM='OBJECT,NODECK',REGION=100K
//SYSPRINT   DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=125,BLKSIZE=629)
//SYSLIN     DD DSN=&&LOADSET,DISP=(MOD,PASS),UNIT=SYSSQ,
//              SPACE=(80,(250,100))
//SYSUT1     DD DSN=&&SYSUT1,UNIT=SYSDA,SPACE=(1024,(60,60),,CONTIG),
//              DCB=BLKSIZE=1024
//GO         EXEC PGM=LOADER,PARM='MAP,PRINT',REGION=100K,
//              COND=(9,LT,PLI)
//SYSLIB     DD DSN=&LKLBDSN,DISP=SHR
//           DD DSN=SYS1.PLIBASE,DISP=SHR
//SYSLIN     DD DSN=&&LOADSET,DISP=(OLD,DELETE)
//SYSLOUT    DD SYSOUT=A
//SYSPRINT   DD SYSOUT=A
```

Figure 11-7. Cataloged procedure PLIXCG

```
//PLIXG   PROC LKLBDSN='SYS1.PLIBASE'
//GO      EXEC PGM=LOADER,PARM='MAP,PRINT',REGION=100K
//SYSLIB DD DSN=&LKLBDSN,DISP=SHR
//        DD DSN=SYS1.PLIBASE,DISP=SHR
//SYSLOUT DD SYSOUT=A
//SYSPRINT DD SYSOUT=A
```

Figure 11-8. Cataloged procedure PLIXG

but uses the loader instead of the linkage editor. However, instead of using two procedure steps (link edit and execute), it has only one. In this procedure step, the loader program is executed. This program processes and executes an object module placed in the data set defined by a DD statement with the name SYSLIN; you must supply this statement with the qualified name GO.SYSLIN.

The REGION parameter of the EXEC statement GO specifies 100K byttes. Since the loader requires about 17K bytes of main storage, there are about 83K bytes for your program; if this is likely to be insufficient, you must modify the REGION parameter. The use of the loader imposes certain restrictions on your PL/I program; before using this cataloged procedure, refer to Chapter 5, which explains how to use the loader.

Chapter 12: Program Checkout

Program checkout is the application of diagnostic and test processes to a program. You should give adequate attention to program checkout during the development of a program so that:

- A program becomes fully operational after the fewest possible test runs, thereby minimizing the time and cost of program development.
- A program is proved to have fulfilled all the design objectives before it is released for production work.
- A program has complete and clear documentation to enable both operators and program maintenance personnel to use and maintain the program without assistance from the original programmer.

The data used for the checkout of a program should be selected to test all parts of the program. Whilst the data should be sufficiently comprehensive to provide a thorough test of the program, it is easier and more practical to monitor the behaviour of the program if the volume of data is kept to a minimum.

Conversational Program Checkout

The optimizing compiler can be used in conversational mode when writing and testing programs at a terminal. The conversational features are available to users where the TSO (Time Sharing Option) facilities of the operating system are present. The conversational facilities enable you to enter a PL/I program from a terminal, through which you will receive diagnostic messages for the compilation. You can also communicate with the program during execution using PL/I files associated with the terminal. Thus a PL/I program can be checked out during its construction, thereby saving a substantial amount of elapsed time that can occur between test compilation and execution runs in batched processing.

The PL/I program is entered and processed using the PLI, EDIT, and other commands and features described in the publication OS TSO: PL/I Optimizing Compiler.

Compile-time Checkout

At compile time, both the preprocessor and the compiler can produce diagnostic messages and listings according to the compiler options selected for a particular compilation. The listings and the associated compiler options are discussed in Chapter 4. The diagnostic messages produced by the optimizing compiler are identified by a number prefixed "IEL". These diagnostic messages are available in both a long form and a short form. The long messages are designed to be as self-explanatory as possible. The short messages are designed for reproduction at a terminal when the compiler is being used in a TSO environment. The short messages are obtained by specifying the SMESSAGE compiler option. Each message is reproduced in the publication: OS PL/I Optimizing Compiler Messages. This publication includes explanatory notes, examples, and any action to be taken.

Always check the compilation listing for occurrences of these messages to determine whether the syntax of the program is correct. Messages of greater severity than warning (that is, error, severe error, and unrecoverable error) should be acted upon if the message does not indicate that the compiler has been able to "fix" the error correctly. You should appreciate that the compiler, in making an assumption as to the intended meaning of any erroneous statement in the source program, can introduce a further, perhaps more severe, error which in turn can produce yet another error, and so on. When this occurs, the result is that the compiler produces a number of diagnostic messages which are all caused either directly or indirectly by the one error.

Other useful diagnostic aids produced by the compiler are the attribute table and cross-reference table. The attribute table, specified by the ATTRIBUTES option, is useful for checking that program identifiers, especially those whose attributes are contextually and implicitly declared, have the correct attributes. The cross-reference table is requested by the XREF option, and indicates, for each program variable, the number of each statement that refers to the variable.

To prevent unnecessary waste of time and resources during the early stages of developing programs, use the NOOPTIMIZE, NOSYNTAX, and NOCOMPILE options. The NOOPTIMIZE option will suppress optimization unconditionally, and the remaining options will suppress compilation, link editing, and execution should the appropriate error conditions be detected.

The NOSYNTAX option specified with the severity level "W", "E", or "S" will cause compilation of the output from the PL/I preprocessor, if used, to be suppressed prior to the syntax-checking stage should the preprocessor issue diagnostic messages at or above the severity level specified in the option.

The NOCOMPILE option specified with the severity level "W", "E", or "S" will cause compilation to be suppressed after the syntax-checking stage if syntax checking or preprocessing causes the compiler to issue diagnostic messages at or above the severity level specified in the option.

Linkage Editor Checkout

When using the linkage editor, check particularly that any required overlay structuring and incorporation of additional object and load modules have been performed correctly. Diagnostic messages produced by the linkage editor are prefixed "IEW". These messages are fully documented in the publication: OS Linkage Editor and Loader.

When checking the processing performed by the linkage editor, refer to the module map produced by the linkage editor showing the structure of the load module. The module map names the modules that have been incorporated into the program. The compiler produces an external symbol dictionary (ESD) listing if requested by the ESD option. The ESD listing indicates the external names that the linkage editor is to resolve in order to create a load module. The linkage editor is described in Chapter 5.

Execution-time Checkout

At execution time, errors can occur in a number of different operations associated with running a program. For instance, an error in the use of a job control statement can cause a job to fail. Most errors that can be detected are indicated by a diagnostic message. The diagnostic messages for errors detected at execution time are also listed in the messages publication for this compiler and identified by the prefix "IEM". The messages are always printed on the SYSPRINT file.

A failure in the execution of a PL/I program could be caused by one of the following:

- Logical errors in source programs.
- Invalid use of PL/I.
- Unforeseen errors.
- Operating error.
- Invalid input data.
- Unidentified program failure.
- A compiler or library subroutine failure.
- System failure.

Logical Errors in Source Programs

Logical errors in source programs can often be difficult to detect. Such errors can sometimes cause a compiler or library failure to be suspected. The more common errors are the failure to convert correctly from arithmetic data, incorrect arithmetic operations and string manipulation operations, and failure to match data lists with their format lists.

Invalid Use of PL/I

It is possible that a misunderstanding of the language, or the failure to provide the correct environment for using PL/I, results in an apparent failure of a PL/I program. For example, the use of uninitialized variables, the use of controlled variables that have not been allocated, reading records into incorrect structures, the misuse of array subscripts, the misuse of pointer variables, conversion errors, incorrect arithmetic operations, and incorrect string manipulation operations can cause this type of failure.

Unforeseen Errors

If an error is detected during execution of a PL/I program in which no on-unit is provided to terminate execution or attempt recovery, the job will be terminated abnormally. However, the status of a program executed in a batch-processing environment, at the point where the error occurred, can be recorded by the use of an ERROR on-unit that contains the statements:

```
ON ERROR BEGIN;
ON ERROR SYSTEM;
PUT DATA;
END;
```

The statement ON ERROR SYSTEM; contained in the on-unit ensures that further errors caused by attempting to transmit uninitialized variables do not result in a permanent loop.

Operating Error

A job could fail because of an operating error, such as running a job twice so that a data set becomes overwritten or erroneously deleted. Other operating errors include getting card decks into the wrong order and the failure to give operators correct instructions for running a job.

Invalid Input Data

A program should contain checks to ensure that any incorrect input data is detected before it can cause the program to fail.

Use the COPY option of the GET statement if you wish to check values obtained by stream-oriented input. The values will be listed on the file named in the COPY option. If no file name is given, SYSPRINT is assumed.

Unidentified Program Failure

In most circumstances, an unidentified program failure should not occur when using the optimizing compiler. Exceptions to this could include the following:

- When the program is executed in conjunction with non-PL/I modules, such as FORTRAN or COBOL.
- When the program obtains, by means of record-oriented transmission, incorrect values for use in label, entry, locator, and file variables.
- Errors in job control statements, particularly in defining data sets.

If execution of a program terminates abnormally without an accompanying PL/I execution-time diagnostic message, it is probable that the error that caused the failure also inhibited the production of a message. In this situation, it is still possible to check the PL/I source program for errors that could result in overwriting areas of the main storage region that contain executable instructions, particularly the communications region, which contains the address tables for the execution-time error-handling routine. These errors may also be present in modules compiled by the checkout compiler with NODIAGNOSE and COMPATIBLE and executed in conjunction with the modules produced by the optimizing compiler. The types of PL/I program that might cause the main storage to be overwritten erroneously are:

- Assignment of a value to a non-existent array element. For example:

  ```
  DCL ARRAY(10);
  .
  .
  .
  DO I = 1 TO 100;
  ARRAY(I) = VALUE;
  ```

  To detect this type of error in a module compiled by the optimizing compiler, enable the SUBSCRIPTRANGE condition. For each attempt to access an element outside the declared range of subscript values, the SUBSCRIPTRANGE condition will be raised. If there is no on-unit for this condition, a diagnostic message will be printed and the ERROR condition raised. This facility, although expensive in execution time and storage space, is a valuable program-checkout aid.

- The use of incorrect locator values for locator (pointer and offset) variables. This type of error is possible if a locator value is obtained by means of record-oriented transmission. Check that locator values created in a program, transmitted to a data set, and subsequently retrieved for use in another program, are valid for use in the second program.

  An error could also be caused by attempting to free a non-based variable. This could be caused by freeing a based variable when its qualifying pointer value has been changed. For example:

  ```
  DCL A STATIC,B BASED (P);
  ALLOCATE B;
  P = ADDR(A);
  FREE B;
  ```

- The use of incorrect values for label, entry, and file variables. Errors similar to those described above for locator values are possible for label, entry, and file values that are transmitted and subsequently retrieved.

- The use of the SUBSTR pseudovariable to assign a string to a position beyond the maximum length of the target string. For example:

```
DCL X CHAR(3);
I=3;
SUBSTR(X,2,I) = 'ABC';
```

  The STRINGRANGE condition can be used to detect this type of error in a module compiled by the optimizing compiler.

<u>Compiler or Library Subroutine Failure</u>

If you are absolutely convinced that the failure is caused by a compiler failure or a library subroutine failure, you should notify your management, who will initiate the appropriate action to correct the error. This could mean calling in IBM personnel for programming support to rectify the problem. Before calling IBM for programming support, refer to the instructions for providing the correct information to be used in diagnosing the problem. These instructions are given in Appendix C, "Requirements for Problem Determination and APAR Submission." Meanwhile, you can attempt to find an alternative way to perform the operation that is causing the trouble. A bypass is often feasible, since the PL/I language frequently provides an alternative method of performing a given operation.

<u>System Failure</u>

System failures include machine malfunctions and operating system errors. These failures should be identified to the operator by a system message.

Statement Numbers and Tracing

The compiler FLOW option provides a valuable program-checkout aid. The FLOW(n,m) option creates a table of the numbers of the last "n" branch-out and branch-in statements, and the last "m" procedures and on-units to be entered. (A "branch-out" statement is a statement that transfers control to a statement other than that which immediately follows it, such as a GOTO statement. A branch-in statement is a statement that receives control from a statement other than that which immediately precedes it, such as a PROCEDURE, ENTRY, or any other labeled statement.) The figure you choose for "n" should be large enough to provide a usable trace of the flow of control through the program. Alternatively, if you do not specify the FLOW option explicitly, defaults for the FLOW option will be used.

The trace table can be obtained by any of the methods described below.

The trace is printed whenever an on-unit with the SNAP option or a PUT ALL statement is encountered. It gives both the statement numbers and the names of the containing procedures or on-units. For example, an ERROR on-unit that results in both the listing of the program variables and the statement number trace can be included in a PL/I program as follows:

```
ON ERROR SNAP BEGIN;
ON ERROR SYSTEM;
PUT DATA;
END;
```

A flow trace can be specified as part of the output from the PL/I dump facility PLIDUMP, discussed later in this chapter.

Dynamic Checking Facilities

It is possible for a syntactically-correct program to produce incorrect results without raising any PL/I error conditions. This can be attributed to the use of incorrect logic in the PL/I source program or to invalid input data. Detection of such errors from the resultant output (if any) can be a difficult task. It is sometimes helpful to have a record of each of the values assigned to a variable, particularly label, entry, loop control, and array subscript variables. This can be obtained by using the CHECK prefix option. Note that, unless care is exercised, the indiscriminate use of the facilities described below will result in a flood of unwanted and unusable printout.

A CHECK prefix option can specify program variables in a list. Whenever a variable that has been included in a check-list is assigned a new value, the CHECK condition is raised. The standard system action for the CHECK condition is to print the name and new value of the variable that caused the CHECK condition to be raised. An example of a CHECK prefix options list is:

```
(CHECK(A,B,C,L)):/* CHECKOUT PREFIX LIST */
    TEST: PROCEDURE OPTIONS(MAIN);
         DECLARE A etc.,
         .
         .
         .
```

If the CHECK condition is to be raised for all the variables used in a program, the CHECK prefix option can be more simply specified without a list of items. For example:

```
(CHECK):  TEST:  PROCEDURE;
```

Control of Exceptional Conditions

During execution of a PL/I object program, a number of exceptional conditions can be raised, either as a result of program-defined action, or as a result of exceeding a hardware limitation. PL/I contains facilities for detecting such conditions. These facilities can be used to determine the circumstances of an unexpected interrupt, perform a recovery operation, and permit the program to continue to run. Alternatively, the facilities can be used to detect conditions raised during normal processing, and initiate program-defined actions for the condition. Note that some of the PL/I conditions are enabled by default, some cannot be disabled, and others have to be enabled explicitly in the program. Refer to the language reference manual for this compiler for a full description of each condition.

Note that the SIGNAL statement can be used to raise any of the PL/I conditions. Such use permits any on-units in the program to be tested during debugging.

The standard system action for the ERROR condition for which there is no on-unit, is, in batched processing, to raise the FINISH condition, and in conversational processing, to give control to the terminal. The FINISH condition is also raised for the following:

- When a SIGNAL FINISH statement is executed.
- When a PL/I program completes execution normally.
- On completion of an ERROR on-unit that does not return control to the PL/I program by means of a GOTO statement.
- When a STOP statement is executed or when an EXIT statement is executed in a major task.

The standard system action for the FINISH condition in batched processing is to terminate the task, and, in conversational processing, to give control to the terminal.

<u>Use of the PL/I Preprocessor in Program Checkout</u>

During program checkout, it is often necessary to use a number of the PL/I conditions (and the on-units associated with them) and subsequently to remove them from the program when it is found to be satisfactory. The PL/I preprocessor can be used to include a standard set of program-checkout statements from the source statement library. When the program is fully operational, the %INCLUDE statement can be removed, and the resultant object program compiled for execution.

A standard set of PL/I program checkout statements would include both the enabling of any conditions that are disabled by default and the provision of the appropriate on-units. The %INCLUDE statement that causes the inclusion of the set of program checkout statements would usually be placed after any on-units that must remain in the program permanently in order to cancel their effect during program checkout.

On-Codes

On-codes can indicate more precisely what type of error has occurred where a condition can be raised by more than one error. For example, the ERROR condition can be raised by a number of different errors, each of which is identified by an on-code. You can obtain the on-code by using the condition built-in function ONCODE in the on-unit. The on-codes are described in the language reference manual for this compiler.

Dumps

Should the checks given above fail to reveal the cause of the error, it may be necessary to obtain a printout, or dump, of the main storage region used by the program. A dump can display the contents of all buffers associated with PL/I files, the PL/I file attributes for each file open when the dump is taken, and a trace of the block invocations that occurred during execution before the dump was taken.

A hexadecimal dump can also be obtained to determine the machine instructions and data present in main storage when the failure occurred. The use of a hexadecimal storage dump requires a knowledge of assembler language programming and an understanding of object program organization.

Refer to the execution logic manual for this compiler for information about the organization of the object programs produced by the optimizing compiler, and how to interpret a storage dump.

To obtain a formatted PL/I dump, you must invoke the PL/I resident library dump module by calling PLIDUMP. Note that a DD statement with the ddname PLIDUMP or PL1DUMP must be supplied to define the data set for the dump.

The data set defined by the PLIDUMP DD statement must have DSORG=PS specified or assumed by default, and must have one of the following attributes:

- It must be allocated to SYSOUT.
- It must be allocated to the terminal or unit-record device.
- DISP=MOD must be specified.

The page size of the PLIDUMP output is taken from the PAGESIZE field of PLITABS.

PLIDUMP can be invoked with two optional arguments. The first argument is a character-string constant used to specify the types of information to be included in the dump. The second argument can be a character-string expression or a decimal constant with which you can identify the output produced by PLIDUMP. The format of the PLIDUMP statement is:

```
CALL PLIDUMP[('options-list'
     [,user-identification])];
```

The options-list is a contiguous string of characters that may include the following:

T — To request a trace of active procedures, begin blocks, on-units, and library modules.

NT — To suppress the output produced by T above.

F — To request a complete set of attributes for all files that are open, and the contents of the buffers used by the files.

NF — To suppress the output produced by F above.

S — To request the termination of the program after the completion of the dump. Note: The FINISH condition is not raised.

C — To request continuation of execution after completion of the dump.

H — To request a hexadecimal dump of the main storage partition used by the program.

NH — To suppress the hexadecimal dump.

B — If T is specified, to produce a separate hexadecimal dump of control blocks such as the TCA and the DSA chain that are used in the trace analysis. If F is specified, to produce a separate hexadecimal dump of control blocks used in the file analysis, such as the FCB.

NB — To suppress hexadecimal dumps of control blocks.

A — To request information relevant to all tasks in a multitasking program.

E — To request that an exit be made from the current task of a multitasking program and that execution of the program continues after completion of the requested dump.

O — To request information relevant only to the current task in a multitasking program.

The defaults assumed for the above options not specified explicitly are:

T F C A NH NB

The user-identification permits you to specify a character-string expression or a decimal constant to identify individual dumps. It cannot be specified without the preceding argument in the argument list.

Trace Information

Trace information produced by PLIDUMP includes a trace through all the active DSAs. (DSAs will be present for compiled blocks, such as procedures and on-units, and for library routines.) For on-units, the dump gives the values of any condition built-in functions that could be used in the on-unit, regardless of whether the on-unit actually used the condition built-in function. If a hexadecimal dump is also

Return Codes	Meaning
0000	Normal termination.
1-999	Return codes available for use with PLIRETC.
1000	Code returned if a STOP statement, an EXIT statement, or a CALL PLIDUMP statement with the "E" or "S" option is executed, or if ISASIZE is insufficient. This will be added to any PLIRETC value.
2000	Code returned if ERROR is raised and there is no ERROR or FINISH on-unit containing a GOTO statement. This value will be added to any PLIRETC value.
4000	Code returned if an interrupt occurs in the PL/I error handler or during program initialization.
4004	Code returned if the PRV (pseudo register vector) is too large.
4008	Code returned if PL/I program has no main procedure.
4012	Not enough main storage available.
4020	Code returned if the program is about to enter a permanent wait state.
4024	Code returned if a task in a multitasking program has terminated without use of the PL/I termination routines.

Figure 12-1. Return codes from execution of a PL/I program

requested, the trace information will also include:

- The address of each DSA (Dynamic Storage Area).
- The address of the TCA (Task Communications Area).
- The contents of the registers on entry to the PL/I error-handler module (IBMCERR).
- The PSW or the address from which the PL/I error handler module (IBMCERR) was invoked.
- The addresses of the library module DSAs back to the most recently-used compiled code DSA.

DSAs and the TCA are described in the execution logic manual for this compiler. A table of statement numbers indicating the flow of control through the program is always produced.

File Information

File information produced by PLIDUMP includes the default and declared attributes of all open files, and the contents of all buffers that are accessible to the dump routine. The information is given in BCD notation, and if hexadecimal output is also requested, in hexadecimal notation also. The address and contents of the FCB are then printed.

Hexadecimal Dump

The hexadecimal dump is a dump of the region of main storage containing the program. The dump is given as three columns of printed output. The left-hand and middle columns contain the contents of storage in hexadecimal notation. The third column contains a BCD translation of the first two columns. For hexadecimal characters that cannot be represented by a printable BCD character, a full stop is printed.

Return Codes

Both the compilation and the link editing of a PL/I program will result in a return code being passed to indicate the severity of any errors found. It is possible to pass a return code from a PL/I program, either for examination in a subsequent job step if execution of that step is conditional upon the value of the code returned, or merely to indicate conditions that were encountered during execution. Conditional execution of a job step is determined by use of the COND parameter of the JOB or EXEC statement.

Return codes can be set in a PL/I program by passing as an argument to the CALL PLIRETC statement a code represented as a variable with the attributes FIXED

BINARY(31,0). The range of codes used should be restricted to 1 through 999. If a return code of greater than 999 is specified, the return code is set to 999 and a diagnostic message is issued. Codes higher than 999 are returned if an error causes the program to terminate. In some cases the return code for the program will be added to any code created by use of the CALL PLIRETC statement. In other cases it will overwrite any code set by use of the CALL PLIRETC statement. Other error situations, listed in Figure 12-1, will also cause a program-generated return code to be overwritten.

If a return code in the 4000-4024 range is encountered and the cause cannot be traced to a source program error, it may be necessary to call in IBM program support personnel. Appendix C, "Problem Determination and APAR Submission", describes the materials that will be required for examination by IBM in such circumstances.

The ABEND Facility

Standard system action when the ERROR condition is raised and there is either no ERROR on-unit, or an ERROR on-unit that terminates normally (that is, one that does not contain a GOTO STATEMENT) is to terminate without issuing an ABEND. If the standard module IBMBEER in the PL/I resident library is altered as indicated below then the ABEND facility becomes available. IBMBEER will be called whenever the PL/I program is to be terminated as a result of the ERROR condition having been raised.

Altering the Standard Module IBMBEER

A non-zero return should be set in register 15. The program termination modules IBMBPIT and IBMTPIT call IBMBEER and interrogate register 15 on return; a non-zero value causes an ABEND to be issued. The value in register 15 is passed as a parameter to the ABEND which allows the options of user completion code, dump, and STEP ABEND to be selected.

When IBMBEER is called, the content of register 1 will be set as follows to signify whether or not there is an ERROR on-unit:

positive - ERROR on-unit
negative - no ERROR on-unit

An example of a user-written IBMBEER module is shown in Figure 12-2.

```
IBMBEER1 CSECT                     CSECT NAME
         ENTRY IBMBEERA            DEFINE ENTRY POINT
         USING *,15                ADDRESSABILITY
IBMBEERA EQU   *                   ENTRY POINT
         LTR   R1,R1               BRANCH
         BNM   ERRB                IF ON-UNIT
         L     15,RETNCOD1         SET RETURN CODE NON-ZERO
         BR    14                  RETURN
ERRB     EQU   *
         L     15,RETNCOD2
         BR    14
         *
DUMP     EQU   128                 128=DUMP, 0=NO DUMP
STEP     EQU   64                  64=STEP ABEND, 0=TASK ABEND
USERCOD1 EQU   3001                USER COMPLETION CODES (MUST BE GREATER
USERCOD2 EQU   3002                THAN 0 AND LESS THAN 4096)
RETNCOD1 DC    AL1(DUMP+STEP)
         DC    AL3(USERCOD1)
RETNCOD2 DC    AL1(DUMP+STEP)
         DC    AL3(USERCOD2)
         END
```

Figure 12-2. Typical User-Written IBMBEER Module

Chapter 13: Linking PL/I and Assembler-Language Modules

This chapter describes how to create programs that combine routines written in PL/I and assembler language. It explains how a PL/I program invokes an assembler-language routine and, conversely, how an assembler-language routine invokes a PL/I procedure.

Before describing any of the linkages in detail, the chapter discusses the PL/I environment that must be preserved when invoking an assembler-language routine from PL/I, and which must be created when invoking a PL/I procedure from an assembler-language routine.

The PL/I Environment

The PL/I environment is the term used to describe a number of control blocks created by routines that are provided by the OS PL/I Resident and Transient Libraries to satisfy the storage-management and error-handling requirements of a PL/I procedure.

When a PL/I program invokes an assembler-language routine, the invoked routine must ensure that the PL/I environment is preserved. The PL/I environment is preserved by observing the standard IBM System/360 linkage conventions, which include the storing of register values in a save area, and by ensuring that the content of register 12 is not modified by the assembler routine if PL/I is to handle interrupts that occur during execution of the assembler routine. Register 13 must be set to the address of a new save area established by the assembler routine.

ESTABLISHING THE PL/I ENVIRONMENT

The PL/I environment is established by the OS PL/I Resident Library routine IBMBPIR and the OS PL/I Transient Library routine IBMBPII for a non-multitasking program and by IBMTPIR and IBMTPII for a multitasking program. An assembler-language routine that invokes a PL/I procedure for which the PL/I environment has not been established can use one of three standard entry points to establish the environment. The routine |IBMBPIR or IBMTPIR (with IBMBPII or IBMTPII) is entered through a control section which has three standard entry points, PLISTART, PLICALLA, and PLICALLB; these are described later in this chapter.

Use of PLIMAIN to Invoke a PL/I Procedure

|Once IBMBPIR or IBMTPIR (with IBMBPII or IBMTPII) has created the environment, it transfers control to the PL/I procedure whose address is contained in the compiler-generated control section PLIMAIN. Normally, after link editing, PLIMAIN will contain the entry point address of the first, or only, PL/I main procedure in the program. If the assembler-language routine is to invoke a PL/I procedure that is not the first, or only, main PL/I procedure in the program, it must insert in PLIMAIN the address of the entry point of the procedure it is to invoke. The example in Figure 13-1 shows how this is done.

If there is no main procedure in the program, the assembler routine should contain an entry point called PLIMAIN at which is held the address of the entry point of the PL/I routine to be invoked. The example in Figure 13-2 shows how the appropriate address is inserted into the location represented by the entry point PLIMAIN. If the assembler program does not include an entry point called PLIMAIN in these circumstances, a dummy module called PLIMAIN will be included from the OS PL/I Resident Library.

Once the PL/I environment has been established, it can, as shown in the example in Figure 13-3, be preserved, and any PL/I procedure can be invoked subsequently by loading the address of its entry point into register 15, and executing a branch-and-link-register instruction to it.

PLISTART, PLICALLA, AND PLICALLB

PLISTART: PLISTART is used when the PL/I environment must be established for a PL/I procedure that can use for its dynamic storage as much of the available space in storage as it requires, or, alternatively, as much as is specified. This entry point is normally used when the PL/I procedure is invoked directly from the operating system. It enables an assembler routine to pass to

```
         LA     1,ARGLIST
         L      2,=V(PLIMAIN)   CHANGE ADDRESS IN PLIMAIN
         L      3,=V(MYPROG)    TO THAT OF
         ST     3,0(2)          MYPROG
         L      15,=V(PLICALLA)
         BALR   14,15
         .
         .
         .
ARGLIST  DC     A(arg1)        FIRST ARGUMENT PASSED TO MYPROG
         DC     X'80'
         DC     AL3(arg2)        LAST ARGUMENT PASSED TO MYPROG
```

Figure 13-1. Inserting a PL/I entry point address in PLIMAIN

```
          ENTRY PLIMAIN
         LA     1,ARGLIST
         L      2,=A(PLIMAIN)   INSERT ADDRESS IN PLIMAIN
         L      3,=V(MYPROG)    OF ENTRY TO
         ST     3,0(2)          MYPROG
         L      15,=V(PLICALLA)
         BALR   14,15
         .
         .
         .
ARGLIST  DC     A(arg1)        FIRST ARGUMENT PASSED TO MYPROG
         DC     X'80'
         DC     AL3(arg2)      LAST ARGUMENT PASSED TO MYPROG
PLIMAIN  DS     F
```

Figure 13-2. Establishing PLIMAIN as an entry in the assembler-language routine

a PL/I procedure a parameter field identical to that which can be specified in the PARM field of a JCL EXEC statement.

PLICALLA: PLICALLA is used when the PL/I environment must be established for a PL/I procedure that can use for its dynamic storage as much of the available space in storage as it requires.

PLICALLB: PLICALLB is used when the PL/I environment must be established for a PL/I procedure that can use for its dynamic storage only a specified amount of the available storage. PLICALLB can optionally specify where that storage is to begin.

Further details and examples using PLISTART, PLICALLA, and PLICALLB are given later in this chapter.

THE DYNAMIC STORAGE AREA (DSA) AND SAVE AREA

Whenever a PL/I procedure is invoked, it requires for its own use a block of storage known as a dynamic storage area (DSA). A DSA for a PL/I procedure consists of a save area for the contents of registers, a backchain address that points to the save area for the previous routine, and storage for automatic variables and miscellaneous housekeeping items.

An assembler routine invoked from PL/I should take the following action to preserve the PL/I environment:

- If the assembler routine is to use the PL/I error-handler, it must store the contents of all registers in the existing PL/I DSA and establish its own save area in which the backchain address of the PL/I DSA must be stored. The first two bytes of the save area must be set to zero. The second word of the save area is the backchain address. The remainder of the save area would only be used by a routine invoked from the assembler routine or by the PL/I error-handler, if used, for saving the assembler routine's registers.
- If the assembler routine is not to use the PL/I error-handler and does not invoke a further function routine, the SPIE macro must be used to reset the

```
//OPT13#3  JOB
//STEP1 EXEC HASMHC,PARM.ASM='LOAD,NODECK'
//ASM.SYSLIN DD DSN=&&LOADSET,UNIT=2314,DISP=(NEW,PASS),
//          SPACE=(80,(200,100)),DCB=BLKSIZE=80
//ASM.SYSIN DD *
MYPROG   CSECT
         ENTRY ASSEM
         STM   14,12,12(13)             ESTABLISH SUPERVISOR REGISTERS
         BALR  10,0                     ESTABLISH ADDRESSABILITY
         USING *,10
         LA    4,SAVEAREA               CURRENT SAVE AREA ADDRESS
         ST    13,4(4)                  STORE CHAINBACK ADDRESS
         ST    4,8(13)                  STORE CHAIN FORWARD ADDRESS
         LR    13,4                     STORE CURRENT SAVE AREA ADDRESS
*
         SR    1,1                      SET REGISTER 1 TO ZERO WHEN
*                                       A PARAMETERLESS ENTRY POINT TO
*                                       PROCEDURE THAT DOES NOT RETURN
*                                       A VALUE IS TO BE INVOKED
*
         L     15,=V(PLICALLA)          CALL THE PL/I PROCEDURE THAT
         BALR  14,15                    HAS OPTIONS(MAIN) AND SO SET
*                                       UP THE PL/I ENVIRONMENT AND
*                                       THEN CALL ASSEM.
*
         L     13,4(13)                 ON RETURNING FROM PL/I
         L     14,12(13)                RESTORE REGISTERS
         LM    1,12,24(13)              AND
         BR    14                       RETURN TO THE SUPERVISOR.
*
         DC    C'ASSEM'                 THE NAME IN PL/I FORMAT
         DC    AL1(5)
ASSEM    EQU   *
         STM   14,12,12(13)              STORE PL/I REGISTERS
         BALR  10,0                     FOR PROCEDURE "MAIN"
         USING *,10                     ESTABLISH ADDRESSABILITY
*                                       GET STORAGE FOR A NEW DSA
         LA    0,104                    LENGTH REQUIRED 104 BYTES
         L     1,76(13)                 ADDRESS OF START OF CURRENTLY-
         ALR   0,1                      AVAILABLE STORAGE
         CL    0,12(12)                 IS THERE ENOUGH SPACE LEFT?
         BNH   ENOUGH                   YES
         L     15,116(12)               LOAD ADDR. OF OVERFLOW ROUTINE
         BALR  14,15                    AND BRANCH TO IT.
ENOUGH   EQU   *
         ST    0,76(1)                  STORE ADDRESS OF START OF
*                                       REMAINING AVAILABLE STORAGE
*                                       IN NEW DSA AT OFFSET 76
         ST    13,4(1)                  SET BACK CHAIN
         ST    1,8(13)                  SET FORWARD CHAIN
         MVC   72(4,1),72(13)           COPY ADDRESS OF WORKSPACE FOR
*                                       USE BY THE PL/I LIBRARY
         LR    13,1                     POINT 13 AT NEW DSA
         MVI   0(13),X'80'              SET FLAGS IN THE DSA TO
         MVI   1(13),X'00'              PRESERVE PL/I
         MVI   86(13),X'91'             ERROR-HANDLING
         MVI   87(13),X'C0'             IN THE ASSEMBLER ROUTINE
*
         SR    5,5                      R5 MUST BE ZERO WHEN CALLING
*                                       AN EXTERNAL PL/I PROCEDURE.
*
         SR    1,1                      SET REGISTER 1 TO ZERO WHEN
*                                       A PARAMETERLESS ENTRY POINT TO
*                                       PROCEDURE THAT DOES NOT RETURN
*                                       A VALUE IS TO BE INVOKED
```

Figure 13-3. (Part 1 of 2). Invoking PL/I procedures from an assembler routine

```
*
         L     15,=V(HEAD)                  CALL PL/I TO 'HEAD' PAGE
         BALR  14,15
*
LOOP     EQU   *
         LA    1,ARGTLST1
         L     15,=V(PLIN)                  CALL PL/I TO READ AND ADD
         BALR  14,15
*
         L     3,RESULT
         LTR   3,3                          TEST RESULT AND
         BM    OUTLOOP                      BRANCH OUT IF IT IS NEGATIVE.
*
         LA    1,ARGTLST2
         L     15,=V(PLOUT)                 CALL PL/I TO OUTPUT RESULT
         BALR  14,15
         B     LOOP
*
OUTLOOP  EQU   *
         SR    1,1                          SET REGISTER 1 TO ZERO
         L     15,=V(FOOT)                  CALL PL/I TO 'FOOT' PAGE
         BALR  14,15
*
         L     13,4(13)                     RETURN TO THE PL/I PROC WITH
         LM    14,12,12(13)                 OPTIONS(MAIN).
         BR    14
*
ARGTLST1 DC    A(DATA)
ARGTLST2 DC    X'80'
         DC    AL3(RESULT)
DATA     DC    F'123'
RESULT   DC    F'0'
SAVEAREA DC    18F'0'
         END   MYPROG
/*
//STEP2 EXEC PLIXCLG
|//PLI.SYSIN DD *
* PROCESS;
| MAIN:  PROC OPTIONS(MAIN);
         DCL ASSEM ENTRY;
         CALL ASSEM;
         END;
* PROCESS;
  PLIN:  PROC(I) RETURNS(FIXED BIN(31));
         DCL (I,J) FIXED BIN(31);
         GET LIST(J);
         RETURN(I+J);
  HEAD:  ENTRY;
         PUT LIST('THE FIRST LINE OF OUTPUT AT THE TOP OF THE PAGE')
               PAGE;
         PUT SKIP(2);
         END;
* PROCESS;
  PLOUT: PROC(K);
         DCL K FIXED BIN(31);
         PUT LIST(K);
         RETURN;
  FOOT:  ENTRY;
         PUT LIST('END OF THE OUTPUT FOR THIS JOB') SKIP(2);
         END;
/*
//GO.SYSIN DD *
 50  77  123  234  345  456  -23  -100  -123  -234
/*
```

Figure 13-3. (Part 2 of 2). Invoking PL/I procedures from an assembler routine

```
         STM    14,11,12(13)      STORE PL/I REGISTERS IN PL/I DSA
         BALR   10,0              ESTABLISH BASE REGISTER
         USING  *,10
         LA     4,SAVEAREA
         ST     13,SAVEAREA+4     STORE PL/I DSA ADDRESS IN SAVE AREA
         LA     13,SAVEAREA        LOAD SAVE AREA ADDRESS
         .
         .                        ASSEMBLER
         .                        ROUTINE
         .
         L      13,4(13)          RESTORE PL/I REGISTERS
         LM     14,11,12(13)      AND
         BR     14                RETURN TO PL/I
SAVEAREA DC     20F'0'            ALLOCATE 80 BYTE SAVE AREA
```

Figure 13-4. Invoking a non-recursive and non-reentrant assembler routine

interrupt handler but only those registers that it modifies must be stored. The SPIE macro is discussed later in this chapter.

The amount of storage allocated for a save area or DSA must be a multiple of eight bytes. The address of the next available block of storage following the save area or DSA must be stored at offset 76 of that save area or DSA. This address is obtained by adding the address of the save area of DSA to its length.

Calling Assembler Routines from PL/I

INVOKING A NON-RECURSIVE AND NON-REENTRANT ASSEMBLER ROUTINE

When a PL/I program invokes a non-recursive and non-reentrant assembler-language routine, the assembler-language routine must follow System/360 linkage conventions and save the registers for use by PL/I on return from the assembler-language routine. The register values are stored in the PL/I DSA, the address of which is contained in register 13 on entry to the assembler-language routine. This address must then be stored in the backchain word in a save area defined by the assembler routine itself. The appropriate assembler instructions should be executed immediately the assembler routine is invoked in order to achieve the given objectives. Before returning to the PL/I routine, the assembler routine must restore the registers to the values held when the PL/I routine invoked the assembler routine. The example in Figure 13-4 assumes that the assembler routine uses register 10 as its base register.

INVOKING A RECURSIVE OR REENTRANT ASSEMBLER ROUTINE

A recursive or reentrant assembler routine invoked from PL/I can use the PL/I storage overflow routine to attempt to obtain further storage when the storage initially available for dynamic use by the program is used up.

A DSA established by the assembler routine must have its first two bytes set to X'00' if it is to handle any program interrupts. Such a DSA must be at least 80 bytes in length to accommodate both the save area and two fullwords required by PL/I for its housekeeping. If the PL/I error-handler is to service any program interrupts in the assembler-language routine, the DSA should be at least 88 bytes in length. The first byte of the DSA should be set to X'80', the second byte set to X'00', and bytes 87 and 88 (the PL/I error-handler enable cells) set to X'91C0'. In addition, a DSA can be as long as is needed to store any values that are to be preserved for use by a particular invocation. Note that a DSA obtained in this way must be a multiple of 8 bytes in length.

Termination of a recursive or reentrant assembler-language routine will release its DSA and cause control to be returned to the invoking routine.

The example in Figure 13-5 shows how to create and release a DSA in a recursive or reentrant assembler routine.

USE OF REGISTER 12

If an assembler routine that modifies register 12 is to be invoked by a PL/I

```
         STM    14,11,12(13)  STORE CALLER'S REGISTERS IN CALLER'S DSA
         BALR   10,0          ESTABLISH BASE REGISTER
         USING  *,10
         LR     4,1           SAVE ANY PARAMETER LIST ADDRESS
*                             PASSED FROM CALLING ROUTINE
         LA     0,96          PUT THE LENGTH OF THE REQUIRED DSA IN REG 0
         L      1,76(13)      LOAD THE ADDRESS OF THE NEXT AVAILABLE
*                             BYTE OF STORAGE AFTER THE CURRENT DSA
         ALR    0,1           ADD ADDRESSES
         CL     0,12(12)      COMPARE RESULT WITH ADDRESS OF LAST AVAILABLE
*                             BYTE IN STORAGE THAT CAN BE USED
         BNH    ENOUGH
         L      15,116(12)    LOAD AND BRANCH TO THE PL/I STORAGE OVERFLOW
         BALR   14,15         ROUTINE TO ATTEMPT TO OBTAIN MORE STORAGE
ENOUGH   EQU    *
         ST     0,76(1)       STORE THE ADDRESS OF THE NEXT AVAILABLE
*                             BYTE IN STORAGE AFTER THE NEW DSA
         ST     13,4(1)       STORE THE CHAIN-BACK ADDRESS OF THE PREVIOUS
*                             DSA IN THE CURRENT DSA
         MVC    72(4,1),72(13) COPY ADDRESS OF LIBRARY
*                             WORKSPACE
         LR     13,1          STORE THE ADDRESS OF THE NEW DSA IN REGISTER 13
         MVI    0(13),X'80'   SET FLAGS IN DSA TO
|        MVI    1(13),X'00'   PRESERVE PL/I
|        MVI    86(13),X'91'  ERROR-HANDLING
         MVI    87(13),X'C0'  IN THE ASSEMBLER ROUTINE
         -
         -                    ASSEMBLER
         -                    ROUTINE
         -
         L      13,4(13)      RELEASE CURRENT DSA
         LM     14,11,12(13)  RESTORE CALLER'S REGISTERS
         BR     14
```

Figure 13-5. Invoking a recursive or reentrant assembler routine

procedure, any program-check interrupts will result in an unpredictable program failure unless the routine establishes its own error handling for program-check interrupts. Consequently, the routine should be amended to use a register other than register 12 so that the PL/I error-handler can be used, or it can issue a supervisor SPIE or STAE macro to establish its own program interrupt or abnormal termination handling facilities. The routine must subsequently restore PL/I error-handling facilities before returning to PL/I. This is discussed further in "Overriding and Restoring PL/I Error-handling in an Assembler-language Routine" later in this chapter. (A routine that changes the content of register 12 should also store it on entry and restore it on return.)

Calling PL/I Procedures from Assembler Language

The simplest way to invoke a single external PL/I procedure from an assembler-language routine is to give the PL/I procedure the MAIN option and invcke it using entry point PLICALLA. All that is required is to load the address of PLICALLA into register 15 and then to branch and link to it. When PLICALLA is used in this way, the PL/I environment is created and control is then passed by way of PLIMAIN to the first (or only) main PL/I procedure in the program. Use of this technique will cause the PL/I environment tc be established separately for each invocation.

ESTABLISHING THE PL/I ENVIRONMENT FOR MULTIPLE INVOCATIONS

If the assembler routine is to invoke either a number of PL/I routines or the same PL/I routine repeatedly, the creation of the PL/I environment for each invocation will be unnecessarily inefficient. The solution is to create the PL/I environment once only for use by all invocations of PL/I procedures. This can be achieved by invoking a main PL/I procedure which immediately reinvokes the assembler routine. The assembler routine must preserve the PL/I environment and is then able to invoke any number of PL/I procedures directly. The example in figure 13-3 contains an assembler-language routine that establishes the PL/I environment once only for multiple invocations of PL/I procedures.

In this example, the assembler routine MYPROG receives control initially from the supervisor, and invokes the PL/I main procedure MAIN using the entry point PLICALLA to the PL/I initialization routine. The PL/I procedure MAIN immediately reinvokes the same assembler routine at the entry point ASSEM. Note that, in this example, this name must be an odd number of characters to ensure that the next instruction is halfword aligned. At this entry point, the PL/I environment is stored, and a new DSA, 104 bytes in length, is created in a manner similar to that previously given for creating a DSA in a recursive or reentrant assembler-language routine. If there is insufficient room for the new DSA, the PL/I overflow routine is invoked to attempt to obtain storage for the DSA elsewhere in storage.

The instructions in the assembler routine following the label ENOUGH through to the instruction that loads the address of the PL/I entry point HEAD are concerned with setting up the DSA so that the correct environment exists when the routine invokes the external PL/I procedures PLIN and PLOUT and the secondary entry points within them. These instructions should always be present in order to preserve the PL/I environment set up by the main procedure for subsequent use by any assembler-invoked PL/I procedures.

Note that when an external PL/I procedure is invoked, register 5 must be set to zero, and that a PL/I procedure, such as PLIN in this example, that returns a value will assign the value to the last address in the argument list, ARGTLST1. This address is the address of the assembler-defined storage for RESULT. The constant X'80' in the first byte of the fullword containing the address of RESULTS in ARGTLST1 indicates that it is the last fullword in the argument list.

If an assembler-language routine invokes a PL/I procedure without passing any parameters to it and without expecting any value to be returned from it, register 1 must be set to zero. In this example, the procedure PLIN contains a RETURN (expression) statement, but when invoked through the parameterless entry point HEAD, does not return a value to the invoking routine. Similarly, the procedure PLOUT contains the parameterless entry point FOOT and does not return a value.

ESTABLISHING THE PL/I ENVIRONMENT SEPARATELY FOR EACH INVOCATION

If it is necessary to reestablish the PL/I environment each time a PL/I procedure is invoked, use the entry point PLISTART, PLICALLA, or PLICALLB to invoke the PL/I initialization routines. The three entry points are used as follows:

For PLISTART, the assembler language routine must insert in register 1 the address of a fullword which in turn contains the address of a halfword prefix to a character string. The character string, which must start on a fullword boundary, can contain a parameter string similar to that which can be specified in the PARM field of a JCL EXEC statement; for example, 'ISASIZE(4K),R/INPUT'. The halfword prefix must contain the number of characters in the string. This entry point is useful when a PL/I routine is "attached" by an assembler routine, because the entry point of the PL/I routine does not have to be changed. The use of PLISTART is illustrated in Figures 13-6 and 13-7.

For PLICALLA, the assembler-language routine must insert in register 1 the address of the argument list that contains the addresses of any arguments to be passed to the PL/I procedure.

For PLICALLB, the assembler-language routine must insert in register 1 the address of an argument list that contains the following:

- The address of the argument list containing addresses to be passed to PL/I, and optionally,
- The address of the length of storage to be made available to the program in a non-multitasking program or the major task in a multitasking program. The default for this length is half the available storage for a non-multitasking program or 8K bytes for the major task of a multitasking program. The length of the initial storage area (ISA) passed must be a multiple of eight bytes, so that the ISA both starts and ends on a double-word boundary.
- The start address of the initial storage area (ISA) to be used by the PL/I program. This storage must be aligned on a double word. For further information, refer to the discussion of the ISASIZE option in Chapter 4.

```
         LA      1,PLISTHWD     GET PLIST ADDRESS
         ATTACH  EP=PLIPROG     ATTACH PL/I PROGRAM
*
PLISTHWD DS      0F
         DC      X'80'          FLAG LAST WORD OF PLIST
         DC      AL3(PLISTHW)
PLISTHW  DC      AL2(L'PLISTCH) LENGTH OF PARM STRING
PLISTCH  DC      C'ISASIZE(8K),R/INPUT'    PARM DATA
```

Figure 13-6. Use of PLISTART for ATTACH

```
         LA      1,PLISTHWD           GET PLIST ADDRESS
         L       15,=V(PLISTART)      GET PL/I ENTRY POINT
         BALR    14,15                CALL PL/I ROUTINE
*
*
         DS      0F
PLISTHWD DC      X'80'                FLAG LAST WORD OF PIIST
         DC      AL3(PLISTHW)
PLISTHW  DC      H'0'
PLISTCH  DC      AL2(0)               NULL PARM STRING
```

Figure 13-7. Use of PLISTART passing null parameter string

Option	Value
REPORT	X'80' in first byte
NOREPORT	X'40' in first byte
SPIE	X'20' in first byte
NOSPIE	X'10' in first byte
STAE	X'08' in first byte
NOSTAE	X'04' in first byte
COUNT	X'02' in first byte
NOCOUNT	X'01' in first byte
FLOW	X'80' in second byte
NOFLOW	X'40' in second byte

Figure 13-8. Coding the options word

- The address of the length of storage to be made available to each of the subtasks in a multitasking program. The default for this length is 8K bytes for each subtask. This value is ignored for a non-multitasking program. The length of the ISA must be a multiple of eight bytes.
- The address of the maximum number of concurrent subtasks that can be attached at any one time. This value is ignored in a non-multitasking program. The default for this value is 20.
- The address of the options word, in which the execution-time options for a program compiled by the optimizing

```
         LA      1,ARGLIST
         L       15,=V(PLICALLA)
         BALR    14,15
         .
         .
         .
ARGLIST  DC      A(arg1)          ADDRESS OF FIRST ARGUMENT PASSED TO PL/I
         DC      A(arg2)          ADDRESS OF SECOND ARGUMENT PASSED TO PL/I
         .
         .
         .
         DC      X'80'              END OF ARGUMENT LIST FLAG
         DC      AL3(argn or return-value) ADDRESS OF LAST ARGUMENT
*                                   OR RETURNED VALUE
```

Figure 13-9. Use of PLICALLA

```
         LA     1,ALIST
         L      15,=V(PLICALLB)
         BALR   14,15
         .
         .
         .
ALIST    DC     A(ARGLIST)       ADDRESS OF ARGUMENT LIST
         DC     A(LENGTH)        LENGTH OF STORAGE FOR PL/I
*                                ON DOUBLE WORD BOUNDARY
         DC     A(ISA)           ADDRESS OF ISA
         DC     A(0)             TASK ISA - NOT USED
         DC     A(0)             NUMBER OF CONCURRENT SUBTASKS - NONE
|        DC     X'80'            END OF ARGUMENT LIST FLAG
         DC     AL3(OPTIONS)     OPTIONS WORD
ARGLIST  DC     A(arg1)         ADDRESS OF FIRST ARGUMENT
         DC     A(arg2)         ADDRESS OF SECOND ARGUMENT
         DC     X'80'            END OF ARGUMENT LIST FLAG
         DC     AL3(argn or return-value) ADDRESS OF LAST ARGUMENT
*                                OR RETURNED VALUE
LENGTH   DC     F'8192'          ROUTINE'S STORAGE LIMITED TC 8K BYTES
ISA      DS   1024D              ROUTINES ISA STARTS HERE
OPTIONS  DC   X'84000000'        REPORT AND NOSTAE REQUESTED
```

Figure 13-10. Use of PLICALLB

compiler are specified. These options are: REPORT; STAE; SPIE; COUNT; and FLOW. They are described in Chapter 4. The hexadecimal value for each option is given in Figure 13-8.

Note that the first byte in the last address word in each of these argument lists must contain X'80'. The examples in Figures 13-9 and 13-10 show the use of PLICALLA and PLICALLB to invoke the first (or only) main PL/I procedure in the program. The PL/I programs in these cases do not perform multitasking.

If it is necessary to reestablish the PL/I environment for each invocation of a PL/I procedure that is not the first (or only) main procedure in the program, the user of either entry point PLICALLA or PLICALLB must insert in PLIMAIN the address of the appropriate entry point to the required PL/I procedure. The example in Figure 13-1 sets the address in PLIMAIN to that of the external entry name MYPROG.

If it is necessary to reestablish the PL/I environment for each invocation of a PL/I procedure where there is no main PL/I procedure in the program, the use of either entry point PLICALLA or PLICALLB must be accompanied by the use of an entry point called PLIMAIN in the assembler-language routine. This entry point must contain the address of the PL/I routine to be invoked. Figure 13-2 shows how this is inserted.

PL/I Calling Assembler Calling PL/I

The information given in the preceding sections should be sufficient to write programs that include a PL/I procedure that invokes an assembler-language routine that invokes a further PL/I procedure. Figure 13-3 contains an example of a program that performs this type of processing.

Assembler Calling PL/I Calling Assembler

The information given in the preceding sections should be sufficient to write programs that include an assembler-language routine that invokes a PL/I procedure that in turn invokes an assembler-language routine. Figure 13-3 contains an example of a program that performs this type of processing.

Overriding and Restoring PL/I Error-handling

An assembler-language routine invcked from PL/I can override PL/I error-handling by issuing its own SPIE macro tc handle program interrupts or STAE macro to handle abnormal terminations. If the SPIE macro is issued, the address of the PL/I PICA must be saved. A routine that cancels PL/I error-handling must restore the PL/I error-

```
PROGA    CSECT
         ENTRY ASSEM              ENTRY-POINT INVOKED FROM PL/I
         STM   14,12,12(13)       STORE PL/I ENVIRONMENT
         BALR  10,0               ESTABLISH BASE REGISTER
         USING *,10
         STAE  (operands)         ESTABLISH NEW ABEND HANDLER
         SPIE  (operands)         ESTABLISH INTERRUPT HANDLER
         ST    1,SAVESPIE         STORE OLD PICA ADDRESS
         .
         .
         .
         STAE  0                  RESTORE PL/I ERROR HANDLING
         L     1,SAVESPIE         RESTORE PICA ADDRESS
         SPIE  MF=(E,(1))
         L     13,4(0,13)         RESTORE PL/I ENVIRONMENT
         LM    14,12,12(13)
         BR    14                 RETURN TO PL/I
SAVESPIE DS    A
```

Figure 13-11. Method of overriding and restoring PL/I error-handling

handling facilities before returning to the PL/I program. It does this by issuing either a STAE macro with an operand of zero or an execute form of the SPIE macro restoring the saved PL/I PICA, according to the macros used to cancel the PL/I error-handling. The example in Figure 13-11 shows how these macros are used to cancel and subsequently restore PL/I error-handling.

Arguments and Parameters

Arguments are passed between PL/I and assembler routines by means of lists of addresses known as "parameter lists". Each address in a parameter list occupies a fullword in main storage. The last fullword in the list contains X'80' in its first byte to enable it to be recognized.

Each address in a parameter list is either the address of a data item or the address of a control block that describes a data item. Data items themselves are never placed directly in parameter lists.

RECEIVING ARGUMENTS IN AN ASSEMBLER-LANGUAGE ROUTINE

When an assembler routine is invoked by a PL/I routine by means of a CALL statement or a function reference, the assembler routine will receive the address of a parameter list in register 1. The meaning of the addresses in the parameter list depends upon whether or not the entry point of the assembler routine has been declared with the ASSEMBLER option. These two cases are discussed separately in the following paragraphs. The ASSEMBLER option is fully described in the language reference manual for this compiler.

Assembler Routine Entry Point Declared with the ASSEMBLER Option

The ASSEMBLER option is provided to simplify the passing of arguments from PL/I to assembler routines. It specifies that the parameter list set up by PL/I is to contain the addresses of actual data items, rather than the addresses of control blocks, irrespective of the types of data that are being passed. Thus if, for example, an array is passed from PL/I to an assembler routine, the address in the parameter list is that of the first element of the array.

Note that if a particular data item is not byte-aligned (for example, an unaligned bit string), the address in the parameter list is that of the byte that contains the start of the data item. Also, varying length character and bit strings are preceded in storage by a two-byte field specifying the current length of the string, and it is the address of this prefix that is placed in the parameter list.

An assembler routine whose entry point has been declared with the ASSEMBLER option can be invoked only by means of a CALL statement.

Assembler Routine Entry Point Declared without the ASSEMBLER Option

If the entry point of the assembler routine has not been declared with the ASSEMBLER option, each address in the parameter list is either the address of a data item or the address of a control block, depending on the type of data that is being passed.

For arithmetic element variables, the address in the parameter list is that of the variable itself. For all other problem data types, the address in the parameter list is that of a control block known as a "locator/descriptor". For program control data, the address in the parameter list is that of a control block. The formats of locator/descriptors and of control blocks for program control data are given in the execution logic manual for this compiler.

It is recommended that the use of this type of linkage is avoided wherever possible. Access to locator descriptors is normally only necessary when the full attributes of the the arguments are not known by the assembler routine. The use of function references (which cannot be used with the ASSEMBLER option) can be avoided by passing the receiving field as a parameter to the assembler routine.

PASSING ARGUMENTS FROM AN ASSEMBLER-LANGUAGE ROUTINE

In order to pass one or more arguments to a PL/I routine, an assembler routine must create a parameter list and set its address in register 1. The last fullword in the parameter list must have X'80' in its first byte. If the PL/I routine executes a RETURN(expression) statement, the last address in the parameter list must be that of the field to which PL/I is to assign the returned value.

Each address in the parameter list must be either the address of a data item or the address of a control block that describes a data item, depending upon the type of data that is being passed. For arithmetic element variables, the address in the parameter list must be that of the of the variable itself. For all other problem data types, the address in the parameter list must be that of a locator/descriptor. For program control data, the address in the parameter list must be that of a control block. The formats of locator descriptors and of control blocks for program control data are given in the execution logic manual for this compiler.

In some cases, it is possible to avoid the use of locator/descriptors when passing aggregates or strings by pretending that the data is an arithmetic variable. Suppose, for example, that an assembler routine is required to pass a fixed-length character string of twenty characters to a PL/I routine. The assembler routine can place the address of the character string itself in the parameter list, and the PL/I routine can be written thus:

```
PP:PROC(X);
   DCL X FIXED,
       A CHAR(20) BASED(P);
   P = ADDR(X);
   .
   .
   .
```

Because X is declared to be arithmetic, the address in the parameter list in interpreted as the start of the data that is being passed. This address is assigned to P, and is subsequently used as a locator for the based character string A, which has the attributes of the data that has actually been passed.

This technique will work for all data types except unaligned bit strings. Note that the dummy arithmetic parameter need not have the same length as the data that is actually being passed; it is used simply to enable the the passed address to be identified as the start of the data.

Chapter 14: PL/I Sort

If you intend to use the PL/I sort facilities, the version of OS generated for your installation must include either a copy of the OS type 1 sort/merge program (Program Number 360S-SM-023) or a copy of the OS program product sort/merge program (Program Number 5734 SM1). The PL/I sort facilities make use of either OS sort/merge program to arrange records according to a predetermined sequence.

Note: If any of the data sets used by the sort program are to reside on an IBM 3330 or IBM 3333 device, the OS program product sort/merge program (Program Number 5734 SM1) must be used.

The sort/merge program includes user exit points to enable user-written routines to be entered at particular stages during the sorting operation and which provide access to records that are being sorted. The PL/I sort facilities provide an interface to enable the sort/merge program to be invoked and to call PL/I procedures through two of the user exits, E15 and E35.

This chapter describes the method of invoking sort/merge from PL/I and the use of the user exits E15 and E35. It should be used in conjuction with the relevant OS Sort/Merge publication. The type 1 program is described in OS Sort/Merge; the program product is described in the publications OS Sort/Merge: Programmer's Guide and OS/VS Sort/Merge: Programmer's Guide. These books are referred to collectively throughout the remainder of this chapter as "the sort/merge publication".

Storage Requirements

The minimum storage requirements for the sort program when used in conjunction with a PL/I program compiled by the optimizing compiler is 12000 bytes or 26000 bytes in an MVT environment. Additional storage requirements exist if the sort program handles records that are greater than 400 bytes in length and if it uses direct-access devices for input, output, or intermediate storage. Efficiency is enhanced if additional main storage can be provided. Refer to the sort/merge publication for further information.

ENTRY NAMES

A PL/I program invokes the sort program by means of a CALL statement that names one of four entry points to a PL/I sort interface subroutine provided by the OS PL/I Resident Library. The CALL statement also passes arguments that specify the requirements for the sorting operation. The arguments include a sequence of sort/merge control statements in the form of character-string expressions. The PL/I sort interface subroutine has entry points for four types of processing, shown in Figure 14-1.

Entry Point	Function
PLISRTA	Invokes the sort/merge program to retrieve records from a data set (SORTIN), sort them, and write them in sorted sequence onto another data set (SORTOUT).
PLISRTB	Invokes the sort/merge program and specifies the use of user exit E15. A PL/I procedure invoked at user exit E15 will supply all the records to be sorted. The sorted records are written directly onto the data set SORTOUT.
PLISRTC	Invokes the sort/merge program and specifies the use of user exit E35. The sort/merge program retrieves records from the data set SORTIN. The sorted records are passed to a PL/I procedure invoked at user exit E35. This procedure will handle any output that is required.
PLISRTD	Invokes the sort/merge program and specifies the use of user exit E15 and user exit E35. The use of these user exits is exactly as described for PLISRTB and PLISRTC.

Figure 14-1. Sort/merge program entry points

After completion of the sort, the sort/merge program passes a return code to the invoking program to indicate whether the sort is successful or not. The invoking procedure must include a variable with the attributes FIXED BINARY(31) to receive this return code, and the name of the variable must always be included in the argument list of the CALL statement that invokes sort/merge. The return codes and their meanings, are:

0 Sort successful

16 Sort unsuccessful

PROCEDURES INVOKED BY WAY OF SORT USER EXITS

Both external and internal PL/I procedures can be invoked by way of sort user exits. The use of external PL/I procedures should present no problems so long as their entry names are declared in the main PL/I procedure and they are link edited with the main PL/I procedure to form a single executable program.

All records passed to a PL/I procedure from the sort/merge program, and all records passed to the sort/merge program, must be in the form of character strings. A PL/I procedure invoked by way of user exit E35 must include a character-string parameter; a PL/I procedure invoked from user exit E15 must pass a record to the sort/merge program by means of a RETURN statement with a character-string expression as its argument.

Varying-length character strings can be returned from an E15 exit procedure and sorted as variable-length records.

Varying-length character strings cannot be received as parameters in an E35 exit procedure. However, a variable-length record passed to an E35 exit procedure can be declared as an adjustable-length character string. For example:

```
E35X: PROC (VREC);
      DCL VREC CHAR(*);
      .
      .
      .
```

A sorting operation can also be specified to handle fixed-length records when the PL/I procedure is to pass varying-length character strings to it. In this situation, the strings are converted to fixed-length records of maximum length by having blanks added to them where necessary.

Similarly, fixed-length character strings passed from a PL/I procedure can be converted into variable-length records and sorted.

A PL/I procedure invoked by way of a sort/merge user exit must pass a return code to the sort program to indicate what action should be taken when the PL/I procedure next relinquishes control. This is effected by invoking from within the procedure the PL/I library interface subroutine PLIRETC as follows:

```
CALL PLIRETC(n);
```

where "n" can have one of the following values to specify the action required:

For procedures invoked by means of user exit E15:

8 Do not return to this procedure.

12 Include the record returned from the procedure in the sort.

16 Stop the sort and return immediately to the invoking procedure. (OS program product sort/merge program only.)

For procedures invoked by means of user exit E35:

4 Pass the next sorted record to the E35 procedure.

8 Do not return to this procedure.

16 Stop the sort and return immediately to the invoking procedure. (OS program product sort/merge program only.)

DATA SETS USED BY SORT/MERGE

The execution step for a PL/I program that uses PL/I sort requires job control DD statements for some or all of the following data sets in addition to those required by the PL/I program.

Input Data Sets

If the sort/merge program is to read the records to be sorted from a data set, include a DD statement for the data set, using the ddname SORTIN.

Arg.	Description
arg1	A character string containing the sort/merge SORT statement; this statement must be preceded and followed by a blank character.
arg2	A character string containing the sort/merge RECORD statement; this statement must be preceded and followed by a blank character.
arg3	Amount of main storage for the sort/merge program.
arg4	Name of the variable in the invoking procedure that is to receive the sort return code.
arg5	Entry point name of the PL/I procedure to be invoked from user exit E15.
arg6	Entry point name of the PL/I procedure to be invoked from user exit E35.
arg7	Replacement ddname characters (see the section "Multiple Invocations of Sort/Merge," later in this chapter).
arg8	Diagnostic message listing option (see the section "Sort/Merge Message Listing Options," later in this chapter).
arg9	Sorting technique option (see the section "Sort/Merge Sorting Techniques," later in this chapter).

Figure 14-2. Arguments used when invoking sort/merge

Work Data Sets

The sort/merge program requires at least three magnetic-tape or direct-access data sets for use as intermediate storage; you can increase efficiency by specifying the direct-access data sets on separate direct-access devices. If the volume of records to be sorted demands more intermediate storage, you can specify up to 32 data sets. Provide a DD statement for each work data set, using the ddnames SORTWK01 to SORTWK32.

Output Data Sets

If the sort/merge program is to write the sorted records onto an output data set, include a DD statement for the data set, using the ddname SORTOUT.

Other Data Sets

For the sort program to execute successfully, it must have access to the following data sets:

SORTLIB	The system sort/merge program library.
SYSOUT	For sort/merge program diagnostic messages.

The following data sets are needed if the associated facility is to be used:

SORTCKPT	If the sort/merge program is to make use of the checkpoint/restart facility.
SYSUDUMP	For dumps of main storage if required for debugging the sort program.
PLIDUMP	For dumps of main storage if required for debugging the PL/I program.

Invoking Sort/Merge from PL/I

The sort/merge program is invoked from a PL/I program by one of the CALL statements listed below. The number of arguments required depends on the entry name invoked.

The arguments include sort/merge program control statements that define the processing to be carried out and describe the records to be sorted. (When the sort/merge program is invoked as an independent job step, these control statements are submitted by way of the SYSIN input stream.) The control statements are described in the sort/merge publication. Note that the MERGE statement cannot be used when invoking the sort/merge program through the PL/I sort interface. The general syntax of the CALL statement for each of the four entry points is:

```
MSORT: PROC OPTIONS(MAIN);

        /* INVOKE THE SORT PROGRAM FOR THE FIRST TIME */

        CALL PLISRTA (' SORT FIELDS=(7,74,CH,A) ',
                      ' RECORD TYPE=F,LENGTH=(80) ',
                      100000,
                      RETURN_CODE);
                      .
                      .
                      .
        /* INVOKE THE SORT PROGRAM FOR THE SECOND TIME */

        CALL PLISRTA (' SORT FIELDS=(7,74,CH,A) ',
                      ' RECORD TYPE=F,LENGTH=(80) ',
                      100000,
                      RETURN_CODE,
                      'TASK');
                      .
                      .
                      .
        END MSORT;
```

Figure 14-3. Multiple invocations of sort/merge

```
CALL PLISRTA(arg1,arg2,arg3,arg4,arg7,
             arg8,arg9);

CALL PLISRTB(arg1,arg2,arg3,arg4,arg5,
             arg7,arg8,arg9);

CALL PLISRTC(arg1,arg2,arg3,arg4,arg6,
             arg7,arg8,arg9);

CALL PLISRTD(arg1,arg2,arg3,arg4,arg5,
             arg6,arg7,arg8,arg9);
```

The arguments are described in Figure 14-2.

Arguments arg7, arg8, and arg9 are optional. If an optional argument is not used, it need not be specified unless another argument that follows it in the given order is specified. In this case, the unused argument must be specified as a null string. The following sections describe how to use the optional arguments.

Multiple Invocations of Sort/Merge

For multiple invocations of the sort/merge program from a single job step, the standard ddnames of sort data sets (SORTIN, SORTOUT, SORTWK, and SORTCKPT) can be changed by replacing up to the first four characters of the ddnames with a similar number of different characters. This is achieved by specifying the optional argument arg7 in the CALL statements that invoke the sort/merge program. For the invocations of the sort/merge program using modified ddnames, the optional argument should be a character string that contains the replacement characters. Note that the first character of the replacement string must be alphabetic.

For the invocation using the standard sort/merge data sets, arg7 need not be specified unless arg8 is specified, when arg7 should be specified as a null string.

An example of multiple invocation is given in Figure 14-3.

In this example, the first invocation of the sort/merge program requires DD statements with the following ddnames:

```
//SORTIN DD ...
//SORTOUT DD ...
//SORTWK01 DD ...
.
.
.
```

The second invocation of the sort/merge program requires DD statements with the following ddnames:

```
//TASKIN DD ...
//TASKOUT DD ...
//TASKWK01 DD ...
.
.
.
```

|Sort/Merge Message Listing Options

It is possible to select one of five options for specifying how the sort/merge program diagnostic messages are to be produced. The selected option can be |specified as an optional argument (arg 8) to the entry point used. The optional argument should contain a character string selected from those given in Figure 14-4.

NO	No messages to be printed
AP	All messages to be printed on the printer
AC	All messages to be printed on the system console
CP	Critical messages only to be printed on the printer
CC	Critical messages only to be printed on the system console

Figure 14-4. Sort/merge message listing options

| If no sort/merge listing option is |specified, the diagnostic messages will be |printed in the way specified when the |sort/merge program was generated.

An example of a CALL PLISRTA statement that does not modify the sort/merge ddnames but that does specify a sort/merge program message listing option is given in Figure 14-5.

```
CALL PLISTRA (' SORT FIELDS=(7,74,CH,A) ',
             ' RECORD TYPE=F,LENGTH=(80) ',
             100000,
             RETURN_CODE,
             '',  /* NULL DDNAME ARGUMENT */
             'CP');
```

Figure 14-5. Specifying a sort/merge message listing option

Sort/Merge Sorting Techniques

It is possible to select one of four sorting techniques for use by the sort/merge program. The techniques are described in the sort/merge program publication. The selected technique must be specified in an optional argument (arg 9) to the entry point used. The optional argument should contain one of the character strings BALN, CRCX, OSCL, or POLY according to the technique that is required.

| If no sorting technique option is |specified, the sort/merge program will use |the method that is most efficient for the |particular job. Specifying that a |particular technique is to be used could |therefore cause the sort/merge operation to |be performed less efficiently.

An example of a CALL PLISRTA statement that neither modifies sort/merge ddnames nor specifies a sort/merge message listing option but that does specify a sorting technique is given in Figure 14-6.

```
CALL PLISRTA (' SORT FIELDS=(7,74,CH,A) ',
             ' RECORD TYPE=F,LENGTH=(80) ',
             100000,
             RETURN_CODE,
             '',
         /* NULL DDNAME ARGUMENT */
             '',
         /* NULL LISTING OPTION ARGUMENT /*
             'POLY');
```

Figure 14-6. Specifying a sort/merge sorting technique option

Examples of Using PL/I Sort

SORTING RECORDS DIRECTLY FROM ONE DATA SET TO ANOTHER (PLISRTA)

The example in Figure 14-7 illustrates the use of entry point PLISRTA to retrieve records from an input data set (SORTIN), sort them, and write them directly in sorted sequence onto an output data set (SORTOUT).

The PL/I program contains the following elements:

- A declaration of the variable RETURN CODE to receive the return code from the sort/merge program.
- A CALL statement to invoke the entry point PLISRTA.
- Statements to test the return code.

The example uses the minimum of data sets; one for input, one for output, and three direct-access storage extents on a single disk storage drive.

```
//OPT14#7  JOB
//STEP1 EXEC PLIXCLG,PARM.PLI='SIZE(130K),OBJECT'
//PLI.SYSIN  DD  *
 EX106: PROC OPTIONS(MAIN);

           DCL RETURN_CODE FIXED BIN(31,0);

           CALL PLISRTA (' SORT FIELDS=(7,74,CH,A) ',
                        ' RECORD TYPE=F,LENGTH=(80) ',
                        45000,
                        RETURN_CODE);
           IF RETURN_CODE = 16 THEN PUT SKIP EDIT ('SORT FAILED')(A);
           ELSE IF RETURN_CODE = 0 THEN PUT SKIP EDIT ('SORT COMPLETE')
                                                  (A);
                ELSE PUT SKIP EDIT ('INVALID SORT RETURN CODE')(A);
           END EX106;
/*
//GO.SORTIN DD *
003329HOOKER S.W. RIVERDALE, SATCHWELL LANE, BACONSFIELD
002886BOOKER R.R. ROTORUA, MILKEDGE LANE, TOBLEY
003077ROOKER & SON, LITTLETON NURSERIES, SHOLTSPAR
059334HOOK E.H. 109 ELMTREE ROAD, GANNET PARK, NORTHAMPTON
073872HOME TAVERN, WESTLEIGH
000931FOREST, IVER, BUCKS
/*
//GO.SORTOUT DD SYSOUT=A,DCB=(RECFM=F,BLKSIZE=80)
//GO.SYSOUT DD SYSOUT=A
//GO.SORTLIB DD DSN=SYS1.SORTLIB,DISP=SHR
//GO.SORTWK01 DD UNIT=2314,SPACE=(TRK,20,,CONTIG)
//GO.SORTWK02 DD UNIT=2314,SPACE=(TRK,20,,CONTIG)
//GO.SORTWK03 DD UNIT=2314,SPACE=(TRK,20,,CONTIG)
```

Figure 14-7. Invoking sort/merge via entry point PLISRTA

USING USER EXIT E15 TO PASS RECORDS TO BE SORTED (PLISRTB)

The example in Figure 14-8 illustrates the use of entry point PLISRTB to enable records to be supplied to the sort by a PL/I procedure.

Like that in the previous example, the main procedure invokes the sort/merge program and tests the return code when processing is complete. Note that records to be sorted can be supplied only by the procedure invoked by way of user exit E15 (in this case, procedure E15X).

Each time procedure E15X is invoked by the sort/merge program, E15X reads a record from the input stream and passes it to the sort after the appropriate return code has been passed.

USING USER EXIT E35 TO HANDLE SORTED RECORDS (PLISRTC)

The example in Figure 14-9 illustrates the use of entry point PLISRTC to enable records to be supplied from the sort to the PL/I procedure E35X. As in previous examples, the main procedure invokes the sort/merge program and tests the return code when processing is complete. Each time procedure E35X is invoked by the sort/merge program, it receives a sorted record as a parameter, prints it, and requests the next record from the sort/merge program by passing it the appropriate return code.

PASSING RECORDS TO BE SORTED, AND RECEIVING SORTED RECORDS (PLISRTD)

The example in Figure 14-10 illustrates the use of entry point PLISRTD to enable records to be supplied to the sort from a PL/I procedure and sorted records to be supplied from the sort to a PL/I procedure. As in previous examples, the main procedure invokes the sort/merge program and tests the return code when processing is complete. The use of the E15 user exit is identical to that in Figure 14-8; the use of the E35 user exit is identical to that

```
//OPT14#8  JOB
//STEP1 EXEC PLIXCLG,PARM.PLI='SIZE(130K),OBJECT'
//PLI.SYSIN  DD  *
 EX107:  PROC OPTIONS(MAIN);

     DCL RETURN_CODE FIXED BIN(31,0);

     CALL PLISRTB (' SORT FIELDS=(7,74,CH,A) ',
                   ' RECORD TYPE=F,LENGTH=(80) ',
                    45000,
                    RETURN_CODE,
                    E15X);
     IF RETURN_CODE = 16 THEN PUT SKIP EDIT ('SORT FAILED')(A);
     ELSE IF RETURN_CODE = 0 THEN PUT SKIP EDIT ('SORT COMPLETE')(A);
          ELSE PUT SKIP EDIT ('INVALID SORT RETURN CODE')(A);

 E15X:    /*  THIS PROCEDURE OBTAINS RECORDS FROM THE INPUT STREAM */
          PROC RETURNS(CHAR(80));
               DCL SYSIN FILE RECORD INPUT,
                   INFIELD CHAR(80) INIT(' ');

               ON ENDFILE(SYSIN) BEGIN;
                 PUT SKIP(3) EDIT ('END OF SORT PROGRAM INPUT')(A);
                 CALL PLIRETC(8);  /*  SIGNAL END OF SORT INPUT   */
                 GOTO ENDE15;
                 END;

               READ FILE (SYSIN) INTO (INFIELD);
               CALL PLIRETC(12);  /*  INPUT TO SORT CONTINUES */
  ENDE15:      RETURN (INFIELD);
               END E15X;
     END EX107;
/*
//GO.SYSIN DD *
003329HOOKER S.W. RIVERDALE, SATCHWELL LANE, BACONSFIELD
002886BOOKER R.R. ROTORUA, MILKEDGE LANE, TOBLEY
003077ROOKER & SON, LITTLETON NURSERIES, SHOLTSPAR
059334HOOK E.H. 109 ELMTREE ROAD, GANNET PARK, NORTHAMPTON
073872HOME TAVERN, WESTLEIGH
000931FOREST, IVER, BUCKS
/*
//GO.SORTOUT DD SYSOUT=A,DCB=(RECFM=F,BLKSIZE=80)
//GO.SYSOUT DD SYSOUT=A
//GO.SORTLIB DD DSN=SYS1.SORTLIB,DISP=SHR
//GO.SORTWK01 DD UNIT=2314,SPACE=(TRK,20,,CONTIG)
//GO.SORTWK02 DD UNIT=2314,SPACE=(TRK,20,,CONTIG)
//GO.SORTWK03 DD UNIT=2314,SPACE=(TRK,20,,CONTIG)
```

Figure 14-8. Invoking sort/merge via entry point PLISRTB

in Figure 14-9.

The sequence of events is as follows:

1. The PL/I program invokes the sort/merge program.

2. The sort/merge program invokes the E15 routine for each input record until the return code is set to 8.

3. The sort/merge program invokes the E35 routine for each sorted record until all the sorted records have been passed or until the E35 routine requests no more records.

SORTING VARIABLE-LENGTH RECORDS

The following points should be considered when sorting variable-length records:

- The portion of a variable-length record that contains the control field or fields on which the sort is to be performed must be present and of the same length for every reccrd to be

```
//OPT14#9  JOB
//STEP1 EXEC PLIXCLG,PARM.PLI='SIZE(130K),OBJECT'
//PLI.SYSIN  DD  *
 EX108:  PROC OPTIONS(MAIN);

     DCL RETURN_CODE FIXED BIN(31,0);

     CALL PLISRTC (' SORT FIELDS=(7,74,CH,A) ',
                  ' RECORD TYPE=F,LENGTH=(80) ',
                   45000,
                   RETURN_CODE,
                   E35X);
     IF RETURN_CODE = 16 THEN PUT SKIP EDIT ('SORT FAILED')(A);
     ELSE IF RETURN_CODE = 0 THEN PUT SKIP EDIT ('SORT COMPLETE')(A);
          ELSE PUT SKIP EDIT ('INVALID SORT RETURN CODE')(A);

 E35X:    /* THIS PROCEDURE OBTAINS SORTED RECORDS */
       PROC (INREC);
            DCL INREC CHAR(80);
            PUT SKIP EDIT (INREC) (A);
            CALL PLIRETC(4); /* REQUEST NEXT RECORD FROM SORT */
            END E35X;
     END EX108;
/*
//GO.SYSOUT DD SYSOUT=A
//GO.SORTLIB DD DSN=SYS1.SORTLIB,DISP=SHR
//GO.SORTWK01 DD UNIT=2314,SPACE=(TRK,20,,CONTIG)
//GO.SORTWK02 DD UNIT=2314,SPACE=(TRK,20,,CONTIG)
//GO.SORTWK03 DD UNIT=2314,SPACE=(TRK,20,,CONTIG)
//GO.SORTIN DD *
003329HOOKER S.W. RIVERDALE, SATCHWELL LANE, BACONSFIELD
002996BOOKER S.W. ROTORUA, MILKEDGE LANE, TOBLEY
003077ROOKER & SON, LITTLETON NURSERIES, SHOLTSPAR
059334HOOK E.H. 109 ELMTREE ROAD, GANNET PARK, NORTHAMPTON
073872HOME TAVERN, WESTLEIGH
000931FOREST, IVER, BUCKS
/*
```

Figure 14-9. Invoking sort/merge via entry point PLISRTC

```
//OPT14#10  JOB
//STEP1 EXEC PLIXCLG,PARM.PLI='SIZE(130K),OBJECT'
//PLI.SYSIN  DD  *
 EX109:   PROC OPTIONS(MAIN);

      DCL RETURN_CODE FIXED BIN(31,0);

      CALL PLISRTD (' SORT FIELDS=(7,74,CH,A) ',
                    ' RECORD TYPE=F,LENGTH=(80) ',
                     45000,
                     RETURN_CODE,
                     E15X,
                     E35X);
      IF RETURN_CODE = 16 THEN PUT SKIP EDIT ('SORT FAILED')(A);
      ELSE IF RETURN_CODE = 0 THEN PUT SKIP EDIT ('SORT COMPLETE')(A);
           ELSE PUT SKIP EDIT ('INVALID SORT RETURN CODE')(A);

 E15X:    /*  THIS PROCEDURE OBTAINS RECORDS FROM THE INPUT STREAM */
        PROC RETURNS(CHAR(80));

             DCL INFIELD CHAR(80) INIT(' ');

             ON ENDFILE(SYSIN) BEGIN;
                 PUT SKIP(3) EDIT ('END OF SORT PROGRAM INPUT.  ',
                     'SORTED OUTPUT SHOULD FOLLOW')(A);
                 CALL PLIRETC(8);  /*  SIGNAL END OF SORT INPUT  */
                 GOTO ENDE15;
                 END;

             GET FILE (SYSIN) EDIT (INFIELD) (A(80));
             PUT SKIP EDIT (INFIELD)(A);
             CALL PLIRETC(12);  /*  INPUT TO SORT CONTINUES */
 ENDE15:     RETURN (INFIELD);
             END E15X;


 E35X:    /* THIS PROCEDURE OBTAINS SORTED RECORDS */
        PROC (INREC);

             DCL INREC CHAR(80);
             PUT SKIP EDIT (INREC)  (A);
 NEXT:       CALL PLIRETC(4); /* REQUEST NEXT RECORD FROM SORT */
             END E35X;
        END EX109;
/*
//GO.SYSOUT DD SYSOUT=A
//GO.SORTLIB DD DSN=SYS1.SORTLIB,DISP=SHR
//GO.SORTWK01 DD UNIT=2314,SPACE=(TRK,20,,CONTIG)
//GO.SORTWK02 DD UNIT=2314,SPACE=(TRK,20,,CONTIG)
//GO.SORTWK03 DD UNIT=2314,SPACE=(TRK,20,,CONTIG)
//GO.SYSIN DD *
003329HOOKER S.W. RIVERDALE, SATCHWELL LANE, BACONSFIELD
002996BOOKER S.W. ROTORUA, MILKEDGE LANE, TOBLEY
003077ROOKER & SON, LITTLETON NURSERIES, SHOLTSPAR
059334HOOK E.H. 109 ELMTREE ROAD, GANNET PARK, NORTHAMPTON
073872HOME TAVERN, WESTLEIGH
000931FOREST, IVER, BUCKS
/*
```

Figure 14-10. Invoking sort/merge via entry point PLISRTD

```
//OPT14#11 JOB
//STEP1 EXEC PLIXCLG,PARM.PLI='SIZE(130K),OBJECT'
//PLI.SYSIN  DD  *
  /* PL/I EXAMPLE USING PLISRTB TO SORT VARIABLE-LENGTH RECORDS */
  EX1306:  PROC OPTIONS(MAIN);
          DCL RETURN_CODE FIXED BIN(31,0);
          CALL PLISRTB (' SORT FIELDS=(11,14,CH,A),WORK=4 ',
                        ' RECORD TYPE=V,LENGTH=(84,,,24,44) ',
                        45000
                        RETURN_CODE,
                        E15X);
          IF RETURN_CODE = 0 THEN PUT SKIP EDIT ('SORT COMPLETE')(A);
          ELSE IF RETURN_CODE=16 THEN PUT SKIP EDIT('SORT FAILED')(A);
               ELSE PUT SKIP EDIT ('INVALID RETURN CODE')(A);
  E15X:  PROC RETURNS (CHAR(80) VARYING);
          DCL STRING CHAR(80) VAR;
          ON ENDFILE(SYSIN) BEGIN;
               PUT SKIP EDIT ('END OF INPUT')(A);
               CALL PLIRETC(8);
               GOTO ENDE15;
               END;
          GET EDIT(STRING)(A(80));
          I=INDEX(STRING||'  ','  ')-1;  /* RESET THE LENGTH OF THE   */
          STRING = SUBSTR(STRING,1,I);   /* STRING FROM 80 TO LENGTH */
                                         /* OF THE TEXT IN EACH INPUT*/
                                         /* RECORD                   */
          PUT SKIP EDIT(I,STRING) (F(2),X(3),A);
          CALL PLIRETC(12);
          RETURN(STRING);
  END15: END E15X;
          END EX1036;
/*
//GO.SYSIN DD *
003329HOOKER S.W. RIVERDALE, SATCHWELL LANE, BACONSFIELD
002886BOOKER R.R. ROTORUA, MILKEDGE LANE, TOBLEY
003077ROOKER & SON, LITTLETON NURSERIES, SHOLTSPAR
059334HOOK E.H. 109 ELMTREE ROAD, GANNET PARK, NORTHAMPTON
073872HOME TAVERN, WESTLEIGH
000931FOREST, IVER, BUCKS
/*
//GO.SORTOUT DD SYSOUT=A,DCB=(RECFM=V,BLKSIZE=88)
//GO.SYSOUT DD SYSOUT=A
//GO.SORTLIB DD DSN=SYS1.SORTLIB,DISP=SHR
//GO.SORTWK01 DD UNIT=2314,SPACE=(TRK,20,,CONTIG)
//GO.SORTWK02 DD UNIT=2314,SPACE=(TRK,20,,CONTIG)
//GO.SORTWK03 DD UNIT=2314,SPACE=(TRK,20,,CONTIG)
```

Figure 14-11. Sorting variable-length records

sorted. A sort cannot be performed on control fields whose length or position within the record is liable to alter. Thus the control fields would be expected within the minimum length given for the records in the record statement.

- The length of each record is recorded in the first four bytes of the record. Provision for this length field should be made when you specify the sort control fields in the SORT control statement.
- Varying-length strings passed from an E15 procedure will have the PL/I length field converted into a length-field for variable-length records. The length will be the current length of the character string plus four bytes for the length field. A fixed-length string will have the length field added to form a variable-length record. Consequently, fixed-length strings of different lengths can be returned from the same procedure.
- An E35 procedure can only use adjustable strings to receive variable-length records from the sort program.

The example in Figure 14-11 shows a

program to read fixed-length (80-byte) records from SYSIN, convert them to varying-length strings, sort them, and print them. The maximum length of each variable-length record after conversion from a string is 84 bytes including the four-byte control field. The maximum block size for these records in the SORTOUT data set is 88 bytes. The sort field starts on byte 7 of the string. Consequently, it is defined as starting on byte 11 of the record to allow for the four-byte control field.

Chapter 15: Checkpoint/Restart

The PL/I Checkpoint/Restart feature provides a convenient method of taking checkpoints during the execution of a long-running program in a batch environment. It cannot be used in a TSO environment.

At points specified in the program, information about the current status of the program is written as a record on a data set. If the program terminates due to a system failure, this information can be used to restart the program close to the point where the failure occurred, avoiding the need to rerun the program completely.

This restart can be either automatic or deferred. An automatic restart is one that takes place immediately (provided the operator authorizes it when requested by a system message). A deferred restart is one that is performed later as a new job.

You can request an automatic restart from within your program without a system failure having occurred.

PL/I Checkpoint/Restart uses the Advanced Checkpoint/Restart Facility of the operating system. This is fully described in the publication Advanced Checkpoint/Restart.

To use checkpoint/restart you must do the following:

- Request, at suitable points in your program, that a checkpoint record is written. This is done with the built-in subroutine PLICKPT.
- Provide a data set on which the checkpoint record can be written.
- Also, to ensure the desired restart activity, you may need to specify the RD parameter in the EXEC or JOB statement (see the publication JCL Reference).

Note: You should be aware of the restrictions affecting data sets used by your program. These are detailed in the publication Advanced Checkpoint/Restart.

Writing a Checkpoint Record

Each time you want a checkpoint record to be written, you must invoke, from your PL/I program, the built-in subroutine PLICKPT.

The CALL statement has the form:

```
CALL PLICKPT[(ddname[,check-
     id[,org[,code]]]])];
```

The four arguments are all optional. If an argument is not used, it need not be specified unless another argument that follows it in the given order is specified. In this case, the unused argument must be specified as a null string. The following paragraphs describe the arguments.

"ddname" is a character string constant or variable specifying the name of the DD statement defining the data set that is to be used for checkpoint records. If this argument is omitted, the system will use the default ddname SYSCHK.

"check-id" is a character string constant or variable specifying the name that you want to assign to the checkpoint record so that you can identify it later, if required. If this argument is omitted, the system will supply a unique identification and print it at the operator's console.

"org" is a character string constant or variable with the attributes CHARACTER(2) whose value indicates, in operating system terms, the organization of the checkpoint data set. PS indicates sequential (that is, CONSECUTIVE) organization; PO represents partitioned organization. If this argument is omitted, PS is assumed.

"code" is a variable with the attributes FIXED BINARY (31), which can receive a return code from PLICKPT. The return code has the following values:

0 A checkpoint has been successfully taken.

4 A restart has been successfully made.

8 A checkpoint has not been taken. The PLICKPT statement should be checked.

12 A checkpoint has not been taken. Check for a missing DD statement, a hardware error, or insufficient space in the data set. A checkpoint will fail if taken while a DISPLAY statement with the REPLY option is still incomplete or if the program is using multitasking.

16 A checkpoint has been taken, but ENQ macro calls are outstanding and will not be restored on restart. This

situation will not normally arise for a PL/I program.

Checkpoint Data Set

A DD statement defining the data set on which the checkpoint records are to be placed, must be included in the job control procedure. This data set can have either CONSECUTIVE or partitioned organization. Any valid ddname can be used. If you use the ddname SYSCHK, you do not need to specify the ddname when invoking PLICKPT.

A data set name need be specified only if you want to keep the data set for a deferred restart. The I/O device can be any magnetic-tape or direct-access device.

If you want to obtain only the last checkpoint record, then specify status as NEW (or OLD if the data set already exists). This will cause each checkpoint record to overwrite the previous one.

If you want to retain more than one checkpoint record, specify status as MOD. This will cause each checkpoint record to be added after the previous one.

If the checkpoint data set is a library, then "check-id" is used as the member-name. Thus a checkpoint will delete any previously-taken checkpoint with the same name.

For direct access storage, enough primary space should be allocated to store as many checkpoint records as you will retain. You can specify an incremental space allocation, but it will not be used. A checkpoint record is approximately 5000 bytes longer than the area of main storage allocated to the step.

No DCB information is required, but you can include any of the following, where applicable:

OPTCD=W, OPTCD=C, RECFM=UT, NCP=2, TRTCH=C

These subparameters are described in Appendix A.

Performing a Restart

A restart can be automatic or deferred. Automatic restarts can be made after a system failure or from within the program itself. All automatic restarts need to be authorized by the operator when requested by the system.

AUTOMATIC RESTART AFTER A SYSTEM FAILURE

If a system failure occurs after a checkpoint has been taken, the automatic restart will occur at the last checkpoint if you have specified RD=R (or omitted the RD parameter) in the EXEC or JOB statement.

If a system failure occurs before any checkpoint has been taken, then an automatic restart, from the beginning of the job step, can still occur if you have specified RD=R in the EXEC or JOB statement.

If a system failure occurs after a checkpoint has been taken, then you can still force automatic restart from the beginning of the job step by specifying RD=RNC in the EXEC or JOB statement.

AUTOMATIC RESTART FROM WITHIN THE PROGRAM

An automatic restart can be requested at any point in your program. The rules applying to the restart are the same as for a restart after a system failure. To request the restart, you must execute the statement:

```
CALL PLIREST;
```

To effect the restart, the compiler terminates the program abnormally, with a system completion code of 4092. Therefore, to use this facility, the system completion code 4092 must not have been deleted from the table of eligible codes at system generation.

DEFERRED RESTART

To ensure that automatic restart activity is canceled, but that the checkpoints are still available for a deferred restart, specify RD=NR in the EXEC or JOB statement when the program is first executed.

If a deferred restart is subsequently required, the program must be submitted as a new job, with the RESTART parameter in the JOB statement. The RESTART parameter specifies the job step at which the restart is to be made and, if you want to restart at a checkpoint, the name of the checkpoint record. The RESTART parameter has the form:

```
RESTART=(stepname[,check-id])
```

For a restart from a checkpoint, you must also provide, immediately before the EXEC statement for the job step, a DD statement, with the name SYSCHK, defining the data set containing the checkpoint record.

MODIFYING CHECKPOINT/RESTART ACTIVITY

You can cancel automatic restart activity from any checkpoints taken in your program by executing the statement:

```
CALL PLICANC;
```

However, if you have specified RD=R or RD=RNC in the JOB or EXEC statement, automatic restart can still take place from the beginning of the job step.

Also, any checkpoints already taken will still be available for a deferred restart.

You can cancel any automatic restart, and also the taking of checkpoints, even if requested in your program, by specifying RD=NC in the JOB or EXEC statement.

Appendix A: DCB Subparameters

This appendix shows you how to code data set information in the DCB parameter of the DD statement and how to make use of existing DCB information. It also contains an alphabetic list of the subparameters that apply to a PL/I program. These subparameters are specified in the DCB parameter of the DD statement. Chapter 3 shows you how to write a DD statement and chapter 6 shows you how to use the name (ddname) of the DD statement. For a full description of the DD statement see the job control language publications.

DCB Parameter

The DCB parameter enables you to add information about your data set to the data control block (DCB) generated when the associated file in your PL/I program is opened. The information to be added is defined in one or more <u>subparameters</u>. These subparameters correspond to the operands of the DCB macro instruction and are specified in the same way. For a full description of macro instructions see the supervisor and data management macro instructions publication.

Code the DCB parameter as follows:

```
DCB=subparameter
```

or

```
DCB=(subparameter,subparameter)
```

For example:

```
DCB=BLKSIZE=80

DCB=(RECFM=FB,LRECL=80)
```

Using Existing DCB Information

You can use the DCB parameter to make use of DCB information that already exists either in the label of a similar data set, or that has been specified in the DCB parameter of an earlier DD statement.

INFORMATION IN SIMILAR DATA SETS

You can copy DCB information from the label of a similar data set by coding:

```
DCB=dsname
```

where "dsname" is the name of the data set containing the information you want to copy. This data set must be cataloged, it must be on a direct-access storage device, and the volume containing it must be mounted before execution of the job step.

INFORMATION IN AN EARLIER DATA SET

You can also copy the DCB information from an earlier DD statement in a job by coding:

```
DCB=*.stepname.ddname
```

where the asterisk tells the operating system that this is to be a backward reference, "stepname" is the name of the job step in which the earlier DD statement appears, and "ddname" is the name of the earlier DD statement. If the earlier DD statement is in a cataloged procedure you must include the procedure step name as well as the job step name, for example by coding:

```
DCB=*.stepname.procstepname.ddname
```

Overriding Existing DCB Information

If the existing DCB information does not meet your requirements exactly you can override any of the subparameters by specifying the required information in a new subparameter. For example, if an existing DD statement named IN in a job step named COMP has the following DCB parameter:

```
DCB=(RECFM=FB,LRECL=80)
```

and you want LRECL to be 100, simply code:

```
DCB=(*.COMP.IN,LRECL=100)
```

Subparameters of the DCB Parameter

The following is a summary of those subparameters that can apply to your PL/I program. The notation used in the descriptions is as follows:

n unsigned decimal integer

| indicates a choice

{} braces indicate that you must select one line from the items enclosed

[] brackets indicate that the item enclosed is optional.

Code capital letters and numbers exactly as shown.

BLKSIZE=n

specifies the length in bytes of a block. The maximum length is 32760 bytes.

For fixed-length records, the block size must be an integral multiple of the record length (LRECL); the minimum size is 1 byte.

For variable-length (V-format and VB-format) records, the block size must be at least eight bytes larger than the largest item of data that you expect to read or write (that is, four bytes larger than the record length specified in LRECL). However, if the records are spanned (VS-format and VBS-format), you can specify block size independently of record length. The minimum block size for data sets on magnetic tape is 18 bytes.

BUFNO=n

specifies the number of buffers to be used in accessing the data set. The maximum number is 255 (unless another maximum has been determined for your installation during system generation). For a STREAM file or BUFFERED RECORD file, if you do not specify the number of buffers or you specify zero buffers, the number is assumed to be two.

CODE=A|B|C|F|I|N|T

specifies the code in which paper tape is punched. (Data is read into main storage and then converted from that code to EBCDIC.)

A ASCII (8-track)

B Burroughs (7-track)

C NCR (8-track)

F Friden (8-track)

I IBM BCD perforated-tape transmission code (8-track)

N No conversion required (F-format records only)

T Teletype (5-track)

If no code is specified, I is assumed.

CYLOFL=n

specifies, for an INDEXED data set, the number of tracks of each cylinder to be reserved for the records that overflow from other tracks in that cylinder. The theoretical maximum is 99, but the practical limit varies with the particular device.

There must be at least one track in each cylinder to hold the prime data.

DEN=0|1|2|3

specifies the recording density for magnetic tape as follows:

Bytes per inch (bpi)

DEN	7-track	9-track
0	200	-
1	556	-
2	800	800
3	-	1600

The density assumed if you omit this subparameter is:

7-track:	200 bpi
9-track (single density):	800 bpi
9-track (dual density):	1600 bpi

(The subparameter TRTCH is required for 7-track tape.)

DSORG=IS|DA

specifies the organization of the data set you are creating:

IS (indexed sequential): INDEXED data set

DA (direct access): REGIONAL data set

This subparameter is not required for CONSECUTIVE data sets.

FUNC=function

specifies the function or functions to be performed by an IBM 3525. The following values of "function" are valid:

I	WT	RWX	PWXT
R	WXT	RWT	RPW
P	RP	RWXT	RPWX
W	RPD	PW	RPWXT
WX	RW	PWX	RPWD

The letters have the following meanings:

I - Interpret
R - Read
P - Punch
W - Print
D - Data protection
X - Printer
T - Two-line printer

KEYLEN=n

specifies the length in bytes of the recorded key of records in INDEXED, REGIONAL(2), and REGIONAL(3) data sets. The maximum key length is 255 bytes.

LIMCT=n

limits the extent of the search for a record or space to add a record in a REGIONAL(2) or REGIONAL(3) data set beyond the region number specified in the source key.

If you do not specify a limit, the search starts at the specified region and continues through the whole of the data set.

For REGIONAL(2), LIMCT specifies the number of records to be searched. The search starts at the beginning of the track on which the record is situated and continues to the end of the track containing the last record to be searched.

For REGIONAL(3), LIMCT specifies the number of tracks to be searched.

LRECL=n

specifies the length of a record in bytes; the maximum length is 32760 bytes for F-format records, and 32756 bytes for V-format records. You must specify a record length for blocked records.

For F-format and FB-format records, the record length must not exceed the block size (BLKSIZE) value; the minimum length is 1 byte.

For V-format records, give the maximum record length including the four control bytes required by the operating system; the minimum record length for V-format records is 14 bytes (ten bytes of data and four control bytes). The record length for V-format and VB-format records must be at least four bytes less than the block size (BLKSIZE) value; however, for VS-format and VBS-format records, it can be specified independently of block size.

MODE={E|C}[O|R]

specifies the mode of operation for a card reader or punch. E indicates EBCDIC, and C indicates column binary. O specifies Optical Mark Read mode on an IBM 3505, and R specifies Read Column Eliminate mode on an IBM 3505 or 3525.

NCP=n

specifies the number of channel programs allocated to a file when it is opened: the number of simultaneous input/output operations on the file (that is, the number of incomplete event variables) cannot exceed the number of channel programs. The NCP subparameter applies only to direct access to INDEXED data sets, or sequential access to CONSECUTIVE or REGIONAL data sets that are unbuffered. The maximum number of channel programs is 99 (unless another maximum was established for your installation at system generation); the default value assumed if you omit the subparameter is 1.

For DIRECT access to an INDEXED data set, simultaneous input/output operations in excess of the number of channel programs are queued until a channel program becomes available.

For UNBUFFERED SEQUENTIAL access to CONSECUTIVE or REGIONAL data sets, the ERROR condition is raised if there are too many concurrent operations.

The NCP subparameter overrides the BUFNO subparameter or the BUFFERS option of the ENVIRONMENT attribute. One buffer is allocated for each channel program.

<u>NTM=n</u>

specifies, for an INDEXED data set, the number of tracks in the cylinder index referred to by each master index entry, and the number of tracks within each level of the master index referred to by each entry in the next higher level. The maximum value for n is 99. (See also OPTCD=M later in this chapter.)

<u>OPTCD=option list</u>

lists optional data management services. To indicate the services you require, code the appropriate letters (see below) without separating blanks, in place of "option list" (for example, OPTCD=LY).

OPTCD=C requests chained scheduling, which improves input/output performance by reducing the time required to transmit blocks to and from auxiliary storage devices. In chained scheduling, the data management routines bypass the normal input/output scheduling routines and chain several input/output operations together; a series of read operations, for example, is issued as a single chain of commands instead of several separate commands.

Chained scheduling is most useful in programs whose performance is input/output limited. If you use this feature, you should request at least three buffers or at least three channel programs. Chained scheduling can be used with CONSECUTIVE or REGIONAL SEQUENTIAL data sets; it should not be used for INPUT or UPDATE with U-format records.

OPTCD=I requests an independent overflow area for an INDEXED data set; you must define this overflow area in a separate DD statement.

OPTCD=L requests that a record in an INDEXED data set be recognized as deleted if its first byte contains (8)'1'B.

OPTCD=M requests the creation of a master index in accordance with the information given in the NTM subparameter.

OPTCD=U suppresses the raising of the TRANSMIT condition when an invalid character is passed to a printer with the universal character set feature. A blank is printed in place of the invalid character.

OPTCD=W requests a write validity check for a direct-access device.

OPTCD=Y requests that the data management routines use the cylinder overflow area for overflow records in an INDEXED data set. The size of the overflow area is established by CYLOFL=n.

<u>RECFM=</u>

```
        ( F[B]   [S] )
RECFM= {  V[B]   [S]  } [T]  [A|M]
        ( U          )
```

indicates the record format as follows:

F Fixed-length records

V Variable-length records

U Undefined-length records

If you do not specify a record format, U-format is assumed, except for PRINT files, for which V-format is the default assumption.

The optional subfields are:

B Blocked records.

S Standard (fixed-length records only). No blocks, except possibly the last, will be shorter than the specified block size.

S Spanned (variable-length records only). If variable-length records are spanned, the record length specified by LRECL can exceed the block size specified by BLKSIZE; if necessary, the records are segmented and the segments are placed in consecutive blocks. If the records are unblocked, each block contains only one record or segment; if the records are blocked, each block contains as many records or segments as it can accommodate.

T Track overflow. Track overflow is an

	Data Conversion	Parity	Translation
C	Yes	Odd	No
T	No	Odd	Yes
E	No	Even	No
ET	No	Even	Yes
default	No	Odd	No

Figure A-1. Specifying tape recording techniques using the TRTCH subparameter

operating system feature that can be incorporateddduring system generation. It allows a block to overflow from one track of a direct-access device to another. Track overflow is useful in achieving greater data-packing efficiency, and also allows the size of a record to exceed the capacity of a track.

Note: You cannot use track overflow for REGIONAL(3) data sets with U-format or V-format records or for INDEXED data sets.

A The first byte of each record contains an ANS printer/punch control code.

M The first byte of each record contains an IBM System/360 printer/punch control code.

RKP=n

specifies for an INDEXED data set, the position (n) of the first byte of an embedded key relative to the beginning of the record (byte 0). RKP=0 implies that the key is not embedded. (For example, if "XYZ" is the key embedded in the record "ABCXYZDEF", RKP=3.)

STACK=1|2

refers to a card reader or punch:

1 All cards read or punched are to be fed into stacker 1.

2 All cards read or punched are to be fed into stacker 2.

Stacker 1 is assumed if you omit this subparameter. If you want stacker 3, specify the ANS machine-code character in the RECFM parameter of the DD statement, and insert the appropriate character as the first data byte.

TRTCH=C|T|E|ET

is required when a data set is recorded or is to be recorded on 7-track tape. It specifies the recording technique to be used as shown in Figure A-1.

Notes

Data conversion and translation: data on 9-track magnetic tape, like that in main storage, is held in 8-bit bytes, a ninth bit being used for parity checking; data on 7-track tape is held in the form of 6-bit characters with a parity bit. The conversion feature of the 2400 series magnetic-tape drives treats all data as if it were in the form of a bit string, breaking the string into groups of six bits for writing on 7-track tape, or into groups of eight bits for reading into main storage. The translation feature changes the form in which character data is held from 8-bit EBCDIC to 6-bit BCD or vice versa. If you specify neither conversion nor translation, only the last six bits of each 8-bit byte are transmitted; the first two are lost on output and are set to zero on input.

Parity: Odd parity checking is normally used in IBM System/360, but you should specify even parity if you want to read a tape that was written by a system using even parity, or to write a tape for a system that demands even parity.

Choice of technique: The use of a technique other than C restricts the character set in which data can be written if it is subsequently to be reread and result in the same bit configuration in main storage. (An 8-bit code offers 256 possible configurations, but a 6-bit code only 64.) For stream-oriented or record-oriented transmission of character strings or pictured data, you can use technique C or T; you can also specify ET if your program is written in the 48-character set. (Seven-track tape recording systems indicate a zero bit by the absence of magnetization of the tape. Even parity checking does not allow the code 000000 to be used to represent the character zero, since an unmagnetized band is not acceptable on the tape. Therefore the code that would otherwise represent a colon (:) is used for the character zero, precluding the use of the full PL/I 60-character set.) For record-oriented transmission of arithmetic data, you must specify technique C.

Block Size: A PL/I program cannot be used to access a data set on a 7-track tape recorded with a block size that is nct a multiple of four bits. For example, a 7-track tape with a block size of 175 has 6*175 bits, that is, 1,050 bits in each block and cannot be read unless it is first modified by the the IEBCOPY utility program.

Appendix B: Compatibility with the PL/I(F) Compiler

Some features of the PL/I Optimizing Compiler implementation are incompatible with the PL/I (F) Compiler implementation. The most significant incompatibilities are listed below. In every case, the description given is of the optimizing compiler implementation. Programs which were written for the (F) compiler and which use any of these features should be reviewed before compiling them with the optimizing compiler to ensure that they will return the same results.

A number of the differences given here are also given in the general information manual for this compiler. The general information manual also contains some of the implementation limitations and restrictions of this compiler. The language reference manual for this compiler gives full details of the implementation of each language feature.

Areas

The (F) compiler holds the length of an area in the first 16 bytes of the area. The optimizing compiler holds the length of an area in a descriptor outside the area.

Arrays and Structures

- The maximum number of dimensions in an array is 15.
- The maximum depth of a structure is 15.

Built-in Functions

- Built-in functions are recognized on the basis of context only, so that all programmer-defined external procedures must be declared explicitly. Built-in functions and pseudovariables without arguments, such as TIME and ONCHAR, must also be declared explicitly with the BUILTIN attribute, or contextually with a null argument list, for example: TIME( ).
- For a variable to be a valid argument to the ADDR built-in function it must be connected and its left extremity must not lie within bytes that contain data belonging to other variables.
- The ALLOCATION built-in function returns a fixed-binary value giving the number of generations of the argument that exist in the current task.
- The NULLO built-in function is not implemented in the optimizing compiler. The NULL built-in function can be used for offset variables as well as for pointer variables.
- The ONCOUNT built-in function can be used in any on-unit and gives the number of interrupts remaining to be processed at any stage in the execution of the current task. In particular, this includes event and non-event I/O and multiple computational interrupts. In the case of event I/O, the value of ONCOUNT is the number of remaining exceptional conditions to be processed as a result of the execution of the WAIT statement.
- When using REGIONAL(1) organization, the value returned by the ONKEY built-in function for a specification error consists of the last eight bytes of the source key, padded on the right with blanks if necessary. This value is returned for all I/O conditions other than ENDFILE, or other than ERROR raised as standard system action for an I/O condition.
- In a RECORD I/O statement with the KEY or KEYFROM option, the ONKEY built-in function returns a null string when the ERROR condition is raised.
- In a RECORD I/O statement referring to a KEYED file (but with no KEY, KEYFROM, or KEYTO option specified) the ONKEY built-in function returns the recorded key.
- The PROD built-in function accepts arguments that are arrays of either fixed-point or floating-point elements. The value returned has the same scale as the argument given, except for fractional fixed-point arguments for which the result is in floating-point.
- If the first argument of the ROUND built-in function is a string, it is converted to arithmetic and rounded; the first argument must be convertible to arithmetic. Also, a different formula is used to determine the precision of a

fixed-point result.

- The SUBSTR built-in function returns a non-varying string.
- The SUM built-in function accepts arguments that are arrays of either fixed-point or floating-point elements. The value returned has the same scale as the argument given.
- The arguments of the TRANSLATE built-in function are converted to character-strings in all cases.
- The first 16 bits of the result returned by the UNSPEC built-in function for a varying string argument represent the current length of the string.

Checkpoint/Restart

The arguments to the function PLICKPT are mandatory.

Conditions

- When used with arrays, the CHECK condition is raised after assignment to each element. The standard system action when an assignment is made to a single element of an array is to print the value of only the element assigned.
- The STRINGRANGE condition is not raised for SUBSTR(string, i, 0) when "i" is one greater than the length of "string". A null string is returned.

Control Variable in DO statement

The pseudovariables COMPLETION, COMPLEX, PRIORITY, and STRING are not allowed as the control variable of a DO statement.

DEFINED Attribute

- Simple defining of strings and areas on a larger base is allowed.

  For example:

  ```
  DECLARE A (6) CHAR (6),
          B (3) CHAR (3) DEFINED A;
  ```

  This example will result in simple defining - B(1) will refer to the first three characters of A(1), B(2) to the first three characters of A(2), and so on.

  If string overlay defining is required, the user must specify POSITION (1) on the declaration of the defined item (B in the example above).

  If the string lengths or bounds of the defined item cannot be contained in the base, simple defining will be assumed.

  For example:

  ```
  DECLARE A (6) CHAR (6),
          B (7) CHAR (3) DEFINED (A);
  ```

  In this example, simple defining will be used because the bounds of array B exceed the bounds of array A.

- If the DEFINED attribute is used with an array of pictures, the defined item must match the base item exactly.

Dependent Declarations

Only one level of dependent declaration is allowed.

DISPLAY Statement

The maximum length of the reply is 72 characters.

Dumps from PL/I Programs

The object-time dump facility of the (F) compiler, IHEDUMP, requires a DD statement with the ddname PL1DUMP. Its equivalent in the optimizing compiler, PLIDUMP, requires a DD statement with the ddname PLIDUMP. The optimizing compiler will attempt to use PL1DUMP if PLIDUMP is not available.

ENDPAGE Condition

When ENDPAGE is signaled it cannot be raised again on the same page, except by the use of a further SIGNAL statement.

Old form	Converted to
F(b)	F BLKSIZE(b) RECSIZE(b)
F(b,r)	FB BLKSIZE(b) RECSIZE(r)
U(b)	U BLKSIZE(b) RECSIZE(b)
V(b)	V BLKSIZE(b) RECSIZE(b-4)
V(b,r)	VB BLKSIZE(b) RECSIZE(r)
VBS(b,r)	VBS BLKSIZE(b) RECSIZE(r)
VS(b,r)	VS BLKSIZE(b) RECSIZE(r)

Figure B-1. Environment options recognized by the compiler

Entry Names, Parameters, and Returned Values

- Each alternative entry expression in a GENERIC attribute is followed by a WHEN clause. The appearance of an entry name alternative does not constitute a declaration of the entry name. The alternative selected is the first for which each descriptor is a subset of the attributes of the corresponding argument in the generic reference.

- The dimension attribute is not allowed in a generic descriptor.

- In general, an entry name in parentheses causes a dummy variable to be created; for the function to be invoked, a null argument list is required. However, an entry name argument in parentheses, or an entry name without arguments, will be invoked if passed to a procedure whose parameter descriptor for the corresponding argument specifies an attribute other than ENTRY.

- External entry names must always be explicitly declared.

- Area and string extents in the RETURNS attribute or option must be represented by a decimal integer constant.

- The maximum depth of nesting in a descriptor list in the ENTRY attribute is 2.

- An aggregate expression involving strings may not be passed as an argument unless there is a corresponding parameter descriptor in which all string lengths are specified as decimal integer constants.

- An internal entry constant cannot be declared in a DECLARE statement. REDUCIBLE and IRREDUCIBLE may be specified on PROCEDURE and ENTRY statements. A scalar cannot be passed to an array parameter of an internal entry constant if the parameter's bounds are specified by asterisks.

ENVIRONMENT Attribute

- The optimizing compiler will recognize and convert the previously-implemented forms of the options shown in Figure B-1, and will issue a message stating that they are obsolete.

- There are two new data set organizations, TP(M) and TP(R), associated with teleprocessing. TP(M) implies the transmission of whole messages; TP(R) implies the transmission of records. Both are valid only for TRANSIENT files. These data-set organizations are equivalent to the options G(m) and R(r) available in Version 5 of the PL/I (F) compiler. The optimizing compiler will recognize and convert these forms of the options as shown in Figure B-2.

Old form	Converted to
G(m)	V TP(M) RECSIZE(m)
R(r)	V TP(R) RECSIZE(r)

Figure B-2. Teleprocessing environment options

Error Correction

The error correction logic differs from that used by the PL/I (F) compiler. Invalid programs that are compiled and corrected by the (F) compiler may not give the same results on the optimizing compiler.

EXCLUSIVE Attribute

- The EXCLUSIVE attribute implies only the RECORD attribute; DIRECT, UPDATE, and KEYED will apply only by default.

- The EXCLUSIVE attribute can be used in non-tasking programs, and jobs in the system can affect each other.

Facility	Entry-point Name
Sort	PLISRTA
	PLISRTB
	PLISRTC
	PLISRTD
Checkpoint/Restart	PLICKPT
	PLIREST
	PLICANC
Return Code	PLIRETC
Dump	PLIDUMP

Figure B-3. Operating system facilities

Expression Evaluation

In a concatenation operation, a BINARY operand is converted to BIT if the other operand is BINARY or BIT.

FIXED BINARY Expressions

The length of FIXED BINARY constants and intermediate results with a precision less than 16 is 2 bytes. The UNSPEC built-in function returns a result whose length is 16 bits.

INITIAL Attribute

The limitations on the length of DECLARE statements imposes some restrictions on the use of the INITIAL attribute. These restrictions are described under "Statement Length" later in this appendix.

LIKE Attribute

The optimizing compiler does not permit a substructure to have the LIKE attribute when another substructure within the major structure is the object of a further LIKE attribute. For example:

```
DCL  1  A LIKE C,
     1  B,
        2 C,
          3 D,
          3 E,
        2 F LIKE X,
     1  X,
        2 Y,
        2 Z;
```

In this example, the structure A has the LIKE attribute which refers to substructure C in structure B. B also contains substructure F with the LIKE attribute.

Link-editing

Programs translated by the optimizing compiler cannot be link-edited with object modules produced by the PL/I (F) compiler.

Locked Records

- The locking action takes place at the data set level.
- If an on-unit is entered as a result of a REWRITE or DELETE statement, the record is unlocked if the on-unit is terminated by a GOTO statement as well as normal completion.
- The ERROR condition is raised if a file is closed while subtasks currently have records in it locked.
- A record is not locked due to "key not found" or "key outside data" conditions.

Multitasking Programs

In certain circumstances, it is possible for multitasking programs compiled by the PL/I Optimizing Compiler to take longer to execute than corresponding programs compiled by the PL/I (F) Compiler. This situation can occur if a subtask, in which no files are opened, is repeatedly called.

NAME Option

When using batched compilation to produce two object modules that will be combined into one load module, the NAME option should not be used in the EXEC statement, because the options in the PARM parameter apply to all procedures in the batch.

Operating System Facilities

- The operating system facilities for sorting, for checkpoint/restart, for generating a return code, and for obtaining a dump are all invoked by means of a CALL statement with the appropriate entry-point name; for example CALL PLISRTA. The entry point names, which are listed in Figure B-3, have the BUILTIN attribute and need not be declared explicitly.

- The optimizing compiler does not recognize the entry names used by the PL/I (F) compiler, that is, IHESRTx, IHESARC, IHEDUMx, and IHECKPT. Existing programs for the PL/I (F) compiler that use these entry names must be amended so that the DECLARE statements for them are removed completely.

Pictures

Sterling picture data is not implemented. Therefore the following picture characters are not allowed:

G, H, M, P, 6, 7, 8.

Preprocessor

- Text replaced by preprocessor statements does not have blanks appended to either end of the replacement value.
- A parameter descriptor list is not allowed in the declaration of a preprocessor variable with the ENTRY attribute.
- The RETURNS attribute may not be specified in a preprocessor DECLARE statement.

Pseudovariables

For a varying string, the first 16 bits of the value of the UNSPEC pseudovariable represent the current length of the string.

Record I/O

- If READ...KEY is used with a sequential data set and no record with the specified key exists in the data set, the KEY condition is raised and the file is positioned at the next record in ascending sequence.
- If an embedded key in a record is not identical to that specified in a WRITE...KEYFROM, LOCATE...KEYFROM, or REWRITE FROM...KEY statement, the latter is moved into the record.
- READ, REWRITE, and DELETE statements are invalid for REGIONAL DIRECT OUTPUT files.
- There is no default record format for RECORD files (unless the file is associated with a DD DUMMY statement, in which case the default is U-format). If the record format is not specified, the UNDEFINEDFILE condition is raised.

Redundant Expression Elimination

The optimization process of eliminating redundant expressions could give rise to an incompatibility for (F) compiler programs that are recompiled by the optimizing compiler. If a program contains an expression, such as IF (A=D)|(C=D) THEN.... such that the condition (A=D) is satisfied, the expression (C=D) is ignored. However, (C=D) might contain a function which, if not evaluated, could give rise to error.

Return Codes

The maximum return code that may be set using PLIRETC is 999.

REWIND Option

The optimizing compiler does not implement the REWIND option. Programs that use this option should be modified. Note that the function of the REREAD option implemented by the optimizing compiler is different to that of the REWIND option. The main difference is that the REREAD option overrides any DISP parameter and controls the positioning of the magnetic tape volume whereas the REWIND option specifies that the DISP parameter is to control the positioning of the magnetic tape volume according to the subparameters specified.

Standard File SYSPRINT

The default record characteristics are: record format = VBA, record length = 125, and block size = 129. The default number of buffers is two. Using the DCB parameter of the DD statement, record format, record length, block size, and the number of buffers can be changed to any valid value.

The following sequence:

```
DCL SYSPRINT FILE;
  .
  .
  .
OPEN FILE(SYSPRINT);
```

will cause the UNDEFINEDFILE condition to be raised. Omission of either or both statements will result in correct execution. The file should be declared implicitly or with the attributes STREAM and OUTPUT.

Statements

The approximate maximum number of statements in a program is 10,000.

Statement Labels

A label on a DECLARE statement is treated as if it were on a null statement.

Statement Lengths

The optimizing compiler has a restriction that any statement must fit into the compiler's work area. The maximum size of this work area varies with the amount of space available to the compiler. The limitations on the length of statements are given in Figure B-4.

Space Available	Maximum Statement Length
50K - 55K	1012 characters
55K - 69K	1600 characters
Over 69K	3400 characters

Figure B-4. Statement length limitations

The DECLARE statement is an exception in that it can be regarded as a sequence of separate statements, each of which starts wherever a comma occurs that is not contained within parentheses. For example:

```
DCL 1 A,
    2 B(10,10) INIT(1,2,3,...),
    2 C(10,100) INIT((1000)(0)),
    (D,E) CHAR(20) VAR,...
```

In this example, each line can be treated by the compiler as a separate DECLARE statement in order to accommodate it in the work area. The compiler will also treat in the same way the INITIAL attribute when it is followed by a list of items separated by commas that are not contained within parentheses. Each item may contain initial values that, when expanded, do not exceed the maximum length. The above also applies to the use of the INITIAL attribute in a DEFAULT statement.

The (F) compiler can use up to 90K bytes for its work area. It is possible that programs with large DECLARE statements will not compile successfully on the optimizing compiler although they had compiled successfully on the (F) compiler. The following techniques are suggested to overcome this problem:

- Increase the main storage available to the compiler, unless it already exceeds 69K bytes.
- Simplify the DECLARE statement so that the compiler can treat the statement in the manner described above.
- Modify any lists of items following the INITIAL attribute so that individual items are smaller and separated by commas not contained in parentheses. For example, the following declaration is followed by an expanded form of the same declaration. The compiler can more readily accomodate the second declaration in its work area:

  1. DCL Y (1000) CHAR(8)
     INIT((1000)(8)'Y');

  2. DCL Y (1000) CHAR(8) INIT
     ((250)(8)'Y',(250)(8)'Y',
     (250)(8)'Y',(250)(8)'Y');

Stream Transmission

- A filemark (or end of string mark for the STRING option) is a valid item delimiter for list-directed and data-directed input. An item thus delimited is processed intact, and ENDFILE (ERROR for string) is raised on attempting to read a further item from the file or string.
- After processing a GET LIST statement, a file is positioned to the next non-blank

character or, if this is a comma, to the character following the comma. A GET EDIT statement following a GET LIST on the same file must take into account the position of the file.

- The NAME condition (ERROR for the STRING option) is raised for all errors (including out of range subscripts) detected on the left-hand side of an item of data-directed input.

- The COPY option causes all items to be copied, including any skipped by the SKIP option. A contextual declaration of SYSPRINT is caused if no file name is specified for the COPY option.

- When transmitting DATA-directed output to a PRINT file, data items less than or equal to the line size will not be split between lines. Data items greater than the line size will, if possible, be split between the equals sign and the data value.

- Execution of a PUT statement in which the LINE option specifies the current line causes the ENDPAGE condition to be raised unless the current column is 1.

<u>Varying-length Strings</u>

The (F) compiler initializes a varying-length string to a null string, the equivalent of:

```
STR = '';
```

whenever such a string is allocated. The optimizing compiler does not perform any initialization of varying-length strings, unless the INITIAL attribute is used.

<u>WAIT Statement</u>

If a WAIT statement requires the completion of an inactive and incomplete event variable in a non-tasking program, then after any I/O event variables named in the same statement are completed, a message is printed and the program is terminated. In a TSO environment, control passes to the terminal.

Appendix C: Requirements for Problem Determination and APAR Submission

When a member of IBM programming support personnel is called to examine the suspected malfunctioning of an IBM program product, he will first determine whether or not the malfunction really is a problem in the program product. If he decides that the program product is at fault, he must then check to see if the fault is a known fault for which he can obtain an existing fix-up. If the fault is not known, he must refer the problem to the appropriate program maintenance group within IBM for analysis and correction. The process of referring a problem to IBM involves submitting a report known as an APAR (Authorized Program Analysis Report), which must be accompanied by material to enable the program maintenance personnel to analyze the problem.

To enable IBM program maintenance personnel to analyze a problem, it must be possible to reproduce it at the IBM program maintenance center. It will therefore be essential to supply with the APAR the source program to enable the problem to be reproduced and analyzed. Faster resolution of the APAR may be possible if some or all of the material listed in Figure C-1 is supplied and if the source program is reduced to the smallest, least complex form that still contains the problem.

All listings that are supplied must relate to a particular execution of the compiler, in the case of a suspected compiler failure, or to the relevant link editing and execution steps, in the case of the failure of the PL/I program during execution. Listings derived from separate compilations or executions are of no value and may, in fact, be misleading to the programming support personnel.

Original Source Program

The original PL/I source program must be supplied in a machine-readable form such as a deck of punched cards or a reel of magnetic tape. The copy of the program supplied must be identical to the listing that is also supplied.

Use of the Preprocessor

If the compilation includes preprocessing, the source program submitted should include, either as a card deck or on magnetic tape, the source module obtained by means of the compiler MDECK option.

If the problem is known to have occurred during preprocessing, a listing of the source program being preprocessed must be supplied. If the preprocessing involves the use of the %INCLUDE statement, a copy of the PL/I source statement module(s) included should be supplied in a machine-readable form. If source statement modules are not supplied in the original submission of the APAR, the APAR will be put into abeyance until they are supplied.

Job Control Statements

Listings of job control statements used to run the program must be supplied. For OS installations, any local cataloged procedures should be shown in expanded form, obtained by specifying MSGLEVEL=1 in the JOB statement. Where there are a large number of job control statements, supply these also in a machine-readable form such as on punched cards or on magnetic tape. This will assist the program maintenance personnel to reproduce the problem more quickly.

Operating Instructions/Console Log

In the case of an execution-time failure of a program that processes a number of data sets or that operates in a complicated environment, such as a teleprocessing application, it is essential that adequate description of the processing and the environment is given to enable it to be recreated. Although it may be impossible to supply console logs and operating procedures, a complete description of the application, the organization of the data sets, and adequate operating instructions are vital for the IBM program maintenance personnel to reproduce the problem.

Terminal Session Listing

If a malfunction is detected during a conversational (TSO), session the entire

Material Required	Compiler Option	When Required
Original source program		C,E,T
Job Control Statements		C,E,T
Operating Instructions/ Console Log		
Terminal session listing		T
LOGON procedure listing		T
Listings:		
Source listing	SOURCE (S)	C,E,T
Cross-reference listing	XREF (X)	C,E,T
Attribute table	ATTRIBUTES (A)	C,E,T
Aggregate table	AGGREGATE (AG)	C,E,T
Storage table	STORAGE (STG)	C,E,T
Compiler options	OPTIONS (OP)	C,E,T
Compiler terminal dump	DUMP (DU)	C,T
Linkage editor map	MAP (linkage editor option)	E,T
Execution-time dump		E,T
User subroutines		E,T
User data sets		E,T
Preprocessor input listing	INSOURCE (IS)	P,T
Preprocessor output	MDECK (MD)	C,E,T
Partition/Region size		C,E,T
List of applied PTFs		C,E,T

Note: "C" indicates the requirements for a compile-time error;
"E" indicates requirements for an execution-time error;
"P" indicates the requirements for a preprocessor error;
"T" indicates the requirements for conversational (TSO) error.

Figure C-1. Summary of requirements for APAR submission

listing produced at the terminal, from LOGON to LOGOFF, must be supplied. If the failure occurs during conversational processing of a large program under TSO, it may be easier to obtain the program's output by listing the PRINT data set on a line printer.

LOGON Procedure

If a malfunction is detected during a conversational (TSO) session, a listing of the LOGON procedure must be supplied to enable the session to be reproduced.

Listings

A listing of the source program is essential. Other compiler-generated listings, while not essential, may assist in producing a faster resolution of the APAR. If any of the compiler options that must be specified in order to obtain material for submission with an APAR have been deleted at system generation, they can be restored for temporary use by means of the compiler CONTROL option.

If the failure occurs during conversational compilation of a large program under TSO, it may be easier to obtain the required listings by running the compilation in a background region. Alternatively, the output PRINT data set may be printed on a line printer.

Linkage Editor Map

When a problem occurs at execution time, a linkage editor map that was obtained when the copy of the program that has failed was link edited is essential. The linkage editor map will be used in the analysis of the storage dump that must also be obtained when the program failed.

Execution-time Dumps

If the problem occurs during execution of the PL/I program, a storage dump must be supplied. A dump can be obtained by using a stand-alone dump program or by using the the system SYSABEND or SYSUDUMP facilities. However, if possible, a formatted PL/I dump produced by the PL/I error-handling facilities should be provided. A PL/I dump is obtained by including the following statement in an ERROR on-unit that will be entered when the program fails:

```
CALL PLIDUMP('TFHB');
```

Applied PTFs

A list of any program temporary fixes (PTF) and local fixes (s/zaps) applied to either the compiler or its libraries must be supplied. The IBM service aid program IMAPTFLS, described in the publication _OS Service Aids_, Order No. GC28-6719, can be used to obtain from a program library a listing showing those members of the library that have PTF or local fixes, provided that when the fix was made, the correct system status index (SSI) was included in the library directory. However, if a module contains more than one temporary fix, only the last fix to be applied will be listed by the IMAPTFLS program.

Submitting the APAR

When submitting material for an APAR to IBM, ensure that any magnetic tapes and decks of punched cards that are supplied containing source programs, job stream data, data sets, or libraries are carefully packed and clearly identified.

Each magnetic tape submitted should have the following information attached and visible:

- The APAR number assigned by IBM.
- The contents of the volume (source program, job control statements, or data, etc.).
- The recording mode and density.
- All relevant information about the labels used for the volume and its data sets.
- The record format and blocking sizes used for each data set.
- The name of the program that created each data set.

Each card deck submitted must have the following information attached and visible:

- The APAR number assigned by IBM.
- The contents of the card deck (source program, job control statements, or data, etc.).

This information will ensure that a magnetic tape or card deck will not be lost if it becomes separated from the rest of the APAR material, and that its contents are readily accessed.

Appendix D: IBM System/360 Models 91 and 195

This appendix explains how exceptions and interrupts in Models 91 and 195 are handled by the operating system. An <u>exception</u> is a hardware occurrence (such as an overflow error) which can cause a program interrupt. An <u>interrupt</u> is a suspension of normal program activities. There are many possible causes of interrupts, but the following discussion is concerned only with interrupts resulting from hardware exceptions.

IBM System/360 Models 91 and 195 are high-speed processing systems in which more than one instruction may be executed concurrently. As a result, an exception may be detected and an interrupt occur when the address of the instruction which caused the exception is no longer held in the central processing unit. Consequently, the instruction causing the interrupt cannot be precisely identified. Interrupts of this type are termed <u>imprecise</u>. When an exception occurs, the machine stops decoding further instructions and ensures that all instructions which were decoded prior to the exception are executed before honoring the exception. Execution of the remaining decoded instructions may result in further exceptions occurring. An imprecise interrupt in which more than one exception has occurred is known as a <u>multiple-exception imprecise interrupt</u>.

The optimizing compiler permits processing of imprecise interrupts only when the compiler option IMPRECISE is in effect. This is useful when debugging a program. The effect of the option is:

1. To cause the compiler to insert special "no-operation" instructions at certain points in the program to localize imprecise interrupts to a particular segment of the program, thus ensuring that interrupt processing results in the action specified in the source program. These "no-operation" instructions are generated:

   - Before an ON-statement.
   - Before a REVERT statement.
   - Before internal code to set the SIZE condition.
   - Before internal code to change prefix options.
   - Between statements if GOSTMT or GONUMBER apply.
   - For a null statement. (This feature provides the programmer with source language control over the timing of program interrupts.)

2. To provide facilities for:

   - Detecting multiple-exception imprecise interrupts.
   - Setting the value that is required by the ONCOUNT built-in function.
   - Raising the appropriate PL/I conditions.

The order of processing the exceptions is as follows:

1. PL/I conditions in the order:

   UNDERFLOW

   FIXEDOVERFLOW or SIZE

   ERROR (if system action is required for either FIXEDOVERFLOW or SIZE)

   FINISH (if system action is required for the previous ERROR condition)

   OVERFLOW

   ERROR (if system action is required for OVERFLOW)

   FINISH (if system action is required for the previous ERROR condition)

   ZERODIVIDE

   ERROR (if system action is required for ZERODIVIDE)

   FINISH (if system action is required for the previous ERROR condition)

<u>Note</u>: The conditions FIXEDOVERFLOW and SIZE cannot occur together, because the same hardware condition raises both of them.

2. Hardware exceptions in the order:

   data

   specification

   addressing

   protection

Conditions and exceptions are raised in the above order until one of the following situations occurs:

- A GO TO statement in an on-unit is executed. All other exceptions will then be lost.
- The ERROR condition is raised. If the program is terminated as a result of this action (that is, system action causing the ERROR condition to be raised, followed by the FINISH condition), messages will be printed to indicate the nature of the unprocessed exceptions. The exceptions themselves will not be processed.

When an interrupt results from multiple exceptions, only one of the PL/I conditions is raised for each type of exception that occurred.

When a multiple-exception imprecise interrupt occurs, the ONCOUNT built-in function provides a binary integer count of the number of exception types (that have PL/I on-conditions associated with them) that remain to be processed. If the ONCOUNT built-in function is used when only a single exception has occurred, or if it is used outside an on-unit, a count value of zero is indicated.

Appendix E: Shared Library Cataloged Procedures

The shared library is a PL/I facility that allows an installation to load PL/I resident library modules into the link pack area (LPA) so that they are available to all PL/I programs. This reduces space overheads.

The resident library subroutines to be included in the shared library can be chosen by the installation; they must include the initialization routine, the error-handling routine, the open file routine, and all modules addressed from the TCA that are not identical for multitasking and non-multitasking programs. Further details of the shared library are given in the publications OS PL/I Optimizing Compiler: Execution Logic and OS PL/I Optimizing Compiler: System Information.

The routines in the shared library are held in two of three link-pack-area modules: IBMBPSM, and either IBMBPSL or its multitasking equivalent IBMTPSL. Each of the link-pack modules contains a number of library routines, and is headed by an addressing control block known as a transfer vector. IBMBPSM contains those modules in the shared library that are common to both multitasking and non-multitasking PL/I environments. IBMBPSL contains the non-multitasking versions of those modules that are not identical in multitasking and non-multitasking PL/I environments. This module has a multitasking counterpart, IBMTPSL, which holds the multitasking versions of such modules.

Two further modules are also involved in handling the shared library. These are the shared library addressing modules IBMBPSR and its multitasking counterpart IBMTPSR. One or other of these modules, each of which has the alias PLISHRE, is link-edited with compiled code and held in the program region: IBMBPSR for non-multitasking programs, or IBMTPSR for multitasking programs. IBMBPSR and its multitasking counterpart hold dummy entry points which duplicate the names of all entry points of modules within the shared library. References to such entry points in compiled code are resolved to the dummy entry points in IBMBPSR or IBMTPSR.

You can use the shared library by using standard IBM-supplied cataloged procedures and overriding the link-edit and loader procedure steps.

Execution when Using the Shared Library

Use of the shared library is specified by the linkage editor statement INCLUDE PLISHRE. PLISHRE is an alias for the program region modules IBMBPSR and IBMTPSR. The appropriate module will therefore be loaded by the linkage editor (IBMBPSR for non-multitasking programs; IBMTPSR for multitasking programs). All compiled code external references to shared library module entry points are then resolved to the dummy entry points in IBMBPSR (or IBMTPSR). Similarly WXTRNs in the program region module are resolved if compiled code issues an EXTRN for the entry point.

A load module created for use with one shared library will not execute with a different shared library. You will have to link-edit the object module again, including the dummy transfer vector module for the different shared library.

You must remember that the linkage editor or loader require a large amount of main storage for external symbol dictionary tables while processing the dummy transfer vector module. If you specify SIZE=200K in the PARM field of your EXEC statement for the linkage editor or loader (and use a region or partition of equivalent size), you will get sufficient main storage for processing with the largest possible shared library.

Your PL/I program may take slightly longer to execute when using a shared library, because all library calls have to pass through the transfer vectors. However, your main storage requirements for a region will be greatly reduced if you have carefully selected your shared library modules to suit the operating environment.

Multitasking Considerations

The shared library has been designed so that multitasking does not affect it. If PLI.TASK is specified before PLI.BASE, the linkage editor statement INCLUDE PLISHRE will result in the module IBMTPSR being loaded and linked in the program region. When control passes to the code following the IBMBPIR entry point in IBMTPSR, a request is made to the system to load the multitasking shared library module IBMTPSM. The program then runs in the usual manner, with the multitasking modules.

An installation may specify that it does not require either the multitasking or the non-multitasking modules in the shared library. However both multitasking and non-multitasking versions of the program region module will still be created. The module for the unwanted environment will be a dummy. This prevents problems should an INCLUDE PLISHRE statement be included in a program that is intended to run in the environment with no shared library. If this process was not carried out, such a statement could result in the incorrect environment being initialized.

USING STANDARD IBM CATALOGED PROCEDURES

Standard IBM-supplied cataloged procedures that use the linkage editor or loader (see Chapter 11) can be used to specify the shared library. This is done by overriding the SYSLIN DD statement in the link-edit or load-and-go procedure steps to ensure that the shared library addressing module IBMBPSR is the first module to be included by the linkage editor or loader and that its entry point in the resulting load module has the name PLISHRE. For example, the cataloged procedure PLIXCL requires the following statements to make use of the shared library.

```
//STEP1        EXEC    PLIXCL
//LKED.SYSIN   DD      *
  INCLUDE      SYSLIB(PLISHRE)

 (add further input here)

/*
```

You can add other linkage-editor control statements by placing them as indicated. For example, to give the resulting load module the name MINE, add the statement:

```
NAME           MINE(R)
```

between the ENTRY and /* statements.

Appendix F: Programming Example

This appendix, consisting of a PL/I sample program, illustrates all the components of the listings produced by the compiler and the linkage editor. The listings themselves are described in Chapters 4 and 5.

The function of the program is fully documented in both the preprocessor input and the source listing by means of PL/I comments. These comments consist of lines of text each preceded by /* and followed by */. Note that the /* must not appear in columns 1 and 2 of the input record because it will be taken as a job control delimiter statement.

Most pages of the listings contain brief notes explaining the contents of the pages.

TRANSIENT LIBRARY MODULES IN THE LINK PACK AREA

Any module in the PL/I Transient Library may be placed in the link pack area (LPA) without any change in procedure.

```
PL/I OPTIMIZING COMPILER        VERSION 1 RELEASE 2.0                TIME: 21.15.03    DATE: 13 APR 73          PAGE   1

OPTIONS SPECIFIED (1)

 AG,A,C,ESD,GS,LIST,M,MAP,OF,IS,STG,SYN,X,MAR(2,72,1),LC(55)

OPTIONS USED (2)

AGGREGATE      NOCOUNT        CHARSET(60,EBCDIC)
ATTRIBUTES     NODECK         FLAG(I)
COMPILE        NOFLOW         LINECOUNT(55)
ESD            NOGONUMBER     MARGINS(2,72,1)
GOSTMT         NOIMPRECISE    OPTIMIZE(TIME)
INSOURCE       NOINCLUDE      SEQUENCE(73,80)
LIST           NOMARGINI      SIZE(101584)
LMESSAGE       NOMDECK
MACRO          NONUMBER
MAP            NOTERMINAL
NEST
OBJECT
OFFSET
OPTIONS
SOURCE
STMT
STORAGE
SYNTAX
XREF
```

Start of the compiler listing.

(1) List of options specified in the PARM parameter of the EXEC statement.

(2) List of options used, whether obtained by default, or by being specified explicitly.

```
                    PREPROCESSOR INPUT

LINE
  1      /***** PL/I SAMPLE PROGRAM. *****/                                      00269040

  2      %/*******************************************************************/ 00269050
  3       /*                                                                 */ 00269060
  4       /* USES COMPILE-TIME PREPROCESSOR TO MODIFY PL/I (F) SOURCE FOR    */ 00269070
  5       /* USE WITH THIS COMPILER.   THE PREPROCESSOR STATEMENTS FOLLOWING */ 00269080
  6       /* COULD BE PLACED ON A LIBRARY AND USED TO MODIFY SEVERAL SOURCE  */ 00269090
  7       /* PROGRAMS BY MEANS OF THE PREPROCESSOR %INCLUDE STATEMENT. THEY  */ 00269100
  8       /* PERFORM THE FOLLOWING FUNCTIONS:                                */ 00269110
  9       /*                                                                 */ 00269120
 10       /*  1. CONVERT CALLS TO FOLLOWING PL/I (F) IHE... ROUTINES TO THE  */ 00269130
 11       /*     EQUIVALENT NEW PLI.... ROUTINES-                            */ 00269140
 12       /*           IHEDUMP/J/C/T  TO  PLIDUMP,                           */ 00269150
 13       /*           IHESRTA/B/C/D  TO PLISRTA/B/C/D,                      */ 00269160
 14       /*           IHECKPS/T  TO  PLICKPT,                               */ 00269170
 15       /*           IHERESN/T  TO  PLIREST/PLICANC,                       */ 00269180
 16       /*           IHESARC/IHETSAC  TO  PLIRETC.                         */ 00269190
 17       /*                                                                 */ 00269200
 18       /*  2. CHANGE FIRST DECLARE/DCL STATEMENT FOUND TO INCLUDE         */ 00269210
 19       /*     BUILTIN ATTRIBUTE FOR FOLLOWING BUILT-IN FUNCTIONS(WHICH    */ 00269220
 20       /*     DO NOT TAKE ARGUMENTS, AND SO ARE NOT IMPLICITLY DECLARED   */ 00269230
 21       /*     BUILTIN FOR THIS COMPILER - AS THEY WOULD BE FOR PL/I (F))- */ 00269240
 22       /*           DATE, TIME, ONCODE, ONCHAR, ONSOURCE, ONLOC,          */ 00269250
 23       /*           ONFILE, ONKEY, EMPTY, NULL.                           */ 00269260
 24       /*     NOTE: THE ONCOUNT BIF IS OMITTED FROM THIS LIST, & IS USED  */ 00269270
 25       /*           LATER TO SHOW THE EFFECT OF NOT DECLARING IT BUILTIN. */ 00269280
 26       /*           ANY REFERENCES TO IHE--- ROUTINES MUST BE REMOVED     */ 00269290
 27       /*           FROM DECLARE STATEMENTS BEFORE THE SOURCE PROGRAM IS  */ 00269300
 28       /*           PREPROCESSED, OTHERWISE FAILURES MAY OCCUR WHEN THE   */ 00269310
 29       /*           CONVERTED PROGRAM IS LINK-EDITED.                     */ 00269320
 30       /*                                                                 */ 00269330
 31       /*  3. CHANGE 'NULLO' TO 'NULL' - THERE IS NO NULLO BUILTIN        */ 00269340
 32       /*     FUNCTION FOR THIS COMPILER; NULL MUST BE USED BOTH WITH     */ 00269350
 33       /*     POINTER AND OFFSET VARIABLES.                               */ 00269360
 34       /*                                                                 */ 00269370
 35       /*******************************************************************/;00269380
```

Source statements for the sample program, exactly as they appear in the input stream. These statements form the input data for the preprocessor. Preprocessor statements are identified by the % symbol.

1. The first line of the input is included as part of the heading for all pages of the preprocessor and compiler listing.

2. Each input record is numbered sequentially.

3. If an input record has a sequence number, this number is printed.

```
 LINE
   36        %        DCL   (IHEDUMP, IHEDUMJ, IHEDUMC, IHEDUMT, DECLARE, DCL,        00269390
   37                        IHECKPT, IHECKPS) ENTRY;                                  00269400

   38        %        DCL   (IHESRTA, IHESRTB, IHESRTC, IHESRTD, IHEREST,             00269410
   39                        IHERESN, IHESARC, IHETSAC, NULLO) CHAR;                   00269420

   40        %        DCL   COUNT FIXED;                                              00269430


   41        %        COUNT = 0                     /* FIRST-TIME-IN SWITCH.      */;00269440

   42        %        DEACTIVATE DECLARE, DCL       /* ENSURE MODIFIED STATEMENTS */;00269450
   43        %        ACTIVATE DECLARE,             /* ARE NOT RESCANNED DURING   */ 00269460
   44                          DCL NORESCAN         /* PREPROCESSOR REPLACEMENT.  */;00269470
```

```
% DECLARE: DCL:                         /* GENERATE BUILTIN DECLARES. */ 00269480
        PROC RETURNS(CHAR);                                              00269490
        COUNT = COUNT + 1              /* COUNT = 1 IF 1ST TIME IN.  */;00269500
        IF COUNT = 1                                                     00269510
          THEN RETURN('DCL (DATE,TIME,ONCHAR,ONSOURCE,ONCODE,' ||        00269520
                      'ONLOC,ONFILE,ONKEY,EMPTY,NULL) BUILTIN, ' ||      00269530
                      'CKPT_RETC FIXED BIN(31),');                       00269540
          ELSE RETURN('DCL');                                            00269550
%       END;                                                             00269560

% IHEDUMP: IHEDUMJ: IHEDUMC: IHEDUMT: /* REPLACED BY CALL TO        */ 00269570
        PROC(ID#) RETURNS(CHAR)        /* PLIDUMP ROUTINE, INCLUDING */;00269580
        DCL ID# CHAR                   /* ORIGINAL ID(IF PRESENT).   */;00269590
        IF ID# = '' THEN RETURN('PLIDUMP');                              00269600
                    ELSE RETURN('PLIDUMP(''TFCA'',''' || ID# || ''')');00269610
%       END;                                                             00269620

% IHECKPS: IHECKPT:                    /* CHANGE TO PLICKPT. PL/I(F) */ 00269630
        PROC(ARG1, ARG2, ARG3, ARG4)   /* DEFAULTS GENERATED WHERE   */ 00269640
            RETURNS(CHAR)              /* NO ARGUMENTS ORIGINALLY.   */;00269650
        DCL (ARG1, ARG2, ARG3, ARG4) CHAR;                               00269660
        IF ARG1 = '' THEN ARG1 = '''SYSCHK''';                           00269670
        IF ARG2 = '' THEN ARG2 = ' ''''';                                00269680
        IF ARG3 = '' THEN ARG3 = ' ''PS''';                              00269690
        IF ARG4 = '' THEN ARG4 = ' CKPT_RETC';                           00269700
        RETURN('PLICKPT(' || ARG1 || ',' || ARG2 || ','                  00269710
                          || ARG3 || ',' || ARG4 || ')');                00269720
%       END;                                                             00269730

%       IHESRTA = 'PLISRTA'            /* REPLACE                    */;00269740
%       IHESRTB = 'PLISRTB'            /*  CALLS TO                  */;00269750
%       IHESRTC = 'PLISRTC'            /*   IHE---                   */;00269760
%       IHESRTD = 'PLISRTD'            /*    ROUTINES                */;00269770
%       IHEREST = 'PLIREST'            /*     BY                     */;00269780
%       IHERESN = 'PLICANC'            /*      CALLS TO              */;00269790
%       IHESARC = 'PLIRETC'            /*       PLI---               */;00269800
%       IHETSAC = 'PLIRETC'            /*        ROUTINES.           */;00269810

%/*     THERE IS NO NULLO BUILTIN FUNCTION FOR THIS COMPILER;            00269820
        NULL MUST BE USED INSTEAD.                                   */;00269830

%       NULLO = 'NULL';                                                  00269840
```

```
 LINE
   82      %/* END OF PREPROCESSOR STATEMENTS;  SOURCE STATEMENTS FOLLOW HERE: */;00269850


   83      SAMPLE:                                                               00269860
   84              PROC OPTIONS(MAIN);                                           00269870


   85              DECLARE (PDATE, PTIME) CHAR(6);                               00269880

   86              DECLARE CVAR CHAR(255) VAR;                                   00269890

   87              DCL     1  BINVAR,                                            00269900
   88                        2  RETCODE FIXED BIN(31,0),                         00269910
   89                        2  FBVAR FIXED BIN;                                 00269920


   90              PDATE = DATE;                                                 00269930
   91              PTIME = TIME;                                                 00269940
   92              PUT SKIP EDIT('SAMPLE PROGRAM: DATE = ', PDATE, ', TIME = ',  00269950
   93                            PTIME) (A(23), P'99/99/99', A(9), P'Z9.99.99'); 00269960
   94              RETCODE = 0101;                                               00269970


   95              ON ERROR                                                      00269980
   96        BEGIN;                                                              00269990
   97              CALL IHEDUMP;                                                 00270000


   98      /* THESE STATEMENTS ILLUSTRATE PREPROCESSOR REPLACEMENT AND USE OF    00270010
   99         BUILTIN FUNCTIONS.   THEY WILL NEVER BE EXECUTED.                */00270020

  100              CALL IHEDUMJ(127);                                            00270030
  101              CALL IHEDUMC(RETCODE);                                        00270040
  102              CALL IHEDUMT;                                                 00270050

  103              FBVAR = ONCODE;                                               00270060
  104              CVAR = ONCHAR;                                                00270070
  105              CVAR = ONSOURCE;                                              00270080
  106              CVAR = ONLOC;                                                 00270090
  107              CVAR = ONFILE;                                                00270100
  108              CVAR = ONKEY;                                                 00270110
```

```
      /* THIS STATEMENT, WHICH WILL NEVER BE EXECUTED, USES 'ONCOUNT' WHICH  00270120
         IS NEITHER EXPLICITLY NOR IMPLICITLY DECLARED BUILTIN.  THE EFFECT  00270130
         IS SHOWN IN THE ATTRIBUTE LISTING AND DIAGNOSTIC MESSAGES.        */00270140

              FBVAR = ONCOUNT;                                               00270150
        END;                                                                 00270160


      /* THIS IS A DUMMY PROCEDURE TO ILLUSTRATE OTHER PREPROCESSOR          00270170
         REPLACEMENTS/NON-IMPLICITLY DECLARED BUILTIN FUNCTIONS.             00270180
         IT WILL NEVER BE EXECUTED.                                        */00270190

      DUMMY:                                                                 00270200
              PROC;                                                          00270210

              DCL   AVAR AREA BASED(PVAR),                                   00270220
                    OVAR OFFSET(AVAR),                                       00270230
                    A ENTRY RETURNS(CHAR(80)),                               00270240
                    SIZE FIXED BIN(31,0);                                    00270250

              AVAR = EMPTY;                                                  00270260
              PVAR = NULL;                                                   00270270
              OVAR = NULLO;                                                  00270280

              CALL IHESRTA('ARG1', 'ARG2', SIZE, RETCODE);       /*  S     */00270290
              CALL IHESRTB('ARG1', 'ARG2', SIZE, RETCODE, A);    /*   O    */00270300
              CALL IHESRTC('ARG1', 'ARG2', SIZE, RETCODE, B);    /*    R   */00270310
              CALL IHESRTD('ARG1', 'ARG2', SIZE, RETCODE, A, B); /*     T  */00270320
              CALL IHECKPS('ARG1', 'ARG2', 'PS', RETCODE); /* CHECKPOINT   */00270330
              CALL IHECKPT; /* CHECKPOINT   */                               00270340
              CALL IHEREST;                                /* FORCE RESTRT */00270350
              CALL IHERESN;                                /* CANCEL CKPT  */00270360
              CALL IHETSAC(RETCODE);        /* SET RETURN CODE(TASKING)    */00270370

      A:      PROC RETURNS(CHAR(80));   END;               /*  DUMMY EXIT  */00270380
                                                           /*  PROCEDURES  */00270390
      B:      PROC(RECORD);   DCL RECORD CHAR(80);   END;  /*  FOR  SORT.  */00270400

              END DUMMY;                                                     00270410


              CALL IHESARC(RETCODE);        /* SET RETURN CODE(NONTASKING) */00270420
              PUT SKIP LIST('END SAMPLE PROGRAM');                           00270430


              END SAMPLE;                                                    00270440
```

```
PL/I OPTIMIZING COMPILER         /***** PL/I SAMPLE PROGRAM. *****/                                         PAGE    7

PREPROCESSOR DIAGNOSTIC MESSAGES
 (1)         (2)  (3)
ERROR ID L    LINE    MESSAGE DESCRIPTION


SEVERE AND ERROR DIAGNOSTIC MESSAGES


IEL0217I E    97      MISSING LEFT PARENTHESIS FROM ARGUMENT LIST FOR PROCEDURE 'IHEDUMP'.    PROCEDURE INVOKED WITHOUT
                      ARGUMENTS.

IEL0217I E    102     MISSING LEFT PARENTHESIS FROM ARGUMENT LIST FOR PROCEDURE 'IHEDUMT'.    PROCEDURE INVOKED WITHOUT
                      ARGUMENTS.

IEL0217I E    131     MISSING LEFT PARENTHESIS FROM ARGUMENT LIST FOR PROCEDURE 'IHECKPT'.    PROCEDURE INVOKED WITHOUT
                      ARGUMENTS.

WARNING DIAGNOSTIC MESSAGES


IEL0184I W    97      TOO FEW ARGUMENTS TO FUNCTION 'IHEDUMP'.    NULL STRINGS PASSED AS MISSING ARGUMENTS.

IEL0184I W    102     TOO FEW ARGUMENTS TO FUNCTION 'IHEDUMT'.    NULL STRINGS PASSED AS MISSING ARGUMENTS.

IEL0184I W    131     TOO FEW ARGUMENTS TO FUNCTION 'IHECKPT'.    NULL STRINGS PASSED AS MISSING ARGUMENTS.


END OF PREPROCESSOR DIAGNOSTIC MESSAGES
```

Diagnostic messages generated by the preprocessor. All messages generated by the optimizing compiler (including the preprocessor) are documented in the publication OS Optimizing Compiler: Messages.

1. "ERROR ID" This identifies the message as originating from the optimizing compiler (IEL), and gives the message number.

2. "L" This is the severity level of the message.

3. "LINE" This gives the number of the line in which the error occurred.

```
                     SOURCE LISTING
 1                                                                            3
STMT LEV NT                                                                   R
                                                                          2
          /***** PL/I SAMPLE PROGRAM. *****/                          00269040
   1    0 SAMPLE:                                                     00269860
                  PROC OPTIONS(MAIN);                                 00269870

   2  1 0         DCL (DATE,TIME,ONCHAR,ONSOURCE,ONCODE,ONLOC,ONFILE,ONKEY,EMPTY,00269880  2
          NULL) BUILTIN, CKPT_RETC FIXED BIN(31), (PDATE, PTIME) CHAR(6);       00269880  1

   3  1 0         DCL CVAR CHAR(255) VAR;                             00269890  2

   4  1 0         DCL     1  BINVAR,                                  00269900  1
                             2  RETCODE FIXED BIN(31,0),              00269910
                             2  FBVAR FIXED BIN;                      00269920

   5  1 0         PDATE = DATE;                                       00269930
   6  1 0         PTIME = TIME;                                       00269940
   7  1 0         PUT SKIP EDIT('SAMPLE PROGRAM: DATE = ', PDATE, ', TIME = ',  00269950
                         PTIME) (A(23), P'99/99/99', A(9), P'Z9.99.99');  00269960
   8  1 0         RETCODE = 0101;                                     00269970

   9  1 0         ON ERROR                                            00269980
            BEGIN;                                                    00269990  4
  10  2 0         CALL PLIDUMP;                                       00270000  1E

          /* THESE STATEMENTS ILLUSTRATE PREPROCESSOR REPLACEMENT AND USE OF   00270010
             BUILTIN FUNCTIONS.   THEY WILL NEVER BE EXECUTED.               */00270020

  11  2 0         CALL PLIDUMP('TFCA','127');                         00270030  1
  12  2 0         CALL PLIDUMP('TFCA','RETCODE');                     00270040  1
  13  2 0         CALL PLIDUMP;                                       00270050  1E

  14  2 0         FBVAR = ONCODE;                                     00270060
  15  2 0         CVAR = ONCHAR;                                      00270070
  16  2 0         CVAR = ONSOURCE;                                    00270080
  17  2 0         CVAR = ONLOC;                                       00270090
  18  2 0         CVAR = ONFILE;                                      00270100
  19  2 0         CVAR = ONKEY;                                       00270110
```

Source listing. This is the output from the preprocessor and the input to the compiler. All the preprocessor statements have been executed and all preprocessor comments have been deleted

1 Statement nesting levels.

2 Line numbers brought forward from the preprocessor input.

3 Maximum depth of replacement.

4 "E" in this column indicates that an error has occurred during a replacement attempt.

```
STMT LEV NT                                                                                        R

                 /* THIS STATEMENT, WHICH WILL NEVER BE EXECUTED, USES 'ONCOUNT' WHICH  00270120
                    IS NEITHER EXPLICITLY NOR IMPLICITLY DECLARED BUILTIN.  THE EFFECT  00270130
                    IS SHOWN IN THE ATTRIBUTE LISTING AND DIAGNOSTIC MESSAGES.        */00270140

  20   2  0             FBVAR = ONCOUNT;                                                00270150
  21   2  0       END;                                                                  00270160

                 /* THIS IS A DUMMY PROCEDURE TO ILLUSTRATE OTHER PREPROCESSOR          00270170
                    REPLACEMENTS/NON-IMPLICITLY DECLARED BUILTIN FUNCTIONS.             00270180
                    IT WILL NEVER BE EXECUTED.                                        */00270190

  22   1  0  DUMMY:                                                                     00270200
                        PROC;                                                           00270210

  23   2  0             DCL    AVAR AREA BASED(PVAR),                                   00270220  1
                               OVAR OFFSET(AVAR),                                       00270230
                               A ENTRY RETURNS(CHAR(80)),                               00270240
                               SIZE FIXED BIN(31,0);                                    00270250

  24   2  0             AVAR = EMPTY;                                                   00270260
  25   2  0             PVAR = NULL;                                                    00270270
  26   2  0             OVAR = NULL;                                                    00270280  1

  27   2  0             CALL PLISRTA('ARG1', 'ARG2', SIZE, RETCODE);       /*  S      */00270290  1
  28   2  0             CALL PLISRTB('ARG1', 'ARG2', SIZE, RETCODE, A);    /*   O     */00270300  1
  29   2  0             CALL PLISRTC('ARG1', 'ARG2', SIZE, RETCODE, B);    /*    R    */00270310  1
  30   2  0             CALL PLISRTD('ARG1', 'ARG2', SIZE, RETCODE, A, B); /*     T   */00270320  1
  31   2  0             CALL PLICKPT('ARG1', 'ARG2', 'PS', RETCODE); /* CHECKPOINT    */00270330  1
  32   2  0             CALL PLICKPT('SYSCHK', '', 'PS', CKPT_RETC); /* CHECKPOINT    */00270340  1E
                                                                                        00270340
  33   2  0             CALL PLIREST;                                /* FORCE RESTRT */00270350  1
  34   2  0             CALL PLICANC;                                /* CANCEL CKPT  */00270360  1
  35   2  0             CALL PLIRETC(RETCODE);        /* SET RETURN CODE(TASKING)     */00270370  1

  36   2  0  A:         PROC RETURNS(CHAR(80));   END;               /*  DUMMY EXIT  */00270380
                                                                     /*  PROCEDURES  */00270390
  38   2  0  B:         PROC(RECORD);   DCL RECORD CHAR(80);   END;  /*  FOR  SORT.  */00270400  1

  41   2  0             END DUMMY;                                                      00270410

  42   1  0             CALL PLIRETC(RETCODE);        /* SET RETURN CODE(NONTASKING) */00270420  1
  43   1  0             PUT SKIP LIST('END SAMPLE PROGRAM');                            00270430

  44   1  0             END SAMPLE;                                                     00270440
```

ATTRIBUTE AND CROSS-REFERENCE TABLE

1 DCL NO.	3 IDENTIFIER	ATTRIBUTES AND REFERENCES
36	A	4 ENTRY RETURNS(CHARACTER (80)) 5 28,30
23	AVAR	BASED (PVAR) ALIGNED AREA (1000) 24
38	B	ENTRY RETURNS(DECIMAL /* SINGLE */ FLOAT (6)) 29,30
4	BINVAR	AUTOMATIC /* STRUCTURE */
2	CKPT_RETC	AUTOMATIC ALIGNED BINARY FIXED (31,0) 32
3	CVAR	AUTOMATIC UNALIGNED CHARACTER (255) VARYING 15,16,17,18,19
2	DATE	BUILTIN 5
22	DUMMY	ENTRY RETURNS(DECIMAL /* SINGLE */ FLOAT (6))
2	EMPTY	BUILTIN 24
4	FBVAR	/* IN BINVAR */ AUTOMATIC ALIGNED BINARY FIXED (15,0) 14,20
2	NULL	BUILTIN 25,26
2	ONCHAR	BUILTIN 15
2	ONCODE	BUILTIN 14
******** 2	ONCOUNT	AUTOMATIC ALIGNED DECIMAL /* SINGLE */ FLOAT (6) 20
2	ONFILE	BUILTIN 18

Attributes and Cross-reference Table.

1 Number of the statement in the source listing in which the identifier is explicitly declared.

2 Asterisks indicate an undeclared identifier; all of its attributes are implied or supplied by default.

3 All identifiers used in the program listed in alphabetic order.

4 Declared and default attributes are listed. This list also includes descriptive comments.

5 Cross references. These are the numbers of all other statements in which the identifier appears.

PL/I OPTIMIZING COMPILER /***** PL/I SAMPLE PROGRAM. *****/ PAGE 11

DCL NO.	IDENTIFIER	ATTRIBUTES AND REFERENCES
2	ONKEY	BUILTIN 19
2	ONLOC	BUILTIN 17
2	ONSOURCE	BUILTIN 16
23	OVAR	AUTOMATIC ALIGNED OFFSET (AVAR) 26
2	PDATE	AUTOMATIC UNALIGNED CHARACTER (6) 5,7
********	PLICANC	BUILTIN 34
********	PLICKPT	BUILTIN 31,32
********	PLIDUMP	BUILTIN 10,11,12,13
********	PLIREST	BUILTIN 33
********	PLIRETC	BUILTIN 42 35
********	PLISRTA	BUILTIN 27
********	PLISRTB	BUILTIN 28
********	PLISRTC	BUILTIN 29
********	PLISRTD	BUILTIN 30
2	PTIME	AUTOMATIC UNALIGNED CHARACTER (6) 6,7
********	PVAR	AUTOMATIC ALIGNED POINTER 24,25

DCL NO.	IDENTIFIER	ATTRIBUTES AND REFERENCES
39	RECORD	/* PARAMETER */ UNALIGNED CHARACTER (80)
4	RETCODE	/* IN BINVAR */ AUTOMATIC ALIGNED BINARY FIXED (31,0) 8,42 27,28,29,30,31,35
1	SAMPLE	EXTERNAL ENTRY RETURNS(DECIMAL /* SINGLE */ FLOAT (6))
23	SIZE	AUTOMATIC ALIGNED BINARY FIXED (31,0) 27,28,29,30
********	SYSPRINT	EXTERNAL FILE PRINT 7,43
2	TIME	BUILTIN 6

AGGREGATE LENGTH TABLE

(1) DCL NO.	(2) IDENTIFIER	LVL	DIMS	OFFSET	(3) ELEMENT LENGTH.	TOTAL LENGTH.
4	BINVAR	1			6	6
	RETCODE	2		0	4	
	FBVAR	2		4	2	
					SUM OF CONSTANT LENGTHS (4)	6

Aggregate Length Table.

(1) Number of the statement in which the aggregate is declared, or, for a controlled aggregate, the number of the associated ALLOCATE statement.

(2) The elements of the aggregate as declared.

(3) Length of each element of the aggregate.

(4) Sum of the lengths of aggregates whose lengths are constant.

STORAGE REQUIREMENTS

1 BLOCK, SECTION OR STATEMENT	2 TYPE	3 LENGTH	(HEX)	4 DSA SIZE	(HEX)
*SAMPLE1	PROGRAM CSECT	2156	86C		
*SAMPLE2	STATIC CSECT	788	314		
SAMPLE	PROCEDURE BLOCK	454	1C6	552	228
9	ON UNIT	630	276	224	E0
DUMMY	PROCEDURE BLOCK	834	342	232	E8
A	PROCEDURE BLOCK	106	6A	184	B8
B	PROCEDURE BLOCK	124	7C	200	C8

Storage requirements. This table gives the main storage requirements for the program. These quantities do not include the main storage that will be required by the resident and transient library subroutines that will be included by the linkage editor or loaded dynamically during execution.

1. Name of the block, section, or number of the statement in the program.

2. Description of the block, section, or statement.

3. Length in bytes of the storage areas in both decimal and hexadecimal notation.

4. Length in bytes of the dynamic storage area (DSA) in both decimal and hexadecimal notation.

EXTERNAL SYMBOL DICTIONARY

1 SYMBOL	2 TYPE	3 ID	4 ADDR	5 LENGTH
PLISTART	SD	0001	000000	000044
*SAMPLE1	SD	0002	000000	00086C
*SAMPLE2	SD	0003	000000	000314
PLITABS	WX	0004	000000	
PLIXOPT	WX	0005	000000	
PLIFLOW	WX	0006	000000	
PLICOUNT	WX	0007	000000	
IBMBPIRA	ER	0008	000000	
IBMBPIRB	ER	0009	000000	
IBMBPIRC	ER	000A	000000	
PLICALLA	LD		000006	
PLICALLB	LD		00000A	
PLIMAIN	SD	000B	000000	000008
IBMBKCPC	ER	000C	000000	
IBMBKCPA	ER	000D	000000	
IBMBKCPB	ER	000E	000000	
IBMBKCPA	ER	000F	000000	
IBMBKCPA	ER	0010	000000	
IBMBKSTD	ER	0011	000000	
IBMBKSTA	ER	0012	000000	
IBMBKSTC	ER	0013	000000	
IBMBKSTA	ER	0014	000000	
IBMBKSTB	ER	0015	000000	
IBMBKSTA	ER	0016	000000	
IBMBKSTA	ER	0017	000000	
IBMBKDMA	ER	0018	000000	
IBMBPRCA	ER	0019	000000	
IELCGOA	SD	001A	000000	000072
IELCGOB	SD	001B	000000	000070
IBMBSEDA	ER	001C	000000	
IBMBSIOA	ER	001D	000000	
IBMBCCSA	ER	001E	000000	
IBMBCHFD	ER	001F	000000	
IBMBCODE	ER	0020	000000	
IBMBCTHD	ER	0021	000000	
IBMBCUID	ER	0022	000000	
IBMBEOCA	ER	0023	000000	
IBMBEOLA	ER	0024	000000	
IBMBJDTA	ER	0025	000000	
IBMBJTTA	ER	0026	000000	
IBMBOCLA	ER	0027	000000	
IBMBOCLC	WX	0028	000000	
IBMBSEDB	WX	0029	000000	
IBMBSEOA	ER	002A	000000	
IBMBSIOE	WX	002B	000000	
IBMBSIOT	WX	002C	000000	
IBMBSLOA	ER	002D	000000	

External symbol dictionary.

1 "SYMBOL" A list of all the external symbols that make up the object module.

2 "TYPE" Type of external symbol as follows:
- CM Common area.
- ER External reference.
- LD Label definition.
- PR Pseudo-register.
- SD Section definition.
- WX Weak external reference.

Full definitions of all these terms are given in chapter 4.

3 "ID" All entries, except LD-type entries, are identified by a hexadecimal number.

4 "ADDR" Address (in hexadecimal) of LD-type entries only.

5 "LENGTH" Length in bytes (in hexadecimal) of LD, CM, and PR type entries only.

```
IBMBSPLA      ER     002E    000000
IBMBSPOA      ER     002F    000000
IBMBCKDD      ER     0030    000000
IBMBSXCA      WX     0031    000000
IBMBSXCB      WX     0032    000000
IBMBSIST      WX     0033    000000
SAMPLE        LD             000008
SYSPINT       SD     0034    000000    000020
```

STATIC INTERNAL STORAGE MAP

1	2	3
000000	00000310	PROGRAM ADCON
000004	00000008	PROGRAM ADCON
000008	00000078	PROGRAM ADCON
00000C	00000096	PROGRAM ADCON
000010	000001C8	PROGRAM ADCON
000014	0000021E	PROGRAM ADCON
000018	00000448	PROGRAM ADCON
00001C	0000049E	PROGRAM ADCON
000020	000004A8	PROGRAM ADCON
000024	00000788	PROGRAM ADCON
000028	000007DE	PROGRAM ADCON
00002C	000007F4	PROGRAM ADCON
000030	0000085C	PROGRAM ADCON
000034	0000085C	PROGRAM ADCON
000038	0000085C	PROGRAM ADCON
00003C	0000085C	PROGRAM ADCON
000040	0000085C	PROGRAM ADCON
000044	00000000	A..IELCGOA
000048	00000000	A..IELCGOB
00004C	00000000	A..IBMBCCSA
000050	00000000	A..IBMBCHFD
000054	00000000	A..IBMBCODE
000058	00000000	A..IBMBCTHD
00005C	00000000	A..IBMBCUID
000060	00000000	A..IBMBEOCA
000064	00000000	A..IBMBEOLA
000068	00000000	A..IBMBJDTA
00006C	00000000	A..IBMBJTTA
000070	00000000	A..IBMBOCLA
000074	00000000	A..IBMBOCLC
000078	00000000	A..IBMBSEDB
00007C	00000000	A..IBMBSEOA
000080	00000000	A..IBMBSIOE
000084	00000000	A..IBMBSIOT
000088	00000000	A..IBMBSLOA
00008C	00000000	A..IBMBSPLA
000090	00000000	A..IBMBSPOA
000094	00000000	A..IBMBCKDD
000098	58000017	FED
00009C	2000	DED..PDATE
00009E	5400000814040680	FED
	0808000000006800	
	00680000	
0000B2	58000009	FED
0000B6	5400000814040680	FED
	0808000008007400	
	00740000	
0000CA	0001	CONSTANT
0000CC		
0000D0	0000000000060000	LOCATOR..PDATE

0000D8	000001DC00120000	LOCATOR
0000E0	0000000000040000	LOCATOR
0000E8	0000000000030000	LOCATOR
0000F0	0000000000070000	LOCATOR
0000F8	0000000000020000	LOCATOR
000100	0000000000000000	LOCATOR
000108	91E091E0	CONSTANT
00010C	00000001	CONSTANT
000110	00000065	CONSTANT
000114	46000000	CONSTANT
000118	00000010	CONSTANT
00011C	FF000000	CONSTANT
000120	00000000	A..DCLCB
000124	80000000	A..PDATE
000128	80000000	A..TEMP
00012C	00000000	A..DCLCB
000130	00000000	A..TEMP
000134	8000010C	A..CONSTANT
000138	00000000	A..ENTRY PLIRETC
00013C	00000000	A..ENTRY PLIDUMP
000140	00000000	A..TEMP
000144	80000000	A..TEMP
000148	80000000	A..FBVAR
00014C	80000000	A..TEMP
000150	00000000	A..TEMP
000154	00000000	A..TEMP
000158	00000000	A..SIZE
00015C	80000000	A..RETCODE
000160	00000000	A..ENTRY PLISRTA
000164	00000000	A..TEMP
000168	00000000	A..TEMP
00016C	00000000	A..SIZE
000170	00000000	A..RETCODE
000174	80000000	A..TEMP
000178	00000000	A..ENTRY PLISRTB
00017C	00000000	A..ENTRY PLISRTC
000180	00000000	A..TEMP
000184	00000000	A..TEMP
000188	00000000	A..SIZE
00018C	00000000	A..RETCODE
000190	00000000	A..TEMP
000194	80000000	A..TEMP
000198	00000000	A..ENTRY PLISRTD
00019C	00000000	A..TEMP
0001A0	00000000	A..TEMP
0001A4	00000000	A..TEMP
0001A8	80000000	A..RETCODE
0001AC	00000000	A..ENTRY PLICKPT
0001B0	00000000	A..ENTRY PLIREST
0001B4	00000000	A..ENTRY PLICANC
0001B8	80000000	A..RETCODE
0001BC	E2C1D4D7D3C540D7	CONSTANT

Static Internal Storage Map. This is a storage map of the static control section for the program. This control section is the third standard entry in the external symbol dictionary.

1 Six-digit offset (in hexadecimal).

2 Text (in hexadecimal).

3 Comment indicating type of item to which the text refers. A comment appears only against the first line of the text for an item.

```
        D9D6C7D9C1D47A40
        C4C1E3C5407E40
0001D3  6B40E3C9D4C5407E      CONSTANT
        40
0001DC  C5D5C440E2C1D4D7      CONSTANT
        D3C540D7D9D6C7D9
        C1D4
0001EE  E3C6C3C1              CONSTANT
0001F2  F1F2F7                CONSTANT
0001F5  D9C5E3C3D6C4C5        CONSTANT
0001FC  C1D9C7F1              CONSTANT
000200  C1D9C7F2              CONSTANT
000204  D7E2                  CONSTANT
000206  E2E8E2C3C8D2          CONSTANT
00020C
000210  0C160000000001C8      STATIC ONCB
```

STATIC EXTERNAL CSECTS

```
000000  FFFFFFFC41201000      DCLCB
        02D70F0000000000
        011300140008E2E8
        E2D7D9C9D5E39040
```

PL/I OPTIMIZING COMPILER /***** PL/I SAMPLE PROGRAM. *****/ PAGE 19

VARIABLE STORAGE MAP

IDENTIFIER	LEVEL	OFFSET	(HEX)	CLASS	BLOCK
BINVAR		192	C0	AUTO	SAMPLE
RETCODE		192	C0	AUTO	SAMPLE
FBVAR		196	C4	AUTO	SAMPLE
CVAR		224	E0	AUTO	SAMPLE
CKPT_RETC		200	C8	AUTO	SAMPLE
PDATE		212	D4	AUTO	SAMPLE
PTIME		218	DA	AUTO	SAMPLE
OVAR	2	168	A8	AUTO	DUMMY
SIZE	2	172	AC	AUTO	DUMMY
PVAR		204	CC	AUTO	SAMPLE
ONCOUNT		208	D0	AUTO	SAMPLE

TABLES OF OFFSETS AND STATEMENT NUMBERS

WITHIN PROCEDURE SAMPLE

OFFSET (HEX)	0	8E	A4	C0	150	158	15C	174	1AE
STATEMENT NO.	1	5	6	7	8	9	42	43	44

WITHIN ON UNIT

OFFSET (HEX)	0	56	60	A8	F0	FA	118	13E	180	1C4	206	248	266
STATEMENT NO.	9	10	11	12	13	14	15	16	17	18	19	20	21

WITHIN PROCEDURE DUMMY

OFFSET (HEX)	0	60	70	78	7C	D4	140	1AC	22C	298	2FE	308	312	32A
STATEMENT NO.	22	24	25	26	27	28	29	30	31	32	33	34	35	41

WITHIN PROCEDURE A

OFFSET (HEX)	0	56
STATEMENT NO.	36	37

WITHIN PROCEDURE B

OFFSET (HEX)	0	68
STATEMENT NO.	38	40

```
 OBJECT LISTING
         1                                       2

* COMPILER GENERATED SUBROUTINE IELCGOA
000000  50 E0 1 00C                  ST     14,12(0,1)
000004  58 F0 1 014                  L      15,20(0,1)
000008  91 10 1 011                  TM     17(1),X'10'
00000C  47 10 7 014                  BO     *+8
000010  96 04 C 002                  OI     2(12),X'04'
000014  D2 03 1 008 F 04C            MVC    8(4,1),76(15)
00001A  48 F0 F 050                  LH     15,80(0,15)
00001E  4B F0 E 002                  SH     15,2(0,14)
000022  07 B6                        BCR    11,6
000024  96 40 1 010                  OI     16(1),X'40'
000028  58 F0 D 04C                  L      15,76(0,13)
00002C  50 F0 1 008                  ST     15,8(0,1)
000030  4A F0 E 002                  AH     15,2(0,14)
000034  4A F0 7 070                  AH     15,112(0,7)
000038  54 F0 7 06C                  N      15,108(0,7)
00003C  55 F0 C 00C                  CL     15,12(0,12)
000040  47 20 7 04A                  BH     *+10
000044  50 F0 D 04C                  ST     15,76(0,13)
000048  07 F6                        BR     6
00004A  50 00 1 01C                  ST     0,28(0,1)
00004E  18 71                        LR     7,1
000050  18 0F                        LR     0,15
000052  58 10 D 04C                  L      1,76(0,13)
000056  58 F0 C 048                  L      15,72(0,12)
00005A  05 EF                        BALR   14,15
00005C  50 00 D 04C                  ST     0,76(0,13)
000060  50 10 7 008                  ST     1,8(0,7)
000064  18 17                        LR     1,7
000066  58 00 1 01C                  L      0,28(0,1)
00006A  07 F6                        BR     6
00006C  FFFFFFF8                     DC     X'FFFFFFF8'
000070                               DC     AL2(7)

* END OF COMPILER GENERATED SUBROUTINE

* COMPILER GENERATED SUBROUTINE IELCGOB
000000  94 FB C 002                  NI     2(12),X'FB'
000004  91 40 1 010                  TM     16(1),X'40'
000008  47 10 7 052                  BO     *+74
00000C  58 F0 1 014                  L      15,20(0,1)
000010  50 70 1 01C                  ST     7,28(0,1)
000014  58 70 1 00C                  L      7,12(0,1)
000018  48 E0 F 050                  LH     14,80(0,15)
00001C  4B E0 7 002                  SH     14,2(0,7)
000020  40 E0 F 050                  STH    14,80(0,15)
000024  58 E0 F 04C                  L      14,76(0,15)
000028  4A E0 7 002                  AH     14,2(0,7)
00002C  50 E0 F 04C                  ST     14,76(0,15)
000030  48 E0 1 020                  LH     14,32(0,1)
000034  41 E0 E 001                  LA     14,1(0,14)
000038  40 E0 1 020                  STH    14,32(0,1)
00003C  40 E0 F 052                  STH    14,82(0,15)
000040  91 10 1 010                  TM     16(1),X'10'
000044  07 86                        BCR    8,6
000046  58 70 1 01C                  L      7,28(0,1)
00004A  58 F0 7 068                  L      15,104(0,7)
00004E  05 EF                        BALR   14,15
000050  07 F6                        BR     6
000052  58 F0 7 06C                  L      15,108(0,7)
000056  05 EF                        BALR   14,15
000058  58 E0 1 008                  L      14,8(0,1)
00005C  50 E0 D 04C                  ST     14,76(0,13)
000060  94 BF 1 010                  NI     16(1),X'BF'
000064  07 F6                        BR     6
000066  07 00                        NOPR   0
000068                               DC     AL4(0)
00006C                               DC     AL4(0)

* END OF COMPILER GENERATED SUBROUTINE

* STATEMENT NUMBER  1
000000                               DC     C' SAMPLE'
000007                               DC     AL1(6)

* PROCEDURE                                 SAMPLE

* REAL ENTRY
000008  90 EC D 00C                  STM    14,12,12(13)
00000C  47 F0 F 014                  B      *+16
000010  00000000                     DC     A(STMT. NO. TABLE)
000014  00000228                     DC     F'552'
000018  00000000                     DC     A(STATIC CSECT)
00001C  58 30 F 010                  L      3,16(0,15)
000020  58 10 D 04C                  L      1,76(0,13)
000024  58 00 F 00C                  L      0,12(0,15)
000028  1E 01                        ALR    0,1
00002A  55 00 C 00C                  CL     0,12(0,12)
00002E  47 D0 F 030                  BNH    *+10
000032  58 F0 C 074                  L      15,116(0,12)
000036  05 EF                        BALR   14,15
000038  58 E0 D 048                  L      14,72(0,13)
00003C  18 F0                        LR     15,0
00003E  90 E0 1 048                  STM    14,0,72(1)
000042  50 D0 1 004                  ST     13,4(0,1)
000046  41 D1 0 000                  LA     13,0(1,0)
00004A  50 50 D 058                  ST     5,88(0,13)
00004E  41 60 D 0A8                  LA     6,168(0,13)
000052  50 60 D 070                  ST     6,112(0,13)
000056  D7 00 D 0A8 D 0A8            XC     168(1,13),168(13)
```

Object listing. This is a listing of the machine instructions generated by the optimizing compiler from the PL/I source program.

1 Machine instructions (in hexadecimal).

2 Assembler-language form of the machine instructions.

```
00005C  92 01 D 0A9          MVI   169(13),X'01'
000060  92 C0 D 000          MVI   0(13),X'C0'
000064  92 24 D 001          MVI   1(13),X'24'
000068  41 80 3 210          LA    8,528(0,3)
00006C  50 80 D 05C          ST    8,92(0,13)
000070  D2 03 D 054 3 108    MVC   84(4,13),264(3)
000076  05 20                BALR  2,0

* PROLOGUE BASE
000078  D2 07 D 0B0 3 0D0    MVC   LOCATOR..PDATE(8),
                                   208(3)
00007E  41 90 D 0D4          LA    9,PDATE
000082  50 90 D 0B0          ST    9,LOCATOR..PDATE
000086  D2 07 D 0B8 3 0D0    MVC   LOCATOR..PTIME(8),
                                   208(3)
00008C  41 40 D 0DA          LA    4,PTIME
000090  50 40 D 0B8          ST    4,LOCATOR..PTIME
000094  05 20                BALR  2,0

* PROCEDURE BASE


* STATEMENT NUMBER  5
000096  41 40 D 0D4          LA    4,PDATE
00009A  50 40 3 124          ST    4,292(0,3)
00009E  96 80 3 124          OI    292(3),X'80'
0000A2  41 10 3 124          LA    1,292(0,3)
0000A6  58 F0 3 068          L     15,A..IBMBJDTA
0000AA  05 EF                BALR  14,15


* STATEMENT NUMBER  6
0000AC  41 40 D 200          LA    4,512(0,13)
0000B0  50 40 3 128          ST    4,296(0,3)
0000B4  96 80 3 128          OI    296(3),X'80'
0000B8  41 10 3 128          LA    1,296(0,3)
0000BC  58 F0 3 06C          L     15,A..IBMBJTTA
0000C0  05 EF                BALR  14,15
0000C2  D2 05 D 0DA D 200    MVC   PTIME(6),512(13)


* STATEMENT NUMBER  7
0000C8  41 40 D 200          LA    4,512(0,13)
0000CC  50 40 3 130          ST    4,304(0,3)
0000D0  92 20 D 211          MVI   529(13),X'20'
0000D4  41 10 3 12C          LA    1,300(0,3)
0000D8  58 F0 3 080          L     15,A..IBMBSIOE
0000DC  05 EF                BALR  14,15
0000DE  41 E0 3 098          LA    14,152(0,3)
0000E2  41 10 D 200          LA    1,512(0,13)
0000E6  50 10 D 1F8          ST    1,504(0,13)
0000EA  58 70 3 044          L     7,A..IELCGOA
```

```
0000EE  05 67                BALR  6,7
0000F0  58 40 D 208          L     4,520(0,13)
0000F4  D2 16 4 000 3 1BC    MVC   0(23,4),444(3)
0000FA  58 70 3 048          L     7,A..IELCGOB
0000FE  05 67                BALR  6,7
000100  41 E0 D 0B0          LA    14,176(0,13)
000104  41 F0 3 09C          LA    15,DED..PDATE
000108  90 EF 1 000          STM   14,15,0(1)
00010C  41 E0 3 09E          LA    14,158(0,3)
000110  50 E0 1 00C          ST    14,12(0,1)
000114  58 F0 3 078          L     15,A..IBMBSEDB
000118  05 EF                BALR  14,15
00011A  41 E0 3 0B2          LA    14,178(0,3)
00011E  58 10 D 1F8          L     1,504(0,13)
000122  58 70 3 044          L     7,A..IELCGOA
000126  05 67                BALR  6,7
000128  58 60 D 208          L     6,520(0,13)
00012C  D2 08 6 000 3 1D3    MVC   0(9,6),467(3)
000132  58 70 3 048          L     7,A..IELCGOB
000136  05 67                BALR  6,7
000138  41 E0 D 0B8          LA    14,184(0,13)
00013C  50 E0 1 000          ST    14,0(0,1)
000140  41 E0 3 0B6          LA    14,182(0,3)
000144  50 E0 1 00C          ST    14,12(0,1)
000148  58 F0 3 078          L     15,A..IBMBSEDB
00014C  05 EF                BALR  14,15
00014E  58 10 D 1F8          L     1,504(0,13)
000152  58 F0 3 084          L     15,A..IBMBSIOT
000156  05 EF                BALR  14,15


* STATEMENT NUMBER  8
000158  58 F0 3 110          L     15,272(0,3)
00015C  50 F0 D 0C0          ST    15,BINVAR.RETCODE


* STATEMENT NUMBER  9
000160  92 0C D 0A8          MVI   168(13),X'0C'


* STATEMENT NUMBER  42
000164  41 40 D 0C0          LA    4,BINVAR.RETCODE
000168  50 40 3 124          ST    4,292(0,3)
00016C  96 80 3 124          OI    292(3),X'80'
000170  1B 55                SR    5,5
000172  41 10 3 124          LA    1,292(0,3)
000176  58 F0 3 138          L     15,312(0,3)
00017A  05 EF                BALR  14,15


* STATEMENT NUMBER  43
00017C  41 40 D 200          LA    4,512(0,13)
```

```
PL/I OPTIMIZING COMPILER          /***** PL/I SAMPLE PROGRAM. *****/                                  PAGE  23

000180   50 40 3 130              ST    4,304(0,3)
000184   92 40 D 211              MVI   529(13),X'40'
000188   41 10 3 12C              LA    1,300(0,3)
00018C   58 F0 3 080              L     15,A..IBMBSIOE
000190   05 EF                    BALR  14,15
000192   41 E0 3 0D8              LA    14,216(0,3)
000196   41 F0 3 09C              LA    15,156(0,3)
00019A   41 10 D 200              LA    1,512(0,13)
00019E   50 10 D 1F8              ST    1,504(0,13)
0001A2   90 EF 1 000              STM   14,15,0(1)
0001A6   58 F0 3 088              L     15,A..IBMBSLOA
0001AA   05 EF                    BALR  14,15
0001AC   58 10 D 1F8              L     1,504(0,13)
0001B0   58 F0 3 084              L     15,A..IBMBSIOT
0001B4   05 EF                    BALR  14,15


* STATEMENT NUMBER  44
0001B6   18 0D                    LR    0,13
0001B8   58 D0 D 004              L     13,4(0,13)
0001BC   58 E0 D 00C              L     14,12(0,13)
0001C0   98 2C D 01C              LM    2,12,28(13)
0001C4   05 1E                    BALR  1,14

* END PROCEDURE
0001C6   07 07                    NOPR  7


* STATEMENT NUMBER  9


* ON UNIT BLOCK
0001C8   90 EC D 00C              STM   14,12,12(13)
0001CC   47 F0 F 014              B     20(0,15)
0001D0   00000000                 DC    A(STMT. NO. TABLE)
0001D4   000000E0                 DC    F'224'
0001D8   00000000                 DC    A(STATIC CSECT)
0001DC   58 30 F 010              L     3,16(0,15)
0001E0   58 10 D 04C              L     1,76(0,13)
0001E4   58 00 F 00C              L     0,12(0,15)
0001E8   1E 01                    ALR   0,1
0001EA   55 00 C 00C              CL    0,12(0,12)
0001EE   47 D0 F 030              BNH   48(0,15)
0001F2   58 F0 C 074              L     15,116(0,12)
0001F6   05 EF                    BALR  14,15
0001F8   58 E0 D 048              L     14,72(0,13)
0001FC   18 F0                    LR    15,0
0001FE   90 E0 1 048              STM   14,0,72(1)
000202   50 D0 1 004              ST    13,4(0,1)
000206   41 D1 0 000              LA    13,0(1,0)
00020A   50 50 D 058              ST    5,88(0,13)
00020E   92 8C D 000              MVI   0(13),X'8C'
000212   92 24 D 001              MVI   1(13),X'24'
000216   D2 03 D 054 3 108        MVC   84(4,13),264(3)
00021C   05 20                    BALR  2,0

* PROCEDURE BASE


* STATEMENT NUMBER  10
00021E   1B 11                    SR    1,1
000220   1B 55                    SR    5,5
000222   58 F0 3 13C              L     15,316(0,3)
000226   05 EF                    BALR  14,15


* STATEMENT NUMBER  11
000228   D2 03 D 0C0 3 1EE        MVC   192(4,13),494(3)
00022E   D2 07 D 0C4 3 0E0        MVC   196(8,13),224(3)
000234   41 80 D 0C0              LA    8,192(0,13)
000238   50 80 D 0C4              ST    8,196(0,13)
00023C   41 40 D 0C4              LA    4,196(0,13)
000240   50 40 3 140              ST    4,320(0,3)
000244   D2 02 D 0CC 3 1F2        MVC   204(3,13),498(3)
00024A   D2 07 D 0D0 3 0E8        MVC   208(8,13),232(3)
000250   41 E0 D 0CC              LA    14,204(0,13)
000254   50 E0 D 0D0              ST    14,208(0,13)
000258   41 40 D 0D0              LA    4,208(0,13)
00025C   50 40 3 144              ST    4,324(0,3)
000260   96 80 3 144              OI    324(3),X'80'
000264   1B 55                    SR    5,5
000266   41 10 3 140              LA    1,320(0,3)
00026A   58 F0 3 13C              L     15,316(0,3)
00026E   05 EF                    BALR  14,15


* STATEMENT NUMBER  12
000270   D2 03 D 0C0 3 1EE        MVC   192(4,13),494(3)
000276   D2 07 D 0C4 3 0E0        MVC   196(8,13),224(3)
00027C   41 80 D 0C0              LA    8,192(0,13)
000280   50 80 D 0C4              ST    8,196(0,13)
000284   41 40 D 0C4              LA    4,196(0,13)
000288   50 40 3 140              ST    4,320(0,3)
00028C   D2 06 D 0CC 3 1F5        MVC   204(7,13),501(3)
000292   D2 07 D 0D4 3 0F0        MVC   212(8,13),240(3)
000298   41 80 D 0CC              LA    8,204(0,13)
00029C   50 80 D 0D4              ST    8,212(0,13)
0002A0   41 40 D 0D4              LA    4,212(0,13)
0002A4   50 40 3 144              ST    4,324(0,3)
0002A8   96 80 3 144              OI    324(3),X'80'
0002AC   1B 55                    SR    5,5
0002AE   41 10 3 140              LA    1,320(0,3)
0002B2   58 F0 3 13C              L     15,316(0,3)
0002B6   05 EF                    BALR  14,15
```

```
* STATEMENT NUMBER  13
0002B8  1B 11                     SR    1,1
0002BA  1B 55                     SR    5,5
0002BC  58 F0 3 13C               L     15,316(0,3)
0002C0  05 EF                     BALR  14,15

* STATEMENT NUMBER  14
0002C2  58 60 D 058               L     6,88(0,13)
0002C6  50 60 D 0B0               ST    6,176(0,13)
0002CA  41 40 6 0C4               LA    4,BINVAR.FBVAR
0002CE  50 40 3 148               ST    4,328(0,3)
0002D2  96 80 3 148               OI    328(3),X'80'
0002D6  41 10 3 148               LA    1,328(0,3)
0002DA  58 F0 3 060               L     15,A..IBMBEOCA
0002DE  05 EF                     BALR  14,15

* STATEMENT NUMBER  15
0002E0  58 40 D 048               L     4,72(0,13)
0002E4  4A 40 4 002               AH    4,2(0,4)
0002E8                    CL.16   EQU   *
0002E8  58 40 4 000               L     4,0(0,4)
0002EC  91 40 4 006               TM    6(4),X'40'
0002F0  47 80 2 0CA               BZ    CL.16
0002F4  58 F0 4 010               L     15,16(0,4)
0002F8  48 70 3 0CA               LH    7,202(0,3)
0002FC  40 70 6 0E0               STH   7,CVAR
000300  D2 00 6 0E2 F 000         MVC   CVAR+2(1),0(15)

* STATEMENT NUMBER  16
000306  58 90 D 048               L     9,72(0,13)
00030A  4A 90 9 002               AH    9,2(0,9)
00030E                    CL.17   EQU   *
00030E  58 90 9 000               L     9,0(0,9)
000312  91 40 9 006               TM    6(9),X'40'
000316  47 80 2 0F0               BZ    CL.17
00031A  58 40 9 018               L     4,24(0,9)
00031E  48 80 9 01C               LH    8,28(0,9)
000322  41 E0 0 0FF               LA    14,255(0,0)
000326  19 E8                     CR    14,8
000328  47 D0 2 110               BNH   CL.18
00032C  18 E8                     LR    14,8
00032E                    CL.18   EQU   *
00032E  40 E0 6 0E0               STH   14,CVAR
000332  4B E0 3 0CA               SH    14,202(0,3)
000336  47 40 2 12A               BM    CL.19
00033A  44 E0 2 124               EX    14,CL.20
00033E  47 F0 2 12A               B     CL.21
000342                    CL.20   EQU   *
000342  D2 00 6 0E2 4 000         MVC   CVAR+2(1),0(4)
000348                    CL.19   EQU   *
000348                    CL.21   EQU   *

* STATEMENT NUMBER  17
000348  41 40 D 0C0               LA    4,192(0,13)
00034C  50 40 3 14C               ST    4,332(0,3)
000350  96 80 3 14C               OI    332(3),X'80'
000354  41 10 3 14C               LA    1,332(0,3)
000358  58 F0 3 064               L     15,A..IBMBEOLA
00035C  05 EF                     BALR  14,15
00035E  58 40 D 0C0               L     4,192(0,13)
000362  48 80 D 0C4               LH    8,196(0,13)
000366  41 E0 0 0FF               LA    14,255(0,0)
00036A  19 E8                     CR    14,8
00036C  47 D0 2 154               BNH   CL.22
000370  18 E8                     LR    14,8
000372                    CL.22   EQU   *
000372  40 E0 6 0E0               STH   14,CVAR
000376  4B E0 3 0CA               SH    14,202(0,3)
00037A  47 40 2 16E               BM    CL.23
00037E  44 E0 2 168               EX    14,CL.24
000382  47 F0 2 16E               B     CL.25
000386                    CL.24   EQU   *
000386  D2 00 6 0E2 4 000         MVC   CVAR+2(1),0(4)
00038C                    CL.23   EQU   *
00038C                    CL.25   EQU   *

* STATEMENT NUMBER  18
00038C  58 40 D 048               L     4,72(0,13)
000390  4A 40 4 002               AH    4,2(0,4)
000394                    CL.26   EQU   *
000394  58 40 4 000               L     4,0(0,4)
000398  91 80 4 006               TM    6(4),X'80'
00039C  47 80 2 176               BZ    CL.26
0003A0  58 E0 4 008               L     14,8(0,4)
0003A4  48 90 4 00C               LH    9,12(0,4)
0003A8  41 40 0 0FF               LA    4,255(0,0)
0003AC  19 49                     CR    4,9
0003AE  47 D0 2 196               BNH   CL.27
0003B2  18 49                     LR    4,9
0003B4                    CL.27   EQU   *
0003B4  40 40 6 0E0               STH   4,CVAR
0003B8  4B 40 3 0CA               SH    4,202(0,3)
0003BC  47 40 2 1B0               BM    CL.28
0003C0  44 40 2 1AA               EX    4,CL.29
0003C4  47 F0 2 1B0               B     CL.30
0003C8                    CL.29   EQU   *
0003C8  D2 00 6 0E2 E 000         MVC   CVAR+2(1),0(14)
```

```
0003CE                       CL.28   EQU   *
0003CE                       CL.30   EQU   *

* STATEMENT NUMBER  19
0003CE  58 40 D 048                  L     4,72(0,13)
0003D2  4A 40 4 002                  AH    4,2(0,4)
0003D6                       CL.31   EQU   *
0003D6  58 40 4 000                  L     4,0(0,4)
0003DA  91 10 4 006                  TM    6(4),X'10'
0003DE  47 80 2 1B8                  BZ    CL.31
0003E2  58 E0 4 020                  L     14,32(0,4)
0003E6  48 90 4 024                  LH    9,36(0,4)
0003EA  41 40 0 0FF                  LA    4,255(0,0)
0003EE  19 49                        CR    4,9
0003F0  47 D0 2 1D8                  BNH   CL.32
0003F4  18 49                        LR    4,9
0003F6                       CL.32   EQU   *
0003F6  40 40 6 0E0                  STH   4,CVAR
0003FA  4B 40 3 0CA                  SH    4,202(0,3)
0003FE  47 40 2 1F2                  BM    CL.33
000402  44 40 2 1EC                  EX    4,CL.34
000406  47 F0 2 1F2                  B     CL.35
00040A                       CL.34   EQU   *
00040A  D2 00 6 0E2 E 000            MVC   CVAR+2(1),0(14)
000410                       CL.33   EQU   *
000410                       CL.35   EQU   *

* STATEMENT NUMBER  20
000410  78 00 6 0D0                  LE    0,ONCOUNT
000414  7E 00 3 114                  AU    0,276(0,3)
000418  70 00 D 0C0                  STE   0,192(0,13)
00041C  91 80 D 0C0                  TM    192(13),X'80'
000420  48 80 D 0C2                  LH    8,194(0,13)
000424  47 80 2 20C                  BZ    CL.36
000428  13 88                        LCR   8,8
00042A                       CL.36   EQU   *
00042A  40 80 6 0C4                  STH   8,BINVAR.FBVAR

* STATEMENT NUMBER  21
00042E  18 0D                        LR    0,13
000430  58 D0 D 004                  L     13,4(0,13)
000434  58 E0 D 00C                  L     14,12(0,13)
000438  98 2C D 01C                  LM    2,12,28(13)
00043C  05 1E                        BALR  1,14

* ON UNIT BLOCK END
00043E  07 07                        NOPR  7
```

```
* STATEMENT NUMBER  22
000440                               DC    C' DUMMY'
000447                               DC    AL1(5)

* PROCEDURE                                DUMMY

* REAL ENTRY
000448  90 EC D 00C                  STM   14,12,12(13)
00044C  47 F0 F 014                  B     *+16
000450  00000000                     DC    A(STMT. NO. TABLE)
000454  000000E8                     DC    F'232'
000458  00000000                     DC    A(STATIC CSECT)
00045C  58 30 F 010                  L     3,16(0,15)
000460  58 10 D 04C                  L     1,76(0,13)
000464  58 00 F 00C                  L     0,12(0,15)
000468  1E 01                        ALR   0,1
00046A  55 00 C 00C                  CL    0,12(0,12)
00046E  47 D0 F 030                  BNH   *+10
000472  58 F0 C 074                  L     15,116(0,12)
000476  05 EF                        BALR  14,15
000478  58 E0 D 048                  L     14,72(0,13)
00047C  18 F0                        LR    15,0
00047E  90 E0 1 048                  STM   14,0,72(1)
000482  50 D0 1 004                  ST    13,4(0,1)
000486  41 D1 0 000                  LA    13,0(1,0)
00048A  50 50 D 058                  ST    5,88(0,13)
00048E  92 80 D 000                  MVI   0(13),X'80'
000492  92 24 D 001                  MVI   1(13),X'24'
000496  D2 03 D 054 3 108            MVC   84(4,13),264(3)
00049C  05 20                        BALR  2,0

* PROLOGUE BASE
00049E  58 60 D 058                  L     6,88(0,13)
0004A2  50 60 D 0B0                  ST    6,176(0,13)
0004A6  05 20                        BALR  2,0

* PROCEDURE BASE

* STATEMENT NUMBER  24
0004A8  58 70 6 0CC                  L     7,PVAR
0004AC  92 00 7 000                  MVI   AVAR,X'00'
0004B0  58 E0 3 118                  L     14,280(0,3)
0004B4  50 E0 7 004                  ST    14,AVAR+4

* STATEMENT NUMBER  25
0004B8  58 70 3 11C                  L     7,284(0,3)
0004BC  50 70 6 0CC                  ST    7,PVAR

* STATEMENT NUMBER  26
```

```
0004C0  50 70 D 0A8           ST    7,OVAR

* STATEMENT NUMBER  27
0004C4  D2 03 D 0C0 3 1FC     MVC   192(4,13),508(3)
0004CA  D2 07 D 0C4 3 0E0     MVC   196(8,13),224(3)
0004D0  41 80 D 0C0           LA    8,192(0,13)
0004D4  50 80 D 0C4           ST    8,196(0,13)
0004D8  41 40 D 0C4           LA    4,196(0,13)
0004DC  50 40 3 150           ST    4,336(0,3)
0004E0  D2 03 D 0CC 3 200     MVC   204(4,13),512(3)
0004E6  D2 07 D 0D0 3 0E0     MVC   208(8,13),224(3)
0004EC  41 40 D 0CC           LA    4,204(0,13)
0004F0  50 40 D 0D0           ST    4,208(0,13)
0004F4  41 40 D 0D0           LA    4,208(0,13)
0004F8  50 40 3 154           ST    4,340(0,3)
0004FC  41 40 D 0AC           LA    4,SIZE
000500  50 40 3 158           ST    4,344(0,3)
000504  41 40 6 0C0           LA    4,BINVAR.RETCODE
000508  50 40 3 15C           ST    4,348(0,3)
00050C  96 80 3 15C           OI    348(3),X'80'
000510  1B 55                 SR    5,5
000512  41 10 3 150           LA    1,336(0,3)
000516  58 F0 3 160           L     15,352(0,3)
00051A  05 EF                 BALR  14,15

* STATEMENT NUMBER  28
00051C  D2 03 D 0C0 3 1FC     MVC   192(4,13),508(3)
000522  D2 07 D 0C4 3 0E0     MVC   196(8,13),224(3)
000528  41 80 D 0C0           LA    8,192(0,13)
00052C  50 80 D 0C4           ST    8,196(0,13)
000530  41 40 D 0C4           LA    4,196(0,13)
000534  50 40 3 164           ST    4,356(0,3)
000538  D2 03 D 0CC 3 200     MVC   204(4,13),512(3)
00053E  D2 07 D 0D0 3 0E0     MVC   208(8,13),224(3)
000544  41 E0 D 0CC           LA    14,204(0,13)
000548  50 E0 D 0D0           ST    14,208(0,13)
00054C  41 40 D 0D0           LA    4,208(0,13)
000550  50 40 3 168           ST    4,360(0,3)
000554  41 40 D 0AC           LA    4,SIZE
000558  50 40 3 16C           ST    4,364(0,3)
00055C  41 40 6 0C0           LA    4,BINVAR.RETCODE
000560  50 40 3 170           ST    4,368(0,3)
000564  50 D0 D 0DC           ST    13,220(0,13)
000568  58 F0 3 024           L     15,36(0,3)
00056C  50 F0 D 0D8           ST    15,216(0,13)
000570  41 40 D 0D8           LA    4,216(0,13)
000574  50 40 3 174           ST    4,372(0,3)
000578  96 80 3 174           OI    372(3),X'80'
00057C  1B 55                 SR    5,5
00057E  41 10 3 164           LA    1,356(0,3)
000582  58 F0 3 178           L     15,376(0,3)
000586  05 EF                 BALR  14,15

* STATEMENT NUMBER  29
000588  D2 03 D 0C0 3 1FC     MVC   192(4,13),508(3)
00058E  D2 07 D 0C4 3 0E0     MVC   196(8,13),224(3)
000594  41 80 D 0C0           LA    8,192(0,13)
000598  50 80 D 0C4           ST    8,196(0,13)
00059C  41 40 D 0C4           LA    4,196(0,13)
0005A0  50 40 3 164           ST    4,356(0,3)
0005A4  D2 03 D 0CC 3 200     MVC   204(4,13),512(3)
0005AA  D2 07 D 0D0 3 0E0     MVC   208(8,13),224(3)
0005B0  41 E0 D 0CC           LA    14,204(0,13)
0005B4  50 E0 D 0D0           ST    14,208(0,13)
0005B8  41 40 D 0D0           LA    4,208(0,13)
0005BC  50 40 3 168           ST    4,360(0,3)
0005C0  41 40 D 0AC           LA    4,SIZE
0005C4  50 40 3 16C           ST    4,364(0,3)
0005C8  41 40 6 0C0           LA    4,BINVAR.RETCODE
0005CC  50 40 3 170           ST    4,368(0,3)
0005D0  50 D0 D 0DC           ST    13,220(0,13)
0005D4  58 F0 3 02C           L     15,44(0,3)
0005D8  50 F0 D 0D8           ST    15,216(0,13)
0005DC  41 40 D 0D8           LA    4,216(0,13)
0005E0  50 40 3 174           ST    4,372(0,3)
0005E4  96 80 3 174           OI    372(3),X'80'
0005E8  1B 55                 SR    5,5
0005EA  41 10 3 164           LA    1,356(0,3)
0005EE  58 F0 3 17C           L     15,380(0,3)
0005F2  05 EF                 BALR  14,15

* STATEMENT NUMBER  30
0005F4  D2 03 D 0C0 3 1FC     MVC   192(4,13),508(3)
0005FA  D2 07 D 0C4 3 0E0     MVC   196(8,13),224(3)
000600  41 80 D 0C0           LA    8,192(0,13)
000604  50 80 D 0C4           ST    8,196(0,13)
000608  41 40 D 0C4           LA    4,196(0,13)
00060C  50 40 3 180           ST    4,384(0,3)
000610  D2 03 D 0CC 3 200     MVC   204(4,13),512(3)
000616  D2 07 D 0D0 3 0E0     MVC   208(8,13),224(3)
00061C  41 E0 D 0CC           LA    14,204(0,13)
000620  50 E0 D 0D0           ST    14,208(0,13)
000624  41 40 D 0D0           LA    4,208(0,13)
000628  50 40 3 184           ST    4,388(0,3)
00062C  41 40 D 0AC           LA    4,SIZE
000630  50 40 3 188           ST    4,392(0,3)
000634  41 40 6 0C0           LA    4,BINVAR.RETCODE
000638  50 40 3 18C           ST    4,396(0,3)
00063C  50 D0 D 0DC           ST    13,220(0,13)
000640  58 F0 3 024           L     15,36(0,3)
```

```
000644  50 F0 D 0D8              ST    15,216(0,13)
000648  41 40 D 0D8              LA    4,216(0,13)
00064C  50 40 3 190              ST    4,400(0,3)
000650  50 D0 D 0E4              ST    13,228(0,13)
000654  58 F0 3 02C              L     15,44(0,3)
000658  50 F0 D 0E0              ST    15,224(0,13)
00065C  41 40 D 0E0              LA    4,224(0,13)
000660  50 40 3 194              ST    4,404(0,3)
000664  96 80 3 194              OI    404(3),X'80'
000668  1B 55                    SR    5,5
00066A  41 10 3 180              LA    1,384(0,3)
00066E  58 F0 3 198              L     15,408(0,3)
000672  05 EF                    BALR  14,15

* STATEMENT NUMBER  31
000674  D2 03 D 0C0 3 1FC        MVC   192(4,13),508(3)
00067A  D2 07 D 0C4 3 0E0        MVC   196(8,13),224(3)
000680  41 80 D 0C0              LA    8,192(0,13)
000684  50 80 D 0C4              ST    8,196(0,13)
000688  41 40 D 0C4              LA    4,196(0,13)
00068C  50 40 3 19C              ST    4,412(0,3)
000690  D2 03 D 0CC 3 200        MVC   204(4,13),512(3)
000696  D2 07 D 0D0 3 0E0        MVC   208(8,13),224(3)
00069C  41 E0 D 0CC              LA    14,204(0,13)
0006A0  50 E0 D 0D0              ST    14,208(0,13)
0006A4  41 40 D 0D0              LA    4,208(0,13)
0006A8  50 40 3 1A0              ST    4,416(0,3)
0006AC  D2 01 D 0DA 3 204        MVC   218(2,13),516(3)
0006B2  D2 07 D 0DC 3 0F8        MVC   220(8,13),248(3)
0006B8  41 80 D 0DA              LA    8,218(0,13)
0006BC  50 80 D 0DC              ST    8,220(0,13)
0006C0  41 40 D 0DC              LA    4,220(0,13)
0006C4  50 40 3 1A4              ST    4,420(0,3)
0006C8  41 40 6 0C0              LA    4,BINVAR.RETCODE
0006CC  50 40 3 1A8              ST    4,424(0,3)
0006D0  96 80 3 1A8              OI    424(3),X'80'
0006D4  1B 55                    SR    5,5
0006D6  41 10 3 19C              LA    1,412(0,3)
0006DA  58 F0 3 1AC              L     15,428(0,3)
0006DE  05 EF                    BALR  14,15

* STATEMENT NUMBER  32
0006E0  D2 05 D 0C2 3 206        MVC   194(6,13),518(3)
0006E6  D2 07 D 0C8 3 0D0        MVC   200(8,13),208(3)
0006EC  41 E0 D 0C2              LA    14,194(0,13)
0006F0  50 E0 D 0C8              ST    14,200(0,13)
0006F4  41 40 D 0C8              LA    4,200(0,13)
0006F8  50 40 3 19C              ST    4,412(0,3)
0006FC  D2 07 D 0D0 3 100        MVC   208(8,13),256(3)
000702  41 E0 D 0D0              LA    14,208(0,13)
000706  50 E0 D 0D0              ST    14,208(0,13)
00070A  41 40 D 0D0              LA    4,208(0,13)
00070E  50 40 3 1A0              ST    4,416(0,3)
000712  D2 01 D 0DA 3 204        MVC   218(2,13),516(3)
000718  D2 07 D 0DC 3 0F8        MVC   220(8,13),248(3)
00071E  41 80 D 0DA              LA    8,218(0,13)
000722  50 80 D 0DC              ST    8,220(0,13)
000726  41 40 D 0DC              LA    4,220(0,13)
00072A  50 40 3 1A4              ST    4,420(0,3)
00072E  41 40 6 0C8              LA    4,CKPT_RETC
000732  50 40 3 1A8              ST    4,424(0,3)
000736  96 80 3 1A8              OI    424(3),X'80'
00073A  1B 55                    SR    5,5
00073C  41 10 3 19C              LA    1,412(0,3)
000740  58 F0 3 1AC              L     15,428(0,3)
000744  05 EF                    BALR  14,15

* STATEMENT NUMBER  33
000746  1B 11                    SR    1,1
000748  1B 55                    SR    5,5
00074A  58 F0 3 1B0              L     15,432(0,3)
00074E  05 EF                    BALR  14,15

* STATEMENT NUMBER  34
000750  1B 11                    SR    1,1
000752  1B 55                    SR    5,5
000754  58 F0 3 1B4              L     15,436(0,3)
000758  05 EF                    BALR  14,15

* STATEMENT NUMBER  35
00075A  41 40 6 0C0              LA    4,BINVAR.RETCODE
00075E  50 40 3 1B8              ST    4,440(0,3)
000762  96 80 3 1B8              OI    440(3),X'80'
000766  1B 55                    SR    5,5
000768  41 10 3 1B8              LA    1,440(0,3)
00076C  58 F0 3 138              L     15,312(0,3)
000770  05 EF                    BALR  14,15

* STATEMENT NUMBER  41
000772  18 0D                    LR    0,13
000774  58 D0 D 004              L     13,4(0,13)
000778  58 E0 D 00C              L     14,12(0,13)
00077C  98 2C D 01C              LM    2,12,28(13)
000780  05 1E                    BALR  1,14

* END PROCEDURE
000782  07 07                    NOPR  7
```

```
* STATEMENT NUMBER  36
000784                      DC     C'  A'
000787                      DC     AL1(1)

* PROCEDURE                        A

* REAL ENTRY
000788   90 EC D 00C        STM    14,12,12(13)
00078C   47 F0 F 014        B      *+16
000790   00000000           DC     A(STMT. NO. TABLE)
000794   000000B8           DC     F'184'
000798   00000000           DC     A(STATIC CSECT)
00079C   58 30 F 010        L      3,16(0,15)
0007A0   58 10 D 04C        L      1,76(0,13)
0007A4   58 00 F 00C        L      0,12(0,15)
0007A8   1E 01              ALR    0,1
0007AA   55 00 C 00C        CL     0,12(0,12)
0007AE   47 D0 F 030        BNH    *+10
0007B2   58 F0 C 074        L      15,116(0,12)
0007B6   05 EF              BALR   14,15
0007B8   58 E0 D 048        L      14,72(0,13)
0007BC   18 F0              LR     15,0
0007BE   90 E0 1 048        STM    14,0,72(1)
0007C2   50 D0 1 004        ST     13,4(0,1)
0007C6   41 D1 0 000        LA     13,0(1,0)
0007CA   50 50 D 058        ST     5,88(0,13)
0007CE   92 80 D 000        MVI    0(13),X'80'
0007D2   92 24 D 001        MVI    1(13),X'24'
0007D6   D2 03 D 054 3 108  MVC    84(4,13),264(3)
0007DC   05 20              BALR   2,0

* PROCEDURE BASE


* STATEMENT NUMBER  37
0007DE   18 0D              LR     0,13
0007E0   58 D0 D 004        L      13,4(0,13)
0007E4   58 E0 D 00C        L      14,12(0,13)
0007E8   98 2C D 01C        LM     2,12,28(13)
0007EC   05 1E              BALR   1,14

* END PROCEDURE
0007EE   07 07              NOPR   7


* STATEMENT NUMBER  38
0007F0                      DC     C'  B'
0007F3                      DC     AL1(1)

* PROCEDURE                        B

* REAL ENTRY
0007F4   90 EC D 00C        STM    14,12,12(13)
0007F8   47 F0 F 014        B      *+16
0007FC   00000000           DC     A(STMT. NO. TABLE)
000800   000000C8           DC     F'200'
000804   00000000           DC     A(STATIC CSECT)
000808   58 30 F 010        L      3,16(0,15)
00080C   58 10 D 04C        L      1,76(0,13)
000810   58 00 F 00C        L      0,12(0,15)
000814   1E 01              ALR    0,1
000816   55 00 C 00C        CL     0,12(0,12)
00081A   47 D0 F 030        BNH    *+10
00081E   58 F0 C 074        L      15,116(0,12)
000822   05 EF              BALR   14,15
000824   58 E0 D 048        L      14,72(0,13)
000828   18 F0              LR     15,0
00082A   90 E0 1 048        STM    14,0,72(1)
00082E   50 D0 1 004        ST     13,4(0,1)
000832   41 D1 0 000        LA     13,0(1,0)
000836   50 50 D 058        ST     5,88(0,13)
00083A   92 80 D 000        MVI    0(13),X'80'
00083E   92 24 D 001        MVI    1(13),X'24'
000842   D2 03 D 054 3 108  MVC    84(4,13),264(3)
000848   58 10 D 004        L      1,4(0,13)
00084C   58 10 1 018        L      1,24(0,1)
000850   D2 03 D 0B0 1 000  MVC    176(4,13),0(1)
000856   92 00 D 0B0        MVI    176(13),X'00'
00085A   05 20              BALR   2,0

* PROCEDURE BASE

* STATEMENT NUMBER  40
00085C   18 0D              LR     0,13
00085E   58 D0 D 004        L      13,4(0,13)
000862   58 E0 D 00C        L      14,12(0,13)
000866   98 2C D 01C        LM     2,12,28(13)
00086A   05 1E              BALR   1,14

* END PROCEDURE

* END PROGRAM
```

```
PL/I OPTIMIZING COMPILER        /***** PL/I SAMPLE PROGRAM. *****/                                          PAGE  29

COMPILER DIAGNOSTIC MESSAGES
    (1) (2)   (3)
ERROR ID L    STMT     MESSAGE DESCRIPTION


SEVERE AND ERROR DIAGNOSTIC MESSAGES


IEL0413I E    23       DECLARATION OF INTERNAL ENTRY NOT ALLOWED.    DECLARATION OF 'A' IGNORED.


WARNING DIAGNOSTIC MESSAGES


IEL0892I W    6        TARGET STRING SHORTER THAN SOURCE.    RESULT TRUNCATED ON ASSIGNMENT.

IEL0518I W    20       'ONCOUNT' IS THE NAME OF A BUILTIN FUNCTION BUT ITS IMPLICIT DECLARATION DOES NOT IMPLY
                       'BUILTIN'.

IEL0916I W    22       ITEM(S) 'SIZE' MAY BE UNINITIALIZED WHEN USED IN THIS BLOCK.


COMPILER INFORMATORY MESSAGES


IEL0541I I    1, 9, 22, 36, 38    'ORDER' OPTION APPLIES TO THIS BLOCK.    OPTIMIZATION MAY BE INHIBITED.


END OF COMPILER DIAGNOSTIC MESSAGES
     (4)                            (5)
COMPILE TIME    0.12 MINS        SPILL FILE:     2 RECORDS, SIZE  3491
```

Diagnostic messages and an end of compile step message generated by the compiler. All diagnostic messages generated by the optimizing compiler are documented in the publication _OS Optimizing Compiler: Messages_.

1. "ERROR ID" This identifies the message as originating from the optimizing compiler (IEL), and gives the message number.
2. "L" This is the severity level of the message.
3. "STMT" This gives the number of the statement in which the error occurred.
4. Compile time in minutes. This time includes the preprocessor.
5. This gives the number of records "spilled" into auxiliary storage and the size in bytes of the spill file.

F88-LEVEL LINKAGE EDITOR OPTIONS SPECIFIED XREF,LIST ①
DEFAULT OPTION(S) USED - SIZE=(102400,57344)

② CROSS REFERENCE TABLE

③ CONTROL SECTION			ENTRY							
NAME	ORIGIN	LENGTH	NAME	LOCATION	NAME	LOCATION	NAME	LOCATION	NAME	LOCATION
PLISTART	00	44								
			PLICALLA	6	PLICALLB	A				
PLIMAIN	48	8								
SYSPINT	50	20								
*SAMPLE2	70	314								
IELCGOA	388	72								
IELCGOB	400	70								
*SAMPLE1	470	86C								
			SAMPLE	478						
IBMBKCP1*	CE0	232								
			IBMBKCPA	CE0	IBMBKCPB	CE2	IBMBKCPC	CE4		
IBMBKST1*	F18	6A0								
			IBMBKSTA	F18	IBMBKSTB	F1A	IBMBKSTC	F1C	IBMBKSTD	F1E
IBMBPIR1*	15B8	2F0								
			IBMBPIRA	15DA	IBMBPIRB	15DC	IBMBPIRC	15DE		
IBMBCCS1*	18A8	180								
			IBMBCCSA	18A8						
IBMBCH01*	1A28	1E0								
			IBMBCHXE	1A28	IBMBCHFE	1A28	IBMBCHXP	1A30	IBMBCHFP	1A30
			IBMBCHXY	1A38	IBMBCHFY	1A38	IBMBCHFH	1A40	IBMBCHXH	1A40
			IBMBCHFD	1A48	IBMBCHXD	1A48	IBMBCHXF	1A50		
IBMBCO01*	1C08	448								
			IBMBCODE	1C08	IBMBCOZE	1C08	IBMBCODP	1C08		
IBMBCT01*	2050	29C								
			IBMBCTHD	2050	IBMBCTHX	2058	IBMBCTHF	2060	IBMBCTHP	2068
			IBMBCTHE	2070						
IBMBCU01*	22F0	308								
			IBMBCUIX	22F0	IBMBCUID	22F8	IBMBCUIP	2300	IBMBCUIE	2308
			IBMBCUIF	2310						
IBMBEOC1*	25F8	E6								
			IBMBEOCA	25F8						
IBMBKDM1*	26E0	F8								
			IBMBKDMA	26E0						
IBMBPRC1*	27D8	48								
			IBMBPRCA	27D8						
IBMBSED1*	2820	488								
			IBMBSEDA	2820	IBMBSEDB	2820				
IBMBSIO1*	2CA8	260								
			IBMBSIOA	2CA8	IBMBSIOB	2CAA	IBMBSIOC			
			IBMBSIOE	2CB0	IBMBSIOT	2E66				
IBMBCK01*	2F08	176								
			IBMBCKDP	2F08	IBMBCKZP	2F08	IBMBCKDD			
IBMBEOL1*	3080	A0								
			IBMBEOLA	3080						

First page of the linkage editor listing.

① Statement identifying the version and level of the linkage editor and giving the options as specified in the PARM parameter of the EXEC statement that invokes the cataloged procedure.

② Cross reference table. This table consists of a module map and the cross-reference table.

③ The module map shows each control section and its associated entry points, if any, listed across the page. An asterisk after the name means that these are library subroutines obtained by automatic library call.

④ The cross-reference table gives all the locations in a control section at which a symbol is referenced. $UNRESOLVED(W) identifies a wak external reference that has not been resolved.

NAME	ORIGIN	LENGTH	NAME	LOCATION	NAME	LOCATION	NAME	LOCATION	NAME	LOCATION
IBMBERR1*	3120	6C0	IBMBERRA	3120	IBMBERRB	3162	IBMBERRC	3734		
IBMBJDT1*	37E0	8C	IBMBJDTA	37E0						
IBMBJTT1*	3870	68	IBMBJTTA	3870						
IBMBOCL1*	38D8	10C	IBMBOCLA	38D8	IBMBOCLB	38DA	IBMBOCLC	38DC	IBMBOCLD	38DE
IBMBSEO1*	39E8	E8	IBMBSEOA	39E8						
IBMBSLO1*	3AD0	6E0	IBMBSLOA	3AD0	IBMBSLOB	3AD2				
IBMBSPL1*	41B0	2D0	IBMBSPLA	41B0	IBMBSPLB	41B2	IBMBSPLC	41B4		
IBMBSPO1*	4480	120	IBMBSPOA	4480						
IBMBCGT1*	45A0	88	IBMBCGTA	45A0						
IBMBEEF1*	4628	149	IBMBEEFA	4628						
IBMBEER1*	4778	4	IBMBEERA	4778						
IBMBSCV1*	4780	240	IBMBSCVA	4780						

LOCATION	REFERS TO SYMBOL	IN CONTROL SECTION	LOCATION	REFERS TO SYMBOL	IN CONTROL SECTION
10	PLIMAIN	PLIMAIN	14	SYSPINT	SYSPINT
18	PLIFLOW	$UNRESOLVED(W)	1C	PLITABS	$UNRESOLVED(W)
2C	PLICOUNT	$UNRESOLVED(W)	30	PLIXOPT	$UNRESOLVED(W)
38	IBMBPIRA	IBMBPIR1	3C	IBMBPIRB	IBMBPIR1
40	IBMBPIRC	IBMBPIR1	48	*SAMPLE1	*SAMPLE1
74	*SAMPLE1	*SAMPLE1	78	*SAMPLE1	*SAMPLE1
7C	*SAMPLE1	*SAMPLE1	80	*SAMPLE1	*SAMPLE1
84	*SAMPLE1	*SAMPLE1	88	*SAMPLE1	*SAMPLE1
8C	*SAMPLE1	*SAMPLE1	90	*SAMPLE1	*SAMPLE1
94	*SAMPLE1	*SAMPLE1	98	*SAMPLE1	*SAMPLE1
9C	*SAMPLE1	*SAMPLE1	A0	*SAMPLE1	*SAMPLE1
A4	*SAMPLE1	*SAMPLE1	A8	*SAMPLE1	*SAMPLE1
AC	*SAMPLE1	*SAMPLE1	B0	*SAMPLE1	*SAMPLE1
B4	IELCGOA	IELCGOA	B8	IELCGOB	IELCGOB
BC	IBMBCCSA	IBMBCCS1	C0	IBMBCHFD	IBMBCH01
C4	IBMBCODE	IBMBCO01	C8	IBMBCTHD	IBMBCT01
CC	IBMBCUID	IBMBCU01	D0	IBMBEOCA	IBMBEOC1
D4	IBMBEOLA	IBMBEOL1	D8	IBMBJDTA	IBMBJDT1
DC	IBMBJTTA	IBMBJTT1	E0	IBMBOCLA	IBMBOCL1
E4	IBMBOCLC	IBMBOCL1	E8	IBMBSEDB	IBMBSED1
EC	IBMBSEOA	IBMBSEO1	F0	IBMBSIOE	IBMBSIO1
F4	IBMBSIOT	IBMBSIO1	F8	IBMBSLOA	IBMBSLO1
FC	IBMBSPLA	IBMBSPL1	100	IBMBSPOA	IBMBSPO1
104	IBMBCKDD	IBMBCK01	190	SYSPINT	SYSPINT

LOCATION	REFERS TO SYMBOL	IN CONTROL SECTION	LOCATION	REFERS TO SYMBOL	IN CONTROL SECTION
19C	SYSPINT	SYSPINT	1A8	IBMBPRCA	IBMBPRC1
1AC	IBMBKDMA	IBMBKDM1	1D0	IBMBKSTA	IBMBKST1
1E8	IBMBKSTB	IBMBKST1	1EC	IBMBKSTC	IBMBKST1
208	IBMBKSTD	IBMBKST1	21C	IBMBKCPA	IBMBKCP1
220	IBMBKCPB	IBMBKCP1	224	IBMBKCPC	IBMBKCP1
284	*SAMPLE1	*SAMPLE1	28C	*SAMPLE1	*SAMPLE1
2C0	*SAMPLE1	*SAMPLE1	304	*SAMPLE1	*SAMPLE1
34C	*SAMPLE1	*SAMPLE1	364	*SAMPLE1	*SAMPLE1
468	IBMBSIST	$UNRESOLVED(W)	46C	IBMBSEOA	IBMBSEO1
480	*SAMPLE2	*SAMPLE2	488	*SAMPLE2	*SAMPLE2
640	*SAMPLE2	*SAMPLE2	648	*SAMPLE2	*SAMPLE2
8C0	*SAMPLE2	*SAMPLE2	8C8	*SAMPLE2	*SAMPLE2
C00	*SAMPLE2	*SAMPLE2	C08	*SAMPLE2	*SAMPLE2
C6C	*SAMPLE2	*SAMPLE2	C74	*SAMPLE2	*SAMPLE2
15B0	IBMCKEXA	$UNRESOLVED(W)	15B4	IBMCKEXB	$UNRESOLVED(W)
1840	IBMBJWTA	$UNRESOLVED(W)	1844	IBMBTOCA	$UNRESOLVED(W)
1848	IBMBTOCB	$UNRESOLVED(W)	184C	IBMBTPRA	$UNRESOLVED(W)
1800	IBMBOCLB	IBMBOCL1	1814	IBMBOCLB	IBMBOCL1
1830	IBMBOCLD	IBMBOCL1	1838	IBMBERRB	IBMBERR1
183C	IBMBPGOA	$UNRESOLVED(W)	1850	IBMBPQDA	$UNRESOLVED(W)
1868	IBMBERRC	IBMBERR1	182C	IBMBOCLA	IBMBOCL1
1834	IBMBERRA	IBMBERR1	1870	IBMBEERA	IBMBEER1
195C	IBMBCHXD	IBMBCH01	1960	IBMBCHXF	IBMBCH01
196C	IBMBCHXP	IBMBCH01	1970	IBMBCHXY	IBMBCH01
1974	IBMBCHXE	IBMBCH01	199C	IBMBCKDD	IBMBCK01
19AC	IBMBCKDP	IBMBCK01	19DC	IBMBCHFD	IBMBCH01
19E8	IBMBCHFH	IBMBCH01	19EC	IBMBCHFP	IBMBCH01
19F0	IBMBCHFY	IBMBCH01	19F4	IBMBCHFE	IBMBCH01
1998	IBMBCEDX	$UNRESOLVED(W)	19A0	IBMBCEDF	$UNRESOLVED(W)
19D8	IBMBCEFX	$UNRESOLVED(W)	1958	IBMBCYXX	$UNRESOLVED(W)
19E0	IBMBCYFF	$UNRESOLVED(W)	1A18	IBMBCMPX	$UNRESOLVED(W)
1A1C	IBMBCMPD	$UNRESOLVED(W)	1A20	IBMBCMPF	$UNRESOLVED(W)
1A0C	IBMBCUIX	IBMBCU01	1A14	IBMBCUIF	IBMBCU01
19CC	IBMBCTHX	IBMBCT01	19D0	IBMBCTHD	IBMBCT01
19D4	IBMBCTHF	IBMBCT01	19B4	IBMBCODE	IBMBCO01
19B0	IBMBCVDY	$UNRESOLVED(W)	197C	IBMBCRXB	$UNRESOLVED(W)
1984	IBMBCRXB	$UNRESOLVED(W)	19FC	IBMBCRXB	$UNRESOLVED(W)
1A04	IBMBCRXB	$UNRESOLVED(W)	19A8	IBMBCWDH	$UNRESOLVED(W)
1990	IBMBCGZA	$UNRESOLVED(W)	1994	IBMBCGPA	$UNRESOLVED(W)
1978	IBMBCACA	$UNRESOLVED(W)	1980	IBMBCACA	$UNRESOLVED(W)
1988	IBMBCACA	$UNRESOLVED(W)	19B8	IBMBCACA	$UNRESOLVED(W)
19C0	IBMBCACA	$UNRESOLVED(W)	19C8	IBMBCACA	$UNRESOLVED(W)
19F8	IBMBCACA	$UNRESOLVED(W)	1A00	IBMBCACA	$UNRESOLVED(W)
1A08	IBMBCACA	$UNRESOLVED(W)	1A24	IBMBCPBF	$UNRESOLVED(W)
1968	IBMBCHXH	IBMBCH01	19BC	IBMBCEDB	$UNRESOLVED(W)
19C4	IBMBCEDB	$UNRESOLVED(W)	198C	IBMBSCVA	IBMBSCV1
1A2C	IBMBCOZE	IBMBCO01	1A34	IBMBCKZP	IBMBCK01
1A3C	IBMBCVZY	$UNRESOLVED(W)	1A44	IBMBCWZH	$UNRESOLVED(W)
1A4C	IBMBCKZD	IBMBCK01	1BEC	IBMBCGTA	IBMBCGT1
2054	IBMBCKZD	IBMBCK01	2074	IBMBCOZE	IBMBCO01
2064	IBMBCEZF	$UNRESOLVED(W)	206C	IBMBCKZP	IBMBCK01
205C	IBMBCEZX	$UNRESOLVED(W)	22E8	IBMBSCVA	IBMBSCV1

LOCATION	REFERS TO SYMBOL	IN CONTROL SECTION	LOCATION	REFERS TO SYMBOL	IN CONTROL SECTION
22F4	IBMBCEFX	$UNRESOLVED(W)	22FC	IBMBCHFD	IBMBCH01
2304	IBMBCHFP	IBMBCH01	230C	IBMBCHFE	IBMBCH01
25EC	IBMBSCVA	IBMBSCV1	2C8C	IBMBSAIA	$UNRESOLVED(W)
2C9C	IBMBSAOA	$UNRESOLVED(W)	2C84	IBMBSFIA	$UNRESOLVED(W)
2C94	IBMBSFOA	$UNRESOLVED(W)	2C88	IBMBSPIA	$UNRESOLVED(W)
2C98	IBMBSPOA	IBMBSPO1	2C90	IBMBSCIA	$UNRESOLVED(W)
2CA0	IBMBSCOA	$UNRESOLVED(W)	2CA4	IBMBSBOA	$UNRESOLVED(W)
2C80	IBMBSIST	$UNRESOLVED(W)	2EFC	IBMBSPLA	IBMBSPL1
2F00	IBMBSPLB	IBMBSPL1	2F04	IBMBSPLC	IBMBSPL1
2EF8	IBMBOCLA	IBMBOCL1	2F0C	IBMBCODP	IBMBCO01
37B0	IBMBERCA	$UNRESOLVED(W)	37B4	IBMBEEFA	IBMBEEF1
39C4	IBMBRIOB	$UNRESOLVED(W)	39C8	IBMBRIOC	$UNRESOLVED(W)
39CC	IBMBSCPA	$UNRESOLVED(W)	3ACC	IBMBSIST	$UNRESOLVED(W)
41AC	IBMBCACA	$UNRESOLVED(W)	41A8	IBMBCBCA	$UNRESOLVED(W)
41A4	IBMBCZCA	$UNRESOLVED(W)	41A0	IBMBCXOA	$UNRESOLVED(W)
419C	IBMBSIST	$UNRESOLVED(W)	4560	IBMBCHXP	IBMBCH01
4564	IBMBCKDP	IBMBCK01	4568	IBMBCHFP	IBMBCH01
4574	IBMBCMPP	$UNRESOLVED(W)	457C	IBMBCMPP	$UNRESOLVED(W)
4580	IBMBCHXE	IBMBCH01	4584	IBMBCODE	IBMBCO01
4588	IBMBCHFE	IBMBCH01	4594	IBMBCMPE	$UNRESOLVED(W)
459C	IBMBCMPE	$UNRESOLVED(W)	458C	IBMBCPBP	$UNRESOLVED(W)
4590	IBMBCPBE	$UNRESOLVED(W)	4598	IBMBCCSA	IBMBCCS1

```
 LOCATION     20 REQUESTS CUMULATIVE PSEUDO REGISTER LENGTH
ENTRY ADDRESS       00
TOTAL LENGTH      49C0

****GO        DOES NOT EXIST BUT HAS BEEN ADDED TO DATA SET
```

```
SAMPLE PROGRAM: DATE = 73/04/13, TIME = 21.18.17
END SAMPLE PROGRAM
```

Appendix G: Running under a Virtual Storage Operating System(OS/VS)

OS/VS1 and OS/VS2 are the virtual-storage equivalents of OS/MFT and OS/MVT respectively. In general, a program that compiles and executes successfully under OS/MFT or OS/MVT will do so under OS/VS.

OS/VS has the advantage that the size of the partition or region used by the program is not limited by the amount of real storage available. In the case of PL/I programs, partitions or regions large enough to give maximum efficiency during both compilation and execution can be used, and the segmentation of programs to fit restricted amounts of storage becomes unnecessary.

Virtual partitions or regions can be allocated in multiples of 64K bytes. The amount of real storage available to a program at any time is under the control of the Operating System, and cannot be specified by the programmer. The storage requirements given below refer to the amounts of virtual storage available.

The compiler will run in the minimum virtual partition or region size of 64K bytes. However, increased efficiency can be obtained by using a partition or region size large enough to prevent the compiler from using its spill file. The use of partition or region sizes in excess of those required to prevent the compiler from using its spill file may cause a slight degradation in performance, but this will not usually be significant unless the amount of real storage allocated by the operating system is small.

It is inadvisable to limit the amount of storage available to the compiler by specifying the SIZE option. This option should be used only if you require to reserve space for other routines, such as ones that invoke the compiler dynamically. In any case, the compiler requires at least 52K bytes of storage under VS1 and at least 54K bytes under VS2.

The sizes of records on the compiler spill file depend on the amount of storage available to the compiler. Figure G-1 gives record sizes under VS1. For VS2, the specified storage size limits should be increased by 2K bytes.

Storage (bytes)	Record size (bytes)
52-62K	1091
62-78K	1691
78-84K	3491
Over 84K	4051

Figure G-1. Compiler spill file record sizes

Note that the 2311 Disk Storage Unit is not supported by OS/VS.

Index

Where more than one page reference is given, the major reference is first.

A page reference to a paragraph split between two pages will refer to the first of the two pages.

OS
PL/I Optimizing Compiler:
Programmer's Guide
Order No. SC33-0006-3

READER'S COMMENT FORM

Your views about this publication may help improve its usefulness; this form will be sent to the author's department for appropriate action. Using this form to request system assistance or additional publications will delay response, however. *For more direct handling of such requests, please contact your IBM representative or the IBM Branch Office serving your locality.*

Possible topics for comment are:

Clarity Accuracy Completeness Organization Index Figures Examples Legibility

Cut or Fold Along Line

What is your occupation? _______________________________

Number of latest Technical Newsletter (if any) concerning this publication: ___________

Please indicate in the space below if you wish a reply.

Thank you for your cooperation. No postage stamp necessary if mailed in the U.S.A. (Elsewhere, an IBM office or representative will be happy to forward your comments.)

SC33-0006-3

Your comments, please . . .

This manual is part of a library that serves as a reference source for systems analysts, programmers, and operators of IBM systems. Your comments on the other side of this form will be carefully reviewed by the persons responsible for writing and publishing this material. All comments and suggestions become the property of IBM.

Cut or Fold Along Line

Fold Fold

First Class
Permit 40
Armonk
New York

Business Reply Mail
No postage stamp necessary if mailed in the U.S.A.

Postage will be paid by:

International Business Machines Corporation
Department 813 HP
1133 Westchester Avenue
White Plains, New York 10604

Fold Fold

IBM

International Business Machines Corporation
Data Processing Division
1133 Westchester Avenue, White Plains, New York 10604
(U.S.A. only)

IBM World Trade Corporation
821 United Nations Plaza, New York, New York 10017
(International)