File Number S360-24
GC24-5025-5

DOS
TOS

Not Current
5025-6

IBM Systems Reference Library

IBM System/360
Disk and Tape Operating Systems
COBOL Programmer's Guide

Program Number 360N-CB-452
360M-CB-402

This publication describes how to compile, linkage edit, and execute a Disk and Tape COBOL program. The text also describes the output from each of these steps. In addition, it explains options of the compiler and many available features of the operating system.

Procedure MAP
Page 60

Sixth Edition (October 1968)

The specifications contained in this publication correspond to Release 19 of the IBM System/360 Disk Operating System.

This is a major revision of, and makes obsolete, C24-5025-4. In addition to the material in the previous edition, this book contains a revised section dealing with programming considerations and a comprehensive discussion of calling and called programs and overlay techniques. Changes to the text are indicated by a vertical line to the left of the change; revised illustrations are denoted by the symbol • to the left of the caption.

Specifications contained herein are subject to change from time to time. Any such change will be reported in subsequent revisions or Technical Newsletters.

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

Address comments concerning the contents of this publication to IBM Corporation, Programming Publications, 1271 Avenue of the Americas, New York, New York 10020.

The purpose of this publication is to enable programmers to compile, linkage edit, and execute COBOL programs under control of IBM System/360 Disk and Tape Operating Systems. The Disk and Tape COBOL language is described in the publication IBM System/360 Disk and Tape Operating Systems: COBOL Language Specifications, Form C24-3433, which is a corequisite to this publication.

Programmers unfamiliar with the Disk and Tape Operating Systems should read the Introduction and Sections I, II, and III for detailed information about preparing COBOL programs and deck structures for processing by the system.

Programmers who are familiar with the Disk and Tape Operating Systems and wish to know how to run COBOL programs should read Section I. This section contains the control card parameters and specific options needed to prepare deck structures for processing.

Sections IV, V, and VI contain information that is intended to aid programmers in writing efficient programs and in debugging programs that do not execute properly. The remaining sections discuss optional features of the Disk and Tape Operating Systems that are available to COBOL programmers.

Wider and more detailed discussions of the Disk and Tape Operating System are given in the following publications:

Publications closely related to this one are:

IBM System/360 Disk Operating System: System Control and System Service Programs, Form C24-5036.

IBM System/360 Tape Operating System: System Control and System Service Programs, Form C24-5034.

IBM System/360 Disk Operating System: Supervisor and Input/Output Macros, Form C24-5037.

IBM System/360 Tape Operating System: Supervisor and Input/Output Macros, Form C24-5035.

IBM System/360 Disk Operating System: Data Management Concepts, Form C24-3427.

IBM System/360 Tape Operating System: Data Management Concepts, Form C24-3430.

IBM System/360 Disk Operating System: System Generation and Maintenance, Form C24-5033.

IBM System/360 Tape Operating System: System Generation and Maintenance, Form C24-5015.

IBM System/360 Principles of Operation, Form A24-6821.

The titles and abstracts of related publications are listed in the publication IBM System/360 Bibliography, Form A22-6822.

FIGURES

TABLES

A Disk and Tape Operating Systems COBOL program is processed by the IBM System/360 Disk and Tape Operating Systems. The operating system consists of a number of processing programs and a control program. The processing programs include the COBOL compiler, service programs, and user-written programs. The control program supervises the execution of the processing programs and controls the location, storage, and retrieval of data. It also schedules jobs for continuous processing.

A request to the operating system for facilities and scheduling of program execution is called a job. For example, a job could request execution of the COBOL compiler to compile a program. A job consists of one or more job steps, each of which specifies execution of a program. A programmer makes these requests to the operating system by use of job control statements that may be punched into cards.

Each job is preceded by a JOB statement that identifies the job. Each job step is preceded by an EXEC statement that names the program to be executed and calls for execution. Included in each job step and preceding the EXEC statement are other job control statements (such as ASSGN and XTENT) that describe data or request allocation of input/output devices.

The data processed by execution of any processing program must be in the form of a data file. A data file is a named, organized collection of one or more records that are logically related. Information in a data file may or may not be restricted to a specific type, purpose, or storage medium. A data file may be a source program, a library of subroutines, or a file of data records that is to be processed by a COBOL program.

A data file resides in one or more volumes. A volume is a unit of external storage that is accessible to an input/output device. For example, a volume may be a reel of tape or a disk pack.

In the Disk and Tape Operating Systems, input/output devices are given standard symbolic names. A programmer can refer to an input/output device in his program by using the appropriate symbolic name, and the program is not dependent on an actual device address. The actual device address is supplied by a job control statement when the program is executed or at system generation time.

DATA ORGANIZATION

A data file used by a COBOL program can have one of three types of organization: sequential, indexed sequential, or direct. The first type (sequential) may be on any input/output device. All other types must be on direct-access devices.

1. A sequential data file is one in which records are organized solely on the basis of their successive physical positions, as on tape.

2. An indexed sequential data file is one in which records are arranged in logical sequence (according to a key that is part of every record) on the tracks of a direct-access device. A separate index or set of indexes maintained by the system indicates the location of each record. This permits random, as well as sequential, access to any record.

3. A direct data file in COBOL is one in which records are referred to by use of keys. An actual key specifies the actual track address. A symbolic key identifies the record on the track.

EXECUTING A COBOL PROGRAM

Three basic operations are performed to execute a COBOL program: compilation, linkage editing, and actual execution.

COMPILATION

Compilation is the process of translating a COBOL source program into a series of instructions comprehensible to the computer, i.e., machine language. In operating system terminology, the input to the compiler, the source program, is called the source module. The output from the compiler, the compiled source program, is called an object module.

LINKAGE EDITING

The linkage editor is a service program that prepares object modules for execution. It can also be used to combine two or more separately compiled object modules into a format suitable for execution as a single program. During the process of linkage editing, external references between different modules are resolved. The executable output of the linkage editor is called a program phase. The output may consist of one or more program phases.

EXECUTION

Actual execution is under supervision of the control program, which obtains a program phase from the core image library, loads it into main storage, and initiates execution of the machine language instructions contained in the program phase.

LIBRARIES

Another service program in the Disk and Tape Operating Systems is called the librarian. The librarian consists of a group of maintenance routines that service the three system libraries. The maintenance routines provide such operations as adding, deleting, or copying portions of a library.

The three system libraries are: the core image library, the source statement library, and the relocatable library.

CORE IMAGE LIBRARY

All permanent programs in the Disk and Tape Operating System must be added to the core image library. The core image library is required, and the programs are stored in the library in the form of program phases. Unless the program phase has been linkage edited in the previous job step, the core image library is searched at execution time to obtain the program phase named in the EXEC statement.

SOURCE STATEMENT LIBRARY

The source statement library is used to store portions of COBOL source programs that are to be copied into a source program when the COPY or INCLUDE clauses of the COBOL language are used. The source statement library is not required. However, use of the source statement library can reduce the amount of coding needed for each individual program, that is, if standard file descriptions are added to the source statement library, they need not be coded again.

RELOCATABLE LIBRARY

The relocatable library is used to store object modules that can be subsequently linkage edited with other object modules. Each object module may also be a complete program that can be linkage edited and then executed. The relocatable library contains the COBOL library subroutines and the input/output modules used by the COBOL compiler.

MULTIPROGRAMMING

The Disk Operating System provides the capability of simultaneously processing two or three batched job streams for systems with at least 32K of main storage. This support is referred to as fixed partitioned multiprogramming because each job stream is assigned a different area or partition of main storage. The number and size of the partitions are allocated during system generation and may be altered by the operator.

There are two types of problem programs that can be run in a multiprogramming system: batched job processing and SPI (Single Program Initiator). Batched job processing is initiated by job control from the batched-job input stream. This capability is extended to all three programming partitions (BG, F1, and F2) if sufficient storage and separate input/output devices are available. The batched-job foreground option is selected when the system is generated by specifying MPS=BJF in the supervisor macro instructions. Programs run under SPI do not execute from a stack, but are initiated by the operator from the printer-keyboard. When an SPI program completes processing, the operator must explicitly initiate the next program.

The linkage editor determines whether the program to be executed is either a background or a foreground program. Both types of programs are initiated and terminated asynchronously of the other. Neither is aware of the other's existence.

COBOL source modules must be compiled as background programs. COBOL program phases can be executed as either background or foreground programs.

In a multiprogramming environment, control always passes to the program with the highest priority. Priority is assigned according to classification of programs as follows:

1. Supervisor
2. Operator communication routine
3. Foreground-one program
4. Foreground-two program
5. Background program

The background program must be a minimum of 10K. The foreground program areas must be in increments of 2K. The maximum size of a foreground program area is 510K.

This section provides information about preparing COBOL source programs for compilation, linkage editing, and execution. Included are discussions of frequently used job control statements, linkage editor control statements, and librarian control statements. Some individual examples are given, but Sections II and III should be scrutinized for complete examples of deck setups.

A complete list of job control, linkage editor, and librarian control statements and other options can be found in the publications IBM System/360 Disk Operating System: System Control and System Service Programs, Form C24-5036, and IBM System/360 Tape Operating System: System Control and System Service Programs, Form C24-5034.

INPUT/OUTPUT DEVICE ASSIGNMENT

The input/output devices used for compilation, linkage editing, and execution are referred to by a standard set of symbolic names. These symbolic names are used in COBOL programs and in job control statements instead of actual physical device addresses. This provides several advantages for the programmer. For example, a programmer uses the ASSIGN TO clause to assign a file to the appropriate symbolic name. Such a program is not dependent on the physical device address and, as such, does not have to be recompiled unless the device type changes. The symbolic names and their usage are shown in Figure 1.

The symbolic names are assigned to physical devices at system generation time, by the operator, or by means of the job control ASSGN statement.

If a programmer wishes to use the assignments made at system generation time, he need not include any ASSGN statements in his job unless he is using his own data files in the COBOL program.

JOB CONTROL STATEMENTS

Job control statements are read from the device identified as SYSRDR. Not all job control statements are needed by COBOL. Those required are JOB, EXEC, /*, and /&. If disk labels are used, the VOL, XTENT, and DLAB statements, or the DLBL and EXTENT statements, are required. If tape labels are used, the VOL and TPLAB statements, or the TLBL statement, are required. All other statements are optional.

Symbolic Name	Function	Permissible Device Types
SYSRDR	Input unit for control statements	Card reader Magnetic tape unit Disk drive
SYSIPT	Input unit for programs	Card reader Magnetic tape unit Disk drive
SYSPCH	Main unit for punched output	Card punch Magnetic tape Disk drive
SYSLST	Main unit for printed output	Printer Magnetic tape Disk drive
SYSLOG	Operator messages and to log job control statements	Printer-keyboard Printer
SYSLNK	Input to the linkage editor	Disk extent Magnetic tape unit
SYSRES	Contains the operating system, the core image library, relocatable library, and source statement library	Tape unit or Area of a disk drive
SYSSLB	The private source statement library	Magnetic tape unit Disk drive
SYSRLB	Private relocatable library	Magnetic tape unit Disk drive
SYSIN	Must be used when SYSRDR and SYSIPT are assigned to the same disk extent. May be used when they are assigned to the same card reader or magnetic tape. This name can only be specified in a job control statement. COBOL SELECT statement must use the other names.	Disk Tape Card reader
SYSOUT	This name must be used when SYSPCH and SYSLST are assigned to the same magnetic tape unit. It must be assigned by the operator ASSGN command.	Tape
SYS000 to SYS222	These names are available to the programmer as work files or for storing data files. These names are called programmer logical units as opposed to the remaining names which are always referred to as system logical units.	Any unit

Figure 1. Symbolic Names, Their Function, and Permissable Device Type

Statements most likely to be used by the COBOL user are:

Operation	Meaning
JOB	Job name
EXEC	Execute program
ASSGN	Input/output assignments
LBLTYP	Reserve storage for label information
VOL	Volume information
DLAB (Disk only)	Disk file label information
DLBL (Disk only)	Disk file label information
XTENT (Disk only)	Disk file extent
EXTENT (Disk only)	Disk file extent
TPLAB	Tape file label information
TLBL	Tape file label information
RESET	Reset input/output assignments
OPTION	Option
PAUSE	Pause (for message to operator)
/*	End of data file
/&	End of job
*	Comment

SEQUENCE OF JOB CONTROL STATEMENTS

The job control statements for a specific job always begin with a JOB statement and end with a /& (end-of-job) statement. A specific job consists of one or more job steps. Each job step is initiated by an EXEC statement. Preceding the EXEC statement are any job control statements necessary to prepare for the execution of the specific job step. The only limitation on the sequence of statements preceding the EXEC statement is that which is discussed here for the label information statements. The following statements can precede the EXEC statement for a job step and will be frequently used by COBOL programmers.

ASSGN
LBLTYP
VOL
DLAB
XTENT
TPLAB
DLBL
EXTENT
TLBL
OPTION
PAUSE

The label statements must be in the order:

VOL		VOL
TPLAB	or	DLAB
		XTENT (one for each area or file in volume)
	or	TLBL
		DLBL
		EXTENT (one for each area or file in a volume)

and must immediately precede the EXEC statement to which they apply.

FORMAT OF JOB CONTROL STATEMENTS

All job control statements are free form, except for a few restrictive rules.

The general format of the job control statements is, as follows:

1. Name. Two slashes (//) identify the statement as a control statement. They must be in columns 1 and 2. The second slash must be immediately followed by at least one blank. Exceptions to these rules are:

   a. The end-of-job statement contains /& in columns 1 and 2.
   b. The end-of-file statement contains /* in columns 1 and 2.
   c. The comment statement contains * in column 1 and a blank in column 2.

2. Operation. This field describes the type of control statement. It can be up to eight characters long. At least one blank follows its last character.

3. Operand. This field may be blank or may contain one or more entries separated by commas. The last term must be followed by a blank, unless its last character is in column 71.

4. Comments. Comments are permitted anywhere after the trailing blank of the operand field.

CONTINUATION OF JOB CONTROL STATEMENT

Information starts in column 1 and cannot extend past column 71. The exceptions to this are file-label statements (TPLAB and DLAB). Information for file-label statements can be specified on more than one card, in which case a continuation statement is required. Any non-blank character present in column 72 specifies that information is contained in the card image that follows. Columns 1 through 15 of the continuation statement are ignored. Begin continuation statement information in column 16.

The ASSGN Statement

The ASSGN statement is used to assign a logical device address to a physical device. The format of the ASSGN statement is as follows:

```
// ASSGN SYSxxx,device-address [{,X'ss'} ]
                               [{,ALT  } ]
```

SYSxxx is one of the logical devices listed in Figure 1 (with the exception of SYSOUT, which cannot be assigned by means of ASSGN statements). The system permits programmer logical units in the range from SYS000 to SYS222. The number of units actually permitted in a specific installation is defined at system generation time and, normally, is less than 223. Units SYS000 through SYS009 are the minimum configuration provided by the system.

Device-address permits three different formats:

X'cuu' where c is the channel number and uu the unit number in hexadecimal notation. The values of cuu are determined by each installation.

UA Unassign. The job will be canceled if a file attached to this logical unit is referred to by one of the input output statements OPEN, CLOSE, READ, WRITE, or REWRITE.

IGN Indicates the logical unit is to be unassigned, and all program references to the logical device by anything other than logical IOCS are to be ignored. Files that are to be processed by logical IOCS must not be assigned IGN, or the job will be cancelled when an attempt is made to open the file. The IGN option is not valid for SYSRDR, SYSIPT, and SYSIN.

X'ss' is the device specification. It is used for specifying mode settings for 7-track and dual-density 9-track tapes. If X'ss' is not specified, the system assumes X'90' for 7-track tapes and X'C0' for 9-track tapes. The possible specifications for X'ss' are shown in Figure 2.

ss	Bytes per inch	Parity	Translate Feature	Convert Feature
10	200	odd	off	on
20	200	even	off	off
28	200	even	on	off
30	200	odd	off	off
38	200	odd	on	off
50	556	odd	off	on
60	556	even	off	off
68	556	even	on	off
70	556	odd	off	off
78	556	odd	on	off
90	800	odd	off	on
A0	800	even	off	off
A8	800	even	on	off
B0	800	odd	off	off
B8	800	odd	on	off
C0	800	single-density 9-track		
C0	1600	dual-density 9-track		
C0	1600	single-density 9-track		
C8	800	dual-density 9-track		

Note: If SYS001,SYS002, or SYS003 is assigned to a 7-track tape, the mode setting must be: converter on, translator off, odd parity.

Figure 2. Possible Specifications for X'ss' in the ASSGN Statement

ALT indicates an alternate magnetic tape unit that is used when the capacity of the original assignment is reached. The characteristics of the alternate unit must be the same as those of the original unit. Multiple alternates may be assigned to a logical unit.

When an alternate drive assignment is made for a multi-reel file, the primary assignment, as well as the alternate assignment, must be made within the job stack even if the primary assignment is standard. For example,

```
// ASSIGN SYS014,X '184'

// ASSIGN SYS014,X '185' ,ALT
```

Note: All device assignments made with ASSGN statements are reset between jobs to the configuration specified at system generation time plus any modifications that may have been made by the operator (see the section "The JOB Statement").

When preparing ASSGN statements for a compilation job step, the programmer uses the system logical units (SYSIPT, etc.) to refer to input/output devices used in the system configuration. When preparing the ASSGN statement for execution time job steps, the programmer uses the programmer logical units (SYS000 through SYS222) to assign a symbolic unit to a specified physical device. For example,

```
// ASSGN SYS004,X'00C'
```

This example could be used to assign the symbolic unit SYS004 to a card reader at address X'00C'. The first digit specifies the multiplexor channel and the 0C specifies the unit number.

To specify this file in a COBOL program, the programmer writes

```
SELECT filename ASSIGN TO 'SYS004'
```

Note that only the programmer logical units (SYS000 through SYS222) can be used in a COBOL program.

The EXEC Statement

The execution of a job step is initiated by the following job control statement:

```
// EXEC name
```

Name is the name of the first phase of the program to be fetched for execution from the core-image library. Therefore, execution of a COBOL compilation would be initiated by the statement

```
// EXEC COBOL
```

The name must be omitted if a program that was processed by the linkage editor in the previous job step of the same job is to be executed from SYSLNK.

The JOB Statement

Each job begins with the following job control statement:

```
// JOB job-name
```

Job-name is a user-defined name of 1 to 8 characters, the first of which must be alphabetic.

Note: The JOB statement resets the effect of all previously issued OPTION and ASSGN statements.

LBLTYP Statement

THE LBLTYP statement is used to define the amount of main storage to be reserved at linkage edit time for processing tape and nonsequential disk-file labels in the COBOL program area of main storage. It applies to both background and foreground programs and is required if the file contains standard labels. The format of the LBLTYP statement is:

```
// LBLTYP {TAPE[(nn)]}
          {NSD(nn)   }
```

TAPE(nn) For the Tape Operating System, nn is used to specify the decimal number of pairs of VOL, TPLAB statements that appear immediately before the execution of the linkage edited program.

TAPE[(nn)] For the Disk Operating System, TAPE is used only if tape files requiring label information are to be processed, and no nonsequential DASD files are to be processed. nn is optional, and is present only for future expansion (it is ignored by job control).

NSD(nn) (Disk only) Used if any nonsequential DASD files are to be processed, regardless of other file types to be used. nn specifies the largest number of extents to be used for a single file.

VOL Statement

The VOL statement is used to check standard labels for tape or disk files. It is required for each file on a multiple file volume. The format of the VOL statement is:

```
// VOL SYSxxx,filename
```

SYSxxx (the first operand) is the logical unit referenced.

filename (the second operand) identifies the file for the control program.

The occurrence of two identical operands is peculiar to COBOL object modules, because SYS004 is both the file-name by which the file is known to the control program, and the logical unit which is assigned to a device.

Note: The file-name (second operand of the VOL card) must be the system unit number (SYSxxx). DOS COBOL cannot use the FD name as the file-name

because the FD in the COBOL program can be up to 30 positions in length; the file-name in the VOL statement cannot exceed 8 positions. The ASSIGN clause of the SELECT sentence in the COBOL program must also use the SYSxxx name.

For example: SELECT INPUT-MASTER-FILE ASSIGN TO 'SYS004'....

TPLAB Statement

The TPLAB statement contains file label information for tape label checking and writing and must immediately follow the VOL statement. The formats of the TPLAB statements are:

```
// TPLAB 'label fields 3-10'
// TPLAB 'label fields 3-13'
```

TPLAB identifies the tape-label statement and can be written two ways:

1. Input labels require only one statement, and contain fields 3-10 of the standard tape file label. These are the only fields used for checking the label of an input file. Refer to Appendix B for an illustration of standard tape file labels.

2. When writing output labels, additional fields 11 through 13 may be included by use of a continuation statement. (These fields are not required for output files.) Refer to the publication IBM System/360 Disk Operating System: System Control and System Service Programs, Form C24-5036, for details about these fields.

OPTION Statement

This statement specifies one or more of the job control options available. The order in which they appear in the operand field is arbitrary. The format of the option statement is:

```
// OPTION option1 [,option2,...]
```

where the options are:

LOG — Causes the listing of columns 1 through 80 of all control statements on SYSLST. Control statements are not listed until a LOG option is encountered. Once a LOG option statement is read, logging continues from job-step to job-step until a NOLOG option is encountered or until either the JOB or /& control statement is encountered.

NOLOG — Suppresses the listing of all control statements on SYSLST except JOB and /& statements until a LOG option is encountered.

DUMP — Causes a dump of the registers and main storage to be printed on SYSLST in the case of an abnormal program end (such as program check).

NODUMP — Suppresses the DUMP option.

LINK — Indicates that the object module is to be linkage edited after compilation. When the LINK or CATAL option is used, the output of the compiler is written on SYSLNK. The LINK option must always precede an EXEC LNKEDT statement containing a compiler step.

NOLINK	Suppresses the LINK option. The compiler can also suppress the LINK option if the program contains an error that would preclude the successful execution of the program. An EXEC statement with a blank operand also suppresses the LINK option.
DECK	Causes the compiler to punch object modules on SYSPCH. If LINK is specified, the DECK option is ignored.
NODECK	Suppresses the DECK option.
LIST	Causes the compiler to write source statements on SYSLST.
NOLIST	Suppresses the LIST option.
LISTX	Causes the compiler to write the procedure division map in hexadecimal on SYSLST.
NOLISTX	Suppresses the LISTX option.
XREF	Causes the Assembler to write the symbolic cross-reference list on SYSLST.
NOXREF	Suppresses the XREF option.
ERRS	Causes the compiler to write the diagnostic messages related to the source program on SYSLST.
NOERRS	Suppresses the ERRS option.
CATAL	Causes the cataloging of a phase or program in the core image library at the completion of a linkage editor run. CATAL also causes the LINK option to be set.
MINSYS (TOS only)	Causes the linkage editor to generate minimal modules for later runs on systems when linkage editing on systems greater than 16K.
GO (TOS only)	Indicates that a linkage edited program exists on SYSLNK. The program either can be cataloged in the core image library or executed. To catalog the program, specify GO, CATAL in the OPTION statement. To execute the program, specify GO in the OPTION statement and follow it with an EXEC statement with a blank operand. When GO is specified, job control does not open SYSLNK or check the content of SYSLNK.
STDLABEL (DOS only)	Causes all disk labels submitted after this point to be written on the standard label track. Reset to USRLABEL option at end-of-job step.
USRLABEL (DOS only)	Causes all disk labels submitted after this point to be written at the beginning of the user label track.
SYM	Causes the compiler to print the data division map on SYSLST.
PARSTD	Causes all DASD or tape labels submitted after this point to be written at the beginning of the partition standard label track. Reset to USRLABEL option at end-of-job or end-of-job step. All file definition statements submitted after this option will be available to any program in the current partition until another set of partition standard file definition statements is submitted. All file definition statements submitted after OPTION PARSTD will be included in the standard file definition set until one of the following occurs:

1. End-of-job step

2. End-of-job

3. OPTION USRLABEL is specified.

4. OPTION STDLABEL is specified.

For a given file-name, the sequence of search for label information during an OPEN is the USRLABEL area, followed by the PARSTD area, followed by the STDLABEL area.

The options specified in the OPTION statement remain in effect until a contrary option is encountered or until a JOB control statement is read. In the latter case, the options are reset to the standard that was established when the system was originally generated.

Any assignment for SYSLNK, after the occurrence of the OPTION statement, cancels the LINK and CATAL options. These two options are also canceled after each occurrence of an EXEC statement with a blank operand.

PAUSE Statement

This statement can be used for operator action between jobs. Any messages to the operator can appear in the operand of a PAUSE statement. The format for the PAUSE statement is:

```
// PAUSE [comments]
```

An example of this statement is:

```
// PAUSE SAVE SYS004, SYS005, MOUNT NEW TAPES
```

This statement tells the operator to save the output tapes, and mount two new tapes.

When the PAUSE statement is encountered by job control, the printer-keyboard (IBM 1052) is unlocked for operator-message input. The end-of-communication indicator, B (B = alter code 5), causes processing to continue.

DLAB Statement (DOS only)

The disk label statement contains file label information for disk label checking and creation. This card must immediately follow the VOL card. The DLAB statement requires (in the case of card input) two cards for completion, therefore, column 72 of the first card requires a character punch other than a blank. The disk label is known as a FORMAT 1 disk file label. Its format is given in Appendix C. The format of the DLAB statement is:

```
// DLAB 'label fields 1-3',                          C
        xxxx,yyddd,yyddd,'systemcode'[,type]
```

'label fields 1-3' are defined in Appendix D.

xxxx is the volume sequence number in field 4 of the FORMAT 1 label, and must begin in card column 16.

yyddd,yyddd is the file creation date followed by the file expiration date.

'systemcode' is ignored by Disk and Tape Operating Systems but is required by Operating System. It must be 13 characters long.

[,type] indicates the type of file label:

SD - sequential disk (assumed if no entry is made).
DA - direct access
ISC - indexed sequential (used when creating a file)
ISE - indexed sequential (used when updating or retrieving a file) file)

XTENT Statement (DOS only)

This statement is used to define an area in a direct-access storage device (DASD). Each DASD file requires one or more XTENT statements. There are three extent types. Each is identified by a code that informs the control program what the defined area is to be used for. The format of the XTENT statement is:

```
// XTENT type,sequence,lower,upper
        'serial no.',SYSxxx[,B2]
```

type — Extent Type -- occupies 1 or 3 columns, containing:

1 = data area (no split cylinder)

2 = overflow area (for indexed sequential file)

4 = index area (for indexed sequential file)

128 = data area (split cylinder). If type 128 is specified, the lower head $H_1H_2H_2$ is taken from lower, and the upper head $H_1H_2H_2$ is taken from upper.

sequence — Extent Sequence Number -- indicates the sequence number of this extent within a multi-extent file. The sequence number occupies 1 to 3 columns and contains a decimal number from 0 to 255. Extent sequence 0 is used for the master index of an indexed sequential file. If the master index is not used, the first extent of an indexed sequential file has sequence number 1. The extent sequence for all other types of files begins with 0. Direct files can have up to 5 extents. ISAM files can have up to 11 data extents (9 prime, 1 cylinder index, 1 separate overflow).

lower — Lower Limit of Extent -- occupies 9 columns and contains the lowest address of the extent in the form $B_1C_1C_1C_2C_2C_2H_1H_2H_2$

where:

B_1 is the initially assigned cell number. It is equal to:

0 for 2311 and 2314
0 to 9 for 2321

C_1C_1 is the subcell number. It is equal to:

00 for 2311 and 2314
00 to 19 for 2321

$C_2C_2C_2$ is the cylinder number. It can be:

000 to 199 for 2311 and 2314
or strip number:

000 to 009 for 2321

H_1 is the head block position. It is equal to:

0 for 2311 and 2314
0 to 4 for 2321

H_2H_2 is the head number. It can be:

00 to 09 for 2311
00 to 19 for 2321 and 2314

A lower extent of all zeros is invalid.

Note: For 2321, the last five strips of subcell 19 are reserved for alternate tracks.

upper — Upper Limit of Extent -- occupies nine columns containing the highest address of the extent, in the same form as the lower limit.

'serial no.' — Volume Serial Number -- This is a 6-byte alphanumeric character string, contained within apostrophes. The number is the same as in the volume label (volume serial number) and the format 1 label (file serial number).

SYSxxx — This is the symbolic address of the DASD drive. If more than one symbolic address is to be specified on separate XTENT cards for the same file, the symbolic addresses must be in consecutive order.

B_2 — Currently assigned cell number. Its value is:

0 for 2311 or 2314
0-9 for 2321

This field is optional. If missing, job control assigns $B_2 = B_1$.

The RESET Statement

The RESET statement resets input/output assignments to the standard assignments. The standard assignments are those specified at system generation time plus any modifications made by the operator by means of an ASSGN command (as opposed to using an ASSGN control statement) without the TEMP option. The format of the RESET statement is as follows:

```
// RESET   {SYS   }
           {PROG  }
           {ALL   }
           {SYSxxx}
```

SYS resets all system logical units to their standard assignments.

PROG resets all programmer logical units to their standard assignments.

ALL resets all programmer and system logical units to their standard assignments.

SYSxxx resets the specified logical unit to its standard assignment.

The End-of-Data-File Statement

The end-of-data-file statement (/* in columns 1 and 2) serves as a delimiter for the input read from the device assigned to SYSIPT. Therefore, COBOL programs must be terminated by an end-of-data-file statement. This statement is also recognized on the programmer logical units that are assigned to a card reader.

The End-of-Job Statement

The end-of-job statement (/& in columns 1 and 2) indicates that a job has been completed. If this statement is omitted, the Job Control program may skip the next job stacked on the device assigned to SYSRDR and/or SYSIPT. If SYSRDR and SYSIPT are different units, the end-of-job statement should appear on both because both units are advanced to a /& if an abnormal end of job occurs.

The Comments Statement

A special comments statement (* in column 1 and blank in column 2, followed by the desired comments) is available for longer messages. The comments are printed on SYSLOG, but no halt is effected by this statement.

CBL Statement (COBOL Option Control Card)

Although most options for compilation are specified in the job control OPTION statement, the COBOL compiler provides an additional option statement to increase flexibility. The CBL card must be placed between the EXEC COBOL statement and the first statement in the COBOL program. The CBL card cannot be continued. However, if specification of options will continue past column 71, two CBL cards may be used. The format of this card is:

```
CBL   [DMAP=h]   [,PMAP=h]   [,BUFFSIZ=d]      [,DISPCHK=YES]
                                                      NO
            [,INVED][,NOEXIT=([E],[C])]
```

CBL — CBL must begin in column 2, be preceded and followed by at least one blank.

DMAP=h
PMAP=h — DMAP and PMAP specify that the addresses which appear in the coding of both the data division map and the procedure division are to be incremented by the number h. This is only for the listing not for the object module. h is a hexadecimal number of from one to

eight digits and is assumed to be zero if one of these options is not specified. If both options are specified, the value for the last h is the value that is used. h is called a relocation factor.

BUFFSIZ=d — BUFFSIZ specifies the size of the compiler buffer. d is a decimal number from 170 to either 32,760 for magnetic tape or the maximum size of a track for disk. If this option is not specified, 170 is assumed for 16K systems and 1,024 is assumed on 32K or larger systems.

DISPCHK= YES / NO — DISPCHK specifies whether or not a diagnostic check is to be made at execution time for displayed items. If YES is specified, the length of all items to be displayed is checked before moving them to the buffer. If an item is too long, it is truncated, but no message is printed. If NO is specified, no check is made and items are moved directly to the buffer. If an item is too long and thus exceeds the buffer size, it will destroy the contents of the storage area following the buffer. The default value is NO.

INVED — INVED specifies that the roles of the characters "." and "," are to be reversed. This affects report items in the data division, value clauses in the data division, and numeric literals in the procedure division. If this option is not specified, the character "." represents a decimal point and the character "," represents an insertion character.

NOEXIT=([C],[E]) — If the NOEXIT option is used, the compiler does not generate code for handling program checks. E, C, or both E and C may be specified. If C is specified, code for handling program checks is suppressed for CALL coding. Similarly, if E is specified, code for handling program checks for ENTRY coding is suppressed. Hence, this option increases program efficiency by increasing the speed of control transfer between calling and called programs. When using this option, the programmer assumes responsibility for handling interrupts which occur for an ON SIZE ERROR condition. If this option is not specified, the compiler will handle program checks for arithmetic statements in the program.

DLBL Statement

This statement replaces the VOL and DLAB statement combination used in previous versions of the system. It contains file label information for DASD label checking and creation. (This release of the system will continue to support the VOL, DLAB, and XTENT combinations currently in use.) The DLBL statement has the following format.

// DLBL filename,['file-ID'],[date],[codes]

filename — Filename is the symbolic name of the program DTF which identifies the file. For COBOL program data files, this is SYSxxx as it appears in the SELECT sentence.

'file-ID' — The name associated with the file on the volume. This can be from one to 44 bytes of alphanumeric data, contained within apostrophes, including file-ID and, if used, generation number and version number of genera-

tion. If fewer than 44 characters are used, the field will be left-justified and padded with blanks. If this operand is omitted, "filename" will be used.

date — This can be from one to six characters indicating either the retention period of the file in the format d-dddd or the absolute expiration date of the file in the format yy/ddd. If this parameter is omitted, a 0-day retention period is assumed. If this operand is present on an input file, it is ignored.

codes — This is a 2 or 3-character field indicating the type of file label, as follows:

- SD for Sequential Disk or for DTFPH with MOUNTED-SINGLE
- DA for Direct Access or for DTFPH with MOUNTED=ALL
- ISC for Indexed Sequential using Load Create
- ISE for Indexed Sequential using Load Extension, Add, or Retrieve

TLBL Statement

This statement replaces the VOL and TPLAB statement combination used in previous versions of the system. (This release will continue to support the VOL, TPLAB combination currently in use.) The TLBL statement contains file label information for tape label checking and writing. Its format follows:

// TLBL — filename,['file-ID'],[date],[file-serial-number], [volume-sequence-number],[file-sequence-number], [generation-number],[version-number]

filename — This can be from one to seven characters and is identical to the symbolic name of the program DTF which identifies the file. For COBOL program data files, this is SYSxxx as it appears in the SELECT sentence.

'file-ID' — One to 17 characters, contained within apostrophes, indicating the name associated with the file on the volume. This operand may contain embedded blanks. On output files, if this operand is omitted, the "filename" will be used. On input files, if the operand is omitted, no checking will be done.

date — Four to six characters, in the format yy/ddd, indicating the expiration date of the file for output or the creation date for input. (The day of the year may have from 1 to 3 characters.) For output files, a 1 to 4-character retention period (d-dddd) may be specified. If this operand is omitted, a 0 day retention period will be assumed for output files. For input files, no checking will be done if this operand is omitted or if a retention period is specified.

file serial number — One to six characters indicating the volume serial number of the first (or only) reel of the file. If less than six characters are specified, the field will be right-justified and padded with zeros. If this operand is omitted on output, the volume serial number of the first (or only) reel of the file will be used. If the operand is omitted on input, no checking will be done.

volume sequence number — One to four characters in ascending order for each volume of a multiple volume file. This number is incremented automatically by OPEN/CLOSE routines as required. If this operand is omitted on output, BCD 0001 will be used.

file sequence number — One to four characters in ascending order for each file of a multiple file volume. This number is incremented automatically by OPEN/CLOSE routines as required. If omitted on output, BCD 001 will be used. If omitted on input, no checking will be done.

generation number — One to four characters that modify the file-ID. If omitted on output, BCD 0001 is used. If omitted on input, no checking will be done.

version number — One or two characters that modify the generation number. If omitted on output, BCD 01 will be used. If omitted on input, no checking will be done.

For output files, the current date will be used as the creation date and "DOS/TOS/360" will be used as the system code.

EXTENT -- DASD Extent Information

The EXTENT command or statement defines each area, or extent, of a DASD file. One or more EXTENT commands or statements must follow each DLBL command or statement except for single volume input files for Sequential Disk or Direct Access, on either a 2311 or a 2314, for which the DEVADDR parameter has been specified in the DTF table.

This command or statement replaces the XTENT command or statement used in previous versions of the system. (Programming support for XTENT will be continued.)

```
[//] EXTENT,[symbolic-unit],[serial-number],
     [type],[sequence-number],[relative-
     track],[number-of-tracks],[split-
     cylinder-track],[B=bins]
```

Accepted by SPI

```
// EXTENT[symbolic-unit],[serial-number],
     [type],[sequence-number],[relative-
     track],[number-of-tracks],[split-
     cylinder-track],[B=bins]
```

Accepted by JC

symbolic unit — A 6-character field indicating the symbolic unit (SYSxxx) of the volume for which this extent is effective. If this operand is omitted, the symbolic unit of the preceding EXTENT will be used. (This operand is not required for an IJSYSxx filename or for a file defined with the DTF DEVADDR=SYSnnn.)

serial number — From one to six characters indicating the volume serial number of the volume for which this extent is effective. If fewer than six characters are used, the field will be right-justified and padded with zeros. If this operand is omitted, the volume serial number of the preceding EXTENT will be used. If no serial number was provided in the EXTENT command or statement, the serial number will not be checked and it will be

the user's responsibility if files are destroyed due to mounting the wrong volume.

type — One character indicating the type of the extent, as follows:

1 - data area (no split cylinder)
2 - overflow area (for indexed sequential file)
4 - index area (for indexed sequential file)
8 - data area (split cylinder)

If this operand is omitted, type 1 will be assumed.

sequence number — One to three characters containing a decimal number from 0 to 255 indicating the sequence number of this extent within a multi-extent file. Extent sequence 0 is used for the master index of an indexed sequential file. If the master index is not used, the first extent of an indexed sequential file has the sequence number 1. The extent sequence number for all other types of files begins with 0. If this operand is omitted for the first extent of ISFMS files, the extent will not be accepted. For SD or DA files, this operand is not required.

relative track — One to five characters indicating the sequential number of of track, relative to zero, where the data extent is to begin. If this field is omitted on an ISFMS file, the extent will not be accepted. This field is not required for DA input or for SD input files (the extents from the file labels will be used).

Formulas for converting actual to relative track (RT) and relative track to actual for the DASD devices follow.

Actual to Relative

2311 10 x cylinder number + track number = RT
2314 20 x cylinder number + track number = RT
2321 1000 x subcell number + 100 x strip number + 20 x block number + track number = RT

Relative to Actual

2311 $\frac{RT}{10}$ = quotient is cylinder, remainder is track

2314 $\frac{RT}{20}$ = quotient is cylinder, remainder is track

2321 $\frac{RT}{1000}$ = quotient is subcell, remainder1

$\frac{remainder1}{100}$ = quotient is strip, remainder2

$\frac{remainder2}{20}$ = quotient is block, remainder is track

Example: Track 5, cylinder 150 on a 2311 = 1505 in relative track.

number of tracks — One to five characters indicating the number of tracks to be allotted to the file. For SD input or DA input, this field may be omitted. For split cylinders, the number of tracks must be an even multiple of the number of tracks per cylinder specified for the file.

split cylinder track — One or two characters, from 0-19, indicating the upper track number for the split cylinder in SD files.

bins — One or two characters identifying the 2321 bin that the extent was created for or on which the extent is currently located. If the field is one character, the creating bin is assumed to be zero. There is no need to specify a creating bin for SD or ISFMS files. If this operand is omitted, bin zero is assumed for both bins. If the operand is included and positional operands are omitted, only one comma is required preceding the key-word operand. (One comma for each omitted positional operand will be acceptable, but not necessary.)

THE LINKAGE EDITOR

The linkage editor prepares an object module for execution. It can also be used to combine two or more separately compiled object modules into a format suitable for execution. The output of the linkage editor consists of one or more program phases.

If linkage editor processing is desired, the job control OPTION statement specifying the LINK or CATAL option must precede the first linkage editor control card and the first EXEC statement in the job. The linkage editor is called for processing by specifying LNKEDT in an EXEC statement. Processing by the linkage editor is suppressed if severe programming errors are detected during compilation.

Input to the linkage editor may consist of any combination of the following:

1. Object modules compiled in previous job steps (SYSLNK)
2. Object modules from the relocatable library (SYSRES) or (SYSRLB)
3. Object modules in the form of card decks (SYSIPT)

Output from the linkage editor is placed in the core image library as a permanent member if the CATAL option has been specified on the job control OPTION statement. If CATAL has not been specified, the program phase is placed in the temporary part of the core image library for DOS or on SYSLNK for TOS.

LINKAGE EDITOR CONTROL STATEMENTS

The execution of the linkage editor is initiated by linkage editor control statements read from SYSRDR. The general format of linkage editor control statements is similar to that of the job control statements except that the linkage editor control statements must have a blank in column 1 instead of // in columns 1 and 2. The PHASE card and the INCLUDE card are of special interest in preparing object modules to be linkage edited.

The PHASE Statement

The PHASE statement must be specified if the output of the linkage editor is to consist of more than one phase or if the program phase is to be cataloged in the core image library. Each object module that is to begin a phase must be preceded by a PHASE statement of the following format:

PHASE phase-name,origin

The phase-name is the name under which the program phase is to be cataloged. This name does not have to be the program-id name, and in the case of overlay it should not be the same. It must consist of one to eight alphanumeric characters, the first of which must be alphabetic.

The origin indicates to the linkage editor the begin address of this specific phase. An asterisk may be used as an origin specification to indicate that this phase is to follow the previous phase or the Supervisor at the next doubleword boundary. This simple format of the PHASE statement covers all applications that do not include setting up overlay structures. See "Section VII: Subprograms and Overlay" for information on the PHASE statement for overlay applications.

The INCLUDE Statement

The INCLUDE statement must be specified for each object module deck or object module in the relocatable library that is to be included in a program phase. The format of the INCLUDE statement is as follows:

INCLUDE [module-name]

The module-name is not specified when the module to be included is in the form of a card deck being entered from SYSIPT. If the object module is being included from the relocatable library, the module-name is the name under which the module was cataloged in the library.

THE AUTOLINK FEATURE

If any references to external names are still unresolved after all modules have been read from SYSLNK, SYSIPT, and/or the relocatable library, the autolink feature of the linkage editor searches the relocatable library for module-names identical to the unresolved names and includes these modules in the program phase. This feature is required to include COBOL subroutines that are cataloged in the relocatable library.

Examples:

1. Linkage edit one object module compiled in a previous job step.

```
// JOB      N0123
// OPTION   LINK
   PHASE    EXAMPLE,*
// EXEC     COBOL
     COBOL
     source module
/*
// EXEC     LNKEDT
// EXEC
     data

/*
/&
```

2. Linkage edit three object modules and catalog the phase (one module from previous compilation, one from SYSIPT and one named R from the relocatable library).

```
// JOB
// OPTION    CATAL
   PHASE     EXAMPLE,*
// EXEC      COBOL
     COBOL
     source module
/*
   INCLUDE
     (object module)
   INCLUDE R
/*
// EXEC      LNKEDT
/&
```

LIBRARIAN FUNCTIONS

The service program called the librarian takes care of all maintenance functions (such as adding, deleting, and copying or renaming) for the system libraries. Cataloging (which simply means adding) of frequently used program phases, object modules, or source language statements in one of the system libraries greatly reduces the time required for card reading and linkage editor processing. Object modules are cataloged in the relocatable library. Program phases are cataloged in the core image library. Source module statements are cataloged in the source statement library. Each sequence of source statements cataloged in the source statement library is called a book.

The name of a phase, module, or book must be unique for each library. When a phase, module, or book is cataloged in a library, any module, phase, or book already contained in the respective library and having the same name is automatically deleted. This necessitates some naming conventions for each installation in order to prevent a programmer from unintentionally deleting programs that are part of the library.

A complete description of the library maintenance functions and deck set ups used to specify them is included in the publications IBM System/360 Tape or Disk Operating System: System Control and System Service Programs, Forms C24-5036 and C24-5034, respectively. The following discussions show how to catalog.

CATALOGING PROGRAM PHASES--CORE IMAGE LIBRARY

If a program is to be cataloged in the core image library, the job control statement // OPTION with the CATAL option must be given prior to linkage editor processing and it must precede the first PHASE card of the program to be cataloged in the case of compile and link edit runs. Upon successful completion of the linkage editor job step, the program phase(s) are automatically cataloged. The program phase can be executed in the next job step in the same job by specifying the // EXEC statement with a blank name field. When it is executed in a subsequent job, the EXEC statement that calls for execution must specify the name under which it has been cataloged. Note that the phase is cataloged under the name specified in the PHASE statement. The following is an example of cataloging a single phase in the core image library.

```
// JOB FOURA
// OPTION CATAL
   PHASE FOURA,*
   INCLUDE


     object deck
/*
// LBLTYP NSD(nn) or TAPE
// EXEC LNKEDT
/&
```

```
// JOB FOURB
// OPTION CATAL
   PHASE FOURB,*
   INCLUDE MOD4B
// LBLTYP NSD(nn) or TAPE
// EXEC LNKEDT
/&
```

CATALOGING OBJECT MODULES--RELOCATABLE LIBRARY

Object modules are cataloged in the relocatable library in a job step that specifies execution of a library maintenance program. This program is called by specifying MAINT in the operand field of the EXEC statement. Each object module to be cataloged must be preceded by the CATALR control statement. The format of this statement is:

```
CATALR module-name
```

where:

module-name
: must be used in the linkage editor INCLUDE statement. The module may be preceded but not followed by linkage editor control statements.

Note that CATALR statements are read from SYSIPT for DOS and SYSRDR for TOS. Therefore, for TOS the CATALR statements must be put on SYSRDR in the same sequence as the object modules on SYSIPT. The following is an example of cataloging two modules in the relocatable library.

```
// JOB EIGHT
// EXEC MAINT
   CATALR MOD8A


     object deck

   CATALR MOD8B


     object deck

/*
/&
```

CATALOGING BOOKS--SOURCE STATEMENT LIBRARY

Frequently used Data Division, Environment Division, and Procedure Division entries can be cataloged in the source statement library. A book in the source statement library might consist, for example, of a file description or a paragraph of the Procedure Division. Such source language statements are cataloged in the source statement library by using the library maintenance program MAINT. Each part to be entered must be preceded by a control statement of the format:

```
CATALS C.library-name
```

In addition, a control statement of the form BKEND C.library-name must precede and follow the book to be cataloged. Note that the CATALS statement is read from SYSIPT for DOS and SYSRDR for TOS but the BKEND statements are entered on SYSIPT before and after the book. The library-name must follow the rules for external-names in the COBOL language.

The following is an example of cataloging a file description in the source statement library.

```
// JOB ANYNAME
// EXEC MAINT
   CATALS C.FILEA
   BKEND C.FILEA
        DATA RECORD IS RECORD-1,
        LABEL RECORDS ARE STANDARD,
        BLOCK CONTAINS 13 RECORDS,
        RECORD CONTAINS 120 CHARACTERS.
   BKEND C.FILEA
/*
/&
```

This file description can be included in a COBOL source module by writing the following statement:

```
FD FILEB COPY 'FILEA'.
```

Note that the library entry does not include FD or the file-name. It begins with the first clause that is actually to follow the file-name. This is true for all options of COPY or INCLUDE. However, data entries in the library may have level numbers (01 or 77) identical to the level number of the data-name that precedes the COPY clause. In this case, all information about the library data-name is copied but the library data-name and all references to it are replaced by the data-name in the program. For example, assume the following data entry is cataloged under the library-name DATAR.

```
01   PAYFILE USAGE IS DISPLAY.
        02 CALC PICTURE 99.
        02 GRADE PICTURE 9
           OCCURS 1 DEPENDING ON CALC OF PAYFILE.
```

and the following statement is written in a COBOL source module

```
01 GROSS COPY 'DATAR'.
```

The compiler interprets this as:

```
01 GROSS USAGE IS DISPLAY.
     02 CALC PICTURE 99.
     02 GRADE PICTURE 9
              OCCURS 1 DEPENDING ON CALC OF GROSS.
```

Note also that the library-name is used to identify the book in the library. It has no other use in the COBOL program.

For both the relocatable library and the source statement library, several library maintenance operations can be performed in one job step. Except in the case of adding, this is also true for the core image library.

CATALOGING BOOKS--USER PRIVATE LIBRARY

The procedure for cataloging books in a private library is the same as the procedure for cataloging books in the source statement library

except that the logical device SYSSLB must be assigned and defined by DLBL, EXTENT or VOL, DLAB, and XTENT control statements. SYSSLB is the logical device used for private libraries.

A private library is defined by the CORGZ program. The following example defines a private library on physical unit 191.

```
// JOB PRIVLIB
// ASSGN SYSSLB,X'191'
// DLBL IJSYSSL,'DATA SET ID',date information, SD
// EXTENT extent information
// EXEC CORGZ
        NEWVOL SL=cylin(tracks)
/*
/&
```

where:

cylin = number of cylinders allocated to the library

tracks = number of tracks allocated to the directory

To use this private library for COPY and INCLUDE, the ASSGN, DLBL, and EXTENT job control statements which define the private library must be included in the deck structure for compilation. When these cards are present, a search for the book is made in the private library and in the system library. If the cards for the private library are not there, only the system library is searched. A programmer may create several private libraries, but only one private library can be used in a given job.

CHECKPOINTING A PROGRAM

When a program is expected to run for an extended period of time, provision should be made for taking checkpoint information periodically during the run. This information describes the status of the job and the system (main storage, input/output status, general and floating-point registers) at the time the records are written. Thus, it provides a means of restarting at a checkpoint position rather than at the beginning of the entire job, if processing is terminated for any reason before the normal end-of-job. Checkpoints are taken using the COBOL RERUN statement.

In designing a program for which checkpoints are to be taken, the user should consider the fact that, upon restarting, the program must be able to continue as though it had just reached that point in the program at which termination occurred. Hence, the user should ensure that:

1. File handling is organized to permit easy reconstruction of the status of the system as it exists at the time of each checkpoint. For example, when multifile reels are used, the operator should be informed (by message) as to which file is in use at checkpoint time. He requires this information at restart time.

2. The contents of files are not significantly altered between the time of the checkpoint and the time of the restart:

   - For sequential files, all records written on the file at checkpoint time should be unaltered at restart time.

   - For nonsequential files, care must be taken to design the program so that a restart will not duplicate work that has been completed between checkpoint time and restart time. For example, suppose that Checkpoint 5 is taken. By adding an amount representing interest due, account XYZ is updated on a

direct-access file that was opened with the input/output clause. If the program is restarted from Checkpoint 5 and if the interest is recalculated and again added to account XYZ, incorrect results will be produced.

If the program is modular in design, RERUN statements must be included in all modules that handle files for which checkpoints are to be taken. (When an entry point of a module containing a RERUN statement is encountered, a COBOL subroutine -- IHD03800 -- is called. IHD03800 enters the files of the module into the list of files to be repositioned.) Repositioning to the proper record will not occur for any files that were defined in modules other than those containing RERUN statements. Moreover, a restart from any given checkpoint will not reposition other tapes on which checkpoints are stored. Note, too, that only one disk checkpoint file can be used.

Restarting a Program: If the programmer includes checkpoints in his job by means of the COBOL RERUN statement, the message

```
0C00I CHKPT nnnn HAS BEEN TAKEN ON SYSxxx
```

is given each time a checkpoint is taken. (nnnn is the 4-character identification of the checkpoint record.) To restart a job from a checkpoint, the following actions are required:

1. Replace the // EXEC statement with a // RSTRT statement whose format is:

   ```
   // RSTRT SYSxxx,nnnn [,SYSxxx]
   ```

   where:

   SYSxxx is the symbolic name of the device on which the checkpoint records are stored

   nnnn is the 4-character identification of the checkpoint record to be used for restarting

   SYSxxx can be any value from SYS000 through SYS222. (If the checkpoint records are recorded on a direct-access device, SYSxxx must be repeated following the 4-character identification of the checkpoint record.) All other job control statements applicable to the job step should be the same as when the job was originally run. If necessary, the channel and unit addresses for the // ASSGN statements may be changed.

2. Rewind all tapes used by the program being restarted and mount them on devices assigned to the symbolic units required by the program. (If multireel files are involved, mount (on the primary unit) the reel in use at the time that the checkpoint was taken and rewind it. If multifile reels are involved, position the reel to the start of the file referred to at the time of the checkpoint.)

3. Reposition any card file so that only cards not yet read when the checkpoint was taken are in the card reader.

4. Execute the job.

Disk and Tape Operating System COBOL provides a linkage to the system checkpoint routine and re-entry point to the COBOL program from the system restart routine. Therefore, any restrictions applying to these system routines also apply to COBOL's restart procedures except as noted above. These restrictions are outlined in the publications IBM System/360 Disk Operating System: Supervisor and Input/Output Macros, Form C24-5037, and IBM System/360 Tape Operating System: Supervisor and Input/Output Macros, Form C24-5035.

SECTION II: DECK STRUCTURES FOR PROCESSING COBOL PROGRAMS IN A TAPE OPERATING SYSTEM

For each type of processing, certain combinations of job control cards are needed. The examples given illustrate typical basic types of processing within an all tape system configuration.

The examples assume a given tape system configuration, and that the COBOL Tape Compiler is used for processing.

Figure 3 is a diagram of the input/output units used by COBOL in a tape configuration, and should help the user to visualize the logical structure of a configuration. A list of the types of processing discussed, in the order they are presented, follows:

1. Compile and punch
2. Cataloging to the relocatable library
3. Compiling, linkage editing, and executing
4. Executing a previously linkage edited program
5. Cataloging to the source statement library
6. Compiling, linkage editing, and executing

Examples 3 and 6 differ in that example 3 illustrates how job control is used to link with a module cataloged to the relocatable library, while example 6 illustrates how COBOL copies source statement modules cataloged to the source statement library.

ASSUMED TAPE RESIDENT SYSTEM CONFIGURATION

The processing examples given herein assume that the following Tape Operating System was generated at system generation time:

The system includes:

One IBM 1403 Printer
One IBM 2540 Card/Read/Punch
One IBM 1052 Printer-Keyboard
Four IBM Magnetic Tape Units (excluding the resident tape drive)

Assume physical assignments at system generation time are:

1403 Printer assigned to physical unit X'00E'
2540R Reader assigned to physical unit X'00C'
2540P Punch assigned to physical unit X'00D'
1052 Printer-Keyboard assigned to physical unit X'01F'
2402 Magnetic Tape Unit assigned to physical unit X'180'
2402 Magnetic Tape Unit assigned to physical unit X'181',X'90'
2402 Magnetic Tape Unit assigned to physical unit X'182'
2402 Magnetic Tape Unit assigned to physical unit X'183'
2402 Magnetic Tape Unit assigned to physical unit X'184' (This unit is the resident tape drive.)

The hexadecimal 90 (X'90') in the tape assigned to X'181' determines the device specifications for a 7-track tape.

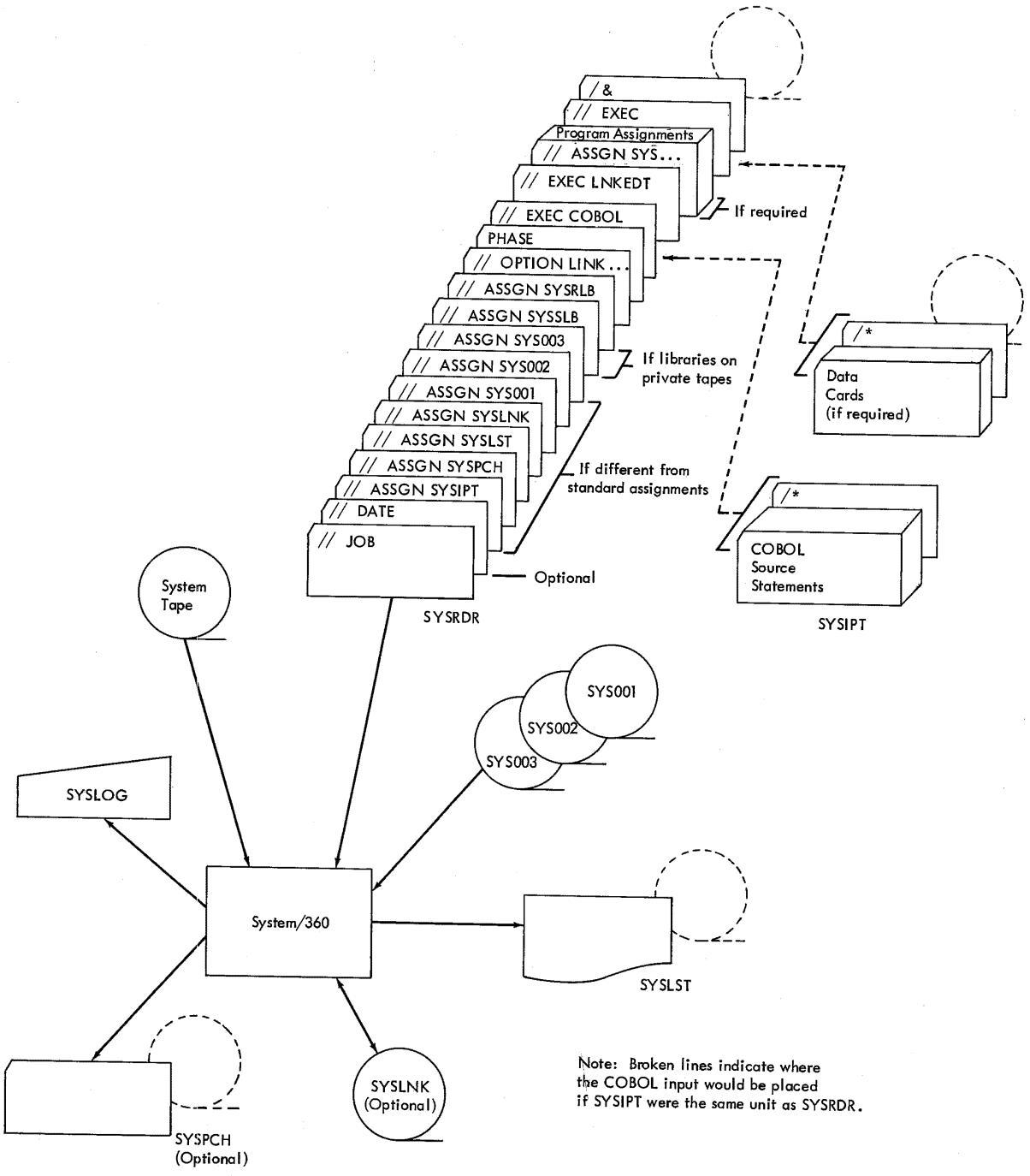


Figure 3. Input/output Units Used by COBOL Program in a Tape System

Assume logical assignments at system generation time are:

```
// ASSGN SYSIPT,X'00C'      }
// ASSGN SYSRDR,X'00C'      }IBM 2540
// ASSGN SYSPCH,X'00D'      }
// ASSGN SYSLST,X'00E'       IBM 1403
// ASSGN SYSLOG,X'01F'       IBM 1052
// ASSGN SYSLNK,X'180'      }
// ASSGN SYS001,X'181',X'90'}
// ASSGN SYS002,X'182'      }IBM 2400's
// ASSGN SYS003,X'183'      }
```

Notice that SYSIPT, SYSRDR, and SYSPCH are assigned to the same physical unit (they need not be), and that SYS001 is a 7-track tape. Observe also that four logical tape assignments are made. The COBOL compiler requires three logical work files to compile. The fourth can be used for compile-and-execute functions.

The user can change these assignments by the use of ASSGN cards following his JOB card. Examples of overriding assignments are given in the text that follows. In the examples that follow, whenever an optional statement is used, it is identified by the words (optional card).

EXAMPLES OF PROCESSING USING TAPE CONFIGURATION

EXAMPLE 1--COMPILE AND PUNCH

Assuming that source statements are card input (SYSIPT) and job-control statements are card input (SYSRDR), the set of job-control cards required (and some helpful options) to compile and punch are:

```
// JOB SUBROTNE
// OPTION LOG,DECK,LIST,LISTX,ERRS      } Input from SYSRDR
// EXEC COBOL

   SUBROTNE
   SOURCE STATEMENTS                    } Input from SYSIPT

/*
/&
// PAUSE REMOVE OBJECT DECK FROM HOPPER } Input from SYSRDR
   (optional card)
```

The options selected on the option card specify:

LOG -- Requests a listing of all control statements on SYSLST.
DECK -- Requests that a deck (object module) be punched on SYSPCH.
LIST -- Causes compiler to write source statements on SYSLST.
LISTX -- Causes compiler to write a procedure division map on SYSLST in hexadecimal.
ERRS -- Causes compiler to write all diagnostics related to the source program on SYSLST.

EXAMPLE 2--CATALOGING AN OBJECT MODULE IN RELOCATABLE LIBRARY

In this example, an object module generated by the compiler (see Example 1) is cataloged in the relocatable library. It is assumed that the relocatable library is on SYSRES (similarly for the source statement

library). Another tape drive may be used as a private library for the relocatable library, in which case the system logical unit SYSRLB is used.

The job-control cards required to catalog an object module to an existing relocatable library are:

```
// JOB RELOCATE
// EXEC MAINT


     CATALR SUBROTNE
     (Object deck to be
     cataloged goes here.)


/*
/&
*                          OBJECT MODULE 'SUBROTNE' IS NOW
*                          CATALOGED TO NEW SYSRES TAPE ON
// PAUSE                   SYS002
   (optional card)
```

When an object module is cataloged to the relocatable library residing on SYSRES, the following points must be considered:

1. SYS002 is the device on which the newly updated library is located (SYSRES is now outdated).

2. If SYS002 is to be established as new SYSRES, it must be mounted on the tape drive assigned to "old" SYSRES, and initial program loaded (IPL). This automatically establishes it as a "new" SYSRES. SYS002 can then be reassigned.

SYS001 is used as a work file.

EXAMPLE 3--COMPILE, LINKAGE EDIT, AND EXECUTE

This example illustrates how an object module cataloged in the relocatable library is included in a compilation, linkage edited with the main program, and executed.

The job control statements required to compile, linkage edit, and execute are:

```
// JOB CALLPROG
// OPTION LINK,LIST,LISTX,ERRS
   PHASE MAIN,*
// EXEC COBOL

   {COBOL SOURCE STATEMENTS}
/*
   INCLUDE SUBROTNE  {Retrieves SUBROTNE from relocatable library}
// EXEC LNKEDT
// EXEC
  (DATA DECK )
  (  (if any))
/*
/&
```

This program consists of one phase that includes the object module SUBROTNE and permits immediate execution of the program. [The name provided in the PHASE statement (main) has no relationship to the external-name given in the COBOL Program-ID statement.]

It is possible to process this program with only three work files; however, the procedure requires special instructions to the operator for making two passes through the system. In this example, such instructions are conveyed to the operator on comment cards.

The output of the first pass (Pass 1) is a punched object deck, which is used in the second pass (Pass 2). To accomplish Pass 2 (linkage edit and execute), the punched object deck must be positioned in the job stream to precede the EXEC LNKEDT and EXEC statements. (This is done when the PAUSE statement is encountered.)

The complete job stream to accomplish both Pass 1 and Pass 2 is, as follows:

```
// JOB CALLPROG
// ASSGN SYS001,X'180' }  Work
// ASSGN SYS002,X'182' }  Files
// ASSGN SYS003,X'183' }
// OPTION DECK,LISTX,ERRS                          } Pass 1
// EXEC COBOL
   [COBOL SOURCE STATEMENTS]                       }
/*
// ASSGN SYS001,X'180'   Assignments
// ASSGN SYS002,X'182'   For Linkage
// ASSGN SYSLNK,X'183'   Edit and Execute
// OPTION LINK
* PLACE THE OUTPUT OF SYSPCH INTO SYSRDR.
* PLACE THE INCLUDE SUBROTNE STATEMENT
* THROUGH THE /& STATEMENT, INCLUSIVE,
* (LABELED PASS 2 IN THIS EXAMPLE)
* BEHIND THE PUNCHED OBJECT DECK JUST
* PUT INTO SYSRDR.
* CONTINUE
// PAUSE
   INCLUDE
   PHASE MAIN,*

     (The punched object deck will be
     positioned here in the job stream.)
/*                                                 }
   INCLUDE SUBROTNE     (Retrieves SUBROTNE)       }
                        (from RELOCATABLE )        }
                        (LIBRARY          )        }
// EXEC LNKEDT                                     }
// EXEC                                            } Pass 2
   (DATA DECK)                                     }
   ((if any) )                                     }
/*                                                 }
/&                                                 }
```

The new option card is needed to accomplish the linkage editing. The entire set of control statements and source statements from // JOB card through /& card are submitted as one job.

Note that the SYS001, SYS002, and SYSLNK units are required to execute the linkage editor.

EXAMPLE 4--EXECUTING A PROGRAM

The job control statements required simply to execute a program, assuming it is in the core image library, are:

```
// JOB CALLPROG
// ASSGN SYS006,X'00C'
// ASSGN SYS004,X'182'
// ASSGN SYS005,X'183'
// EXEC MAIN
   DATA
   DECK
/*
/&
// PAUSE MESSAGE TO OPERATOR IF ANY.
   (optional card)
```

The example can be used for validating data, or making test runs, where many runs might be made with different sets of data decks.

EXAMPLE 5--CATALOGING SOURCE MODULES TO SOURCE STATEMENT LIBRARY

The procedural steps and the job control statements required to catalog two source statement routines in the source statement library follow.

It is assumed that a source statement library is on the system residence volume, SYSRES.

The job control statements are:

```
// JOB CATLSORC
// EXEC MAINT
   CATALS C.DATAIN
   BKEND C.DATAIN
       FD FILEB, DATA RECORDS ARE CAPACITOR-RECORD1,
            INDUCTOR-RECORD1,
            LABEL RECORDS ARE STANDARD,
            BLOCK CONTAINS 12 RECORDS,
            RECORDING MODE IS F.
   BKEND C.DATAIN
   CATALS C.INOUT
   BKEND C.INOUT
       BEGIN.  OPEN INPUT FILEB, FILED OUTPUT FILEA.
       INFO.  READ FILEB AT END GO TO CYCLE.
       MASTER.  READ FILED AT END GO TO LABA.
           GO TO PROCESS.
       LABA.  CLOSE FILEA, FILEB, FILED, STOP RUN.
   BKEND C.INOUT
/*
/&
// PAUSE REMOVE NEW SYSRES ESTABLISHED ON X'182'.
```

The open and close routine is now cataloged in the source statement library under the name INOUT and the file description under the name DATAIN. Notice that DATAIN is cataloged before INOUT. This is because books to be cataloged must be in alphanumeric sequence.

The message is an interruption in the job stream to inform the operator to perform some task. In this example, he is instructed to remove the tape for protection.

EXAMPLE 6--COMPILE (USING SOURCE STATEMENT LIBRARY), LINKAGE EDIT, AND EXECUTE

This example illustrates:

1. How two previously written routines, that were cataloged in the source statement library, are utilized. In this example, the source statement library is on SYSRES.

2. How assignments can be made to process an inventory file with four tapes (not including SYSRES).

Assume an electronics firm stocks quantities of electrical components that are to be maintained at a minimum quantity level, and an input data file is used to check against a master file to determine stock item reorder points.

For the purposes of illustration, only two of its many components--capacitors and inductors--are treated here. They are:

CAPACITORS PART NUMBER	VALUE	QUANTITY ON HAND	REORDER POINT
C61	.010MFD	47	50
C62	.020MFD	60	50
C65	.050MFD	50	50
C121	.001MMFD	90	50
C122	.002MMFD	100	50
C125	.005MMFD	22	50

INDUCTORS PART NUMBER	VALUE	QUANTITY ON HAND	REORDER POINT
L10	.10H	18	35
L20	.20H	15	35
L40	.40H	30	35
L61	10.00MH	60	35
L62	20.00MH	70	35
L64	40.00MH	69	35

Assume further, that an input update file called DATAIN (Example 5, ROUTINE 1) was created on tape and cataloged in the source statement library. Assume its records are, as follows:

```
01 CAPACITOR-RECORD1.
   02 CAPACITOR OCCURS 6.
        03 PART-NUMBER PICTURE XXXX.
        03 VALUE1 PICTURE V999.
        03 VALUE2 PICTURE XXXX.
        03 QUANTITY-ON-HAND PICTURE IS S999.
        03 REORDER-PT PICTURE IS 99.

01 INDUCTOR-RECORD1.
   02 INDUCTOR OCCURS 6.
        03 PART-NUMBER PICTURE XXXX.
        03 VALUE1 PICTURE 99V99.
        03 VALUE2 PICTURE XX.
        03 QUANTITY-ON-HAND PICTURE IS S999.
        03 REORDER-PT PICTURE IS 99.
```

Also assume a program called ORDERPT (to be compiled) was written to process these records (against the master file) to reorder parts when their respective QUANTITY-ON-HAND falls below REORDER-PT.

The following source statements portray, in skeleton form, the program ORDERPT. Included is the Input-Output Section for the program.

```
IDENTIFICATION DIVISION.

PROGRAM-ID. 'ORDERPT'.
        .
        .
        .
ENVIRONMENT DIVISION.
        .
        .
        .
INPUT-OUTPUT SECTION.

FILE-CONTROL.

   SELECT FILEB ASSIGN TO 'SYS004' UTILITY 2400 UNITS.
   SELECT FILEA ASSIGN TO 'SYS005' UTILITY 2400 UNITS, RESERVE NO
    ALTERNATE AREA.
   SELECT FILEC ASSIGN TO 'SYS006' UNIT-RECORD 1403.
   SELECT FILED ASSIGN TO 'SYS007' UTILITY 2400 UNITS.
```

Notice that FILEC is assigned to an IBM 1403 Printer. This enables printing out the REORDER-PT, PART NUMBER of the component, and its VALUE (in MFD or MH) when the QUANTITY-ON-HAND falls below REORDER-PT.

In order to do this, a file description or FD must be written for FILEC in the Data Division:

```
DATA DIVISION.

FD FILEC....

01 REORDER.
   02 REORDER-PT PICTURE IS 99 USAGE IS DISPLAY.
   02 VALUE-OF-PART PICTURE IS ZZ.999.
   02 PART-NUMBER PICTURE IS XXXX.
   02 QUANTITY PICTURE IS 999.
```

Before printing out FILEC, the appropriate values are moved into REORDER-PT (50 or 35), VALUE-OF-PART (.999MFD or ZZ.999H) PART-NUMBER (CXXX or LXXX), and QUANTITY (999).

Specifically, four files are required to process this problem:

FILEA	Updated master file.
FILEB	Updating input file (DATAIN).
FILEC	Output print file.
FILED	Master file.

The control cards to compile, linkage edit, and execute the problem are:

```
// JOB INVNTORY
// OPTION LINK,LIST,DUMP
   PHASE INVNTORY,*
// EXEC COBOL
                .
                .
                .
   DATA DIVISION.              (see
   FD FILEB COPY 'DATAIN'.     Example 5
                .              for expansion)
                .
                .
   PROCEDURE DIVISION.
                .
                .
                .
   START. INCLUDE 'INOUT'.     (see
                  .            Example 5
                  .            for expansion)
                  .
   PROCESS.  (Records on FILEB are processed)


/*
// LBLTYP TAPE(03)
// EXEC LNKEDT
// ASSGN SYS0004,X'181',X'90'    (DATAIN)
// ASSGN SYS005,X'182'           (OUTPUT FILE,NEW MASTER)
// ASSGN SYS006,X'00E'           (PRINT FILE)
// ASSGN SYS007,X'183'           (MASTER FILE)
*       MOUNT INPUT (SYS004) ON X'181',
*       OUTPUT (SYS005) ON X'182',
// PAUSE MASTER (SYS007) ON X'183'.
// VOL SYS004,SYS004
// TPLAB 'DATAIN,etc...'
// VOL SYS007,SYS007,
// TPLAB 'MASTER,etc...'
// VOL SYS005,SYS005
// TPLAB 'NEWMASTER,etc...'
// EXEC
// PAUSE SAVE SYS007 ON X'183' and SYS005 ON X'182'
/*
/&
```

Note that the program that processes the files takes advantage of two previously written routines (routine 1 and routine 2) that were cataloged in the source statement library.

Note also that the VOL and TPLAB job-control statements were used to check header records and write trailer labels on input and output files.

SECTION III: DECK STRUCTURES FOR PROCESSING COBOL PROGRAMS IN A DISK OPERATING SYSTEM

For each type of processing, certain combinations of job control cards are needed. The examples given illustrate basic types of processing within a Disk Operating System.

The examples assume a given Disk Operating System configuration that includes tape, and that the COBOL disk compiler is used for processing.

Because the COBOL disk compiler permits the use of disk or tape work files, some of the examples given in this section use tape work files while others use disk work files. Figure 4 is a diagram of the input/output units used by COBOL in a disk configuration with tape, and should help the user to visualize the logical structure of such a configuration.

Preceding the types of processing discussed is a procedure for establishing labels for COBOL disk work files and SYSLNK on the Standard Label Track. A list of the types of processing discussed, in the order they are presented, follows:

1. Compile and punch
2. Cataloging in the relocatable library
3. Compiling, linkage editing, and executing
4. Executing a previously linkage edited program
5. Cataloging in the source statement library
6. Compiling, linkage editing, and executing.

Examples 3 and 6 differ in that example 3 illustrates how job control is used to link with a module cataloged in the relocatable library, whereas example 6 illustrates how COBOL copies source statement modules cataloged in the source statement library.

Assumed Disk Resident System Configuration

The processing examples given here assume that the following Disk Operating System configuration with tape was generated at system generation time for the COBOL disk compiler.

The system includes:

- One IBM 2540 Card/Read/Punch
- One IBM 1052 Printer-Keyboard
- One IBM 1403 Printer
- Two IBM 2311 Disk Drives
- Four IBM 2400 Magnetic Tape Units

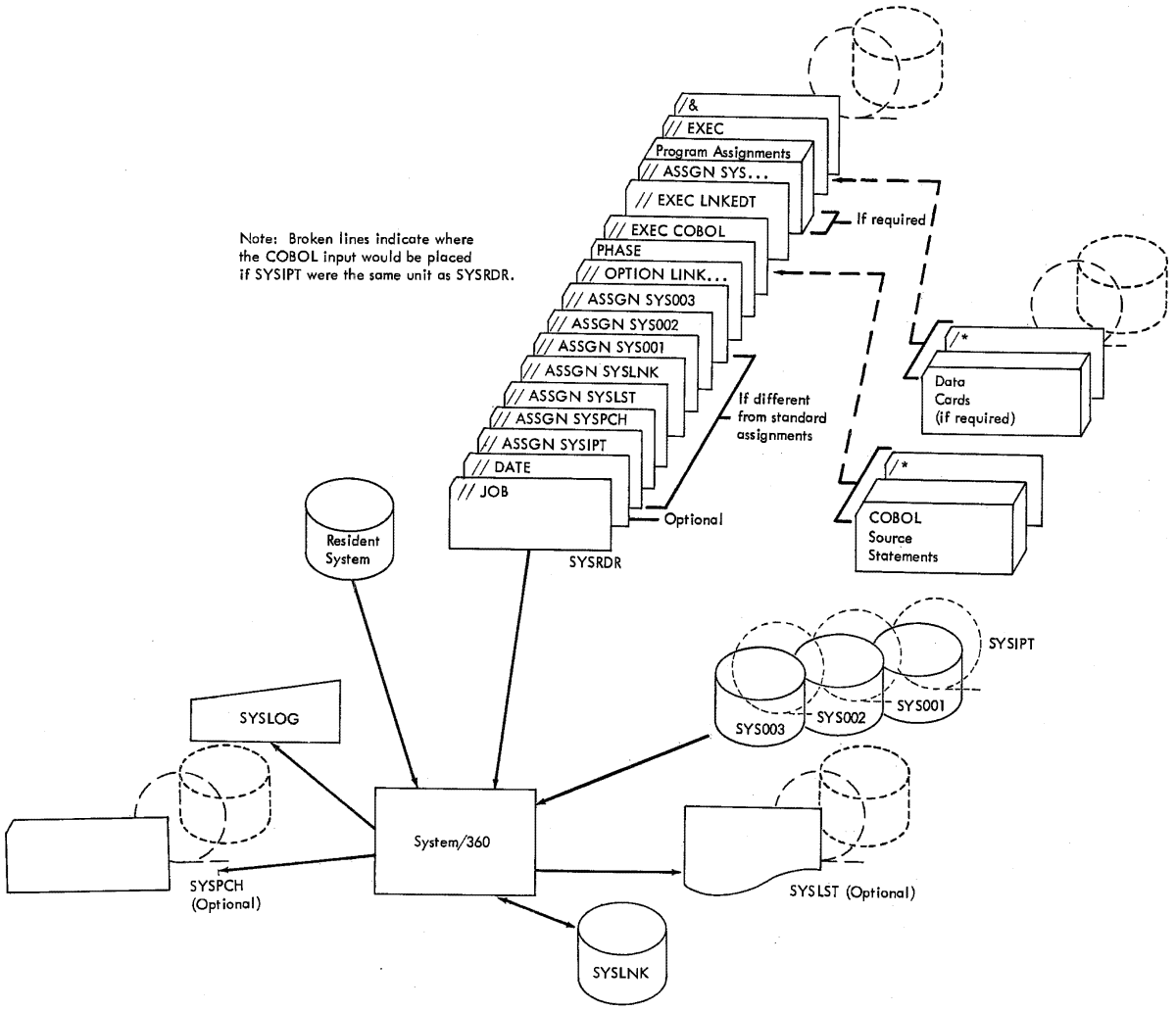


Figure 4. Input/Output Units Used by COBOL Program in a Disk System

Assume physical assignments at system generation time are:

- 2540R Reader assigned to physical unit X'00C'
- 2540P Punch assigned to physical unit X'00D'
- 1052 Printer-keyboard assigned to physical unit X'01F'
- 1403 Printer assigned to physical unit X'00E'
- 2311 Disk pack assigned to physical unit X'190'
- 2311 Disk pack assigned to physical unit X'191'
- 2402 Magnetic tape unit assigned to physical unit X'281'
- 2402 Magnetic tape unit assigned to physical unit X'282'
- 2402 Magnetic tape unit assigned to physical unit X'283'
- 2402 Magnetic tape unit assigned to physical unit X'284', X'90'

The hexadecimal 90 (X'90') in the last tape assignment determines the device specifications for a 7-track tape.

Assume logical assignments at system generation time are:

```
// ASSGN SYSIPT,X'00C'  }
// ASSGN SYSRDR,X'00C'  }   IBM 2540
// ASSGN SYSPCH,X'00D'  }
// ASSGN SYSLST,X'00E'      IBM 1403
// ASSGN SYSLOG,X'01F'      IBM 1052
// ASSGN SYSLNK,X'190'  }
// ASSGN SYS003,X'190'  }   IBM 2311's
// ASSGN SYS001,X'191'  }
// ASSGN SYS002,X'191'  }
```

When logical assignments are made at system generation time for the disk compiler, the following must be considered:

- SYSLNK must be assigned to disk.
- SYS001, SYS002, and SYS003 (work files) can be assigned to disk or tape, but must all be assigned to the same device type.
- When the linkage editor function is being performed, work file SYS-001 can be assigned to either disk or tape.

When tape work files are to be used instead of the given logical assignments for disk work files (SYS001, SYS002, SYS003), the user must assign tape work files at system generation time. For example:

```
// ASSGN SYS001,X'281'
// ASSGN SYS002,X'282'
// ASSGN SYS003,X'283'
```

Note that SYSIPT, SYSRDR, and SYSPCH are assigned to the same physical unit.

The programmer can change these assignments using ASSGN cards following his JOB card. Examples of overriding assignments are given in the text that follows. In the examples that follow, whenever an optional statement is used, it is identified by the words "optional card."

EXAMPLES OF PROCESSING USING DISK CONFIGURATION

When processing programs with the COBOL disk compiler, the information provided by the VOL, DLAB, and XTENT statements for the work files SYS-001, SYS002 and SYS003 must be available for each job processed. This information can be supplied by the programmer with each job processed, or is provided for the programmer on the Standard Label Track for each job processed as required. In addition to establishing the labels required for the disk work files SYS001, SYS002, and SYS003, the labels required for SYSLNK can also be established on the Standard Label Track, where they will be available for subsequent use.

The following procedure enables setting up the Standard Label Track for COBOL disk compiler work files and SYSLNK. Once established, the labels remain in effect for use with subsequent jobs processed, until overridden.

```
// JOB BUILD STANDARD LABELS
*   ALL VOL, DLAB, AND EXTENT STATEMENTS SUBMITTED IN THIS JOB
*   WILL BE PERMANENTLY WRITTEN ON TRACK 0 OF THE LABEL STORAGE
*   CYLINDER OF DOS SYSTEM RESIDENCE FILE SYSRES.  THUS THESE
*   LABELS NEED NOT BE SUBMITTED FOR EVERY JOB THAT REQUIRES
*   SYSLNK AND SYS001-SYS003
// OPTION STDLABEL
// VOL SYSLNK,IJSYSLM
// DLAB 'SYSTEM WORK FILE SYSLNK                          1111111',        C
               0001,66001,66001,'DISK OPER SYS',SD
// XTENT 1,0,000190000,000198009,'111111',SYSLNK
// VOL SYS001,IJSYS01
// DLAB 'SYSTEM WORK FILE NO. 1                           1111111',        C
               0001,66001,66001,'DISK OPER SYS',SD
// XTENT 128,0,000142000,000189003,'111111',SYS001
// VOL SYS002,IJSYS02
// DLAB 'SYSTEM WORK FILE NO. 2          02.G0000V001111111',              C
               0001,66001,66001,'SYSTEM CODE 1',SD
// XTENT 128,0,000142004,000189007,'111111',SYS002
// VOL SYS003,IJSYS03
// DLAB 'SYSTEM WORK FILE NO. 3          02.G0000V001111111',              C
               0001,66001,66001,'SYSTEM CODE 1',SD
// XTENT 128,0,000142008,000189009,'111111',SYS003
```

EXAMPLE 1--COMPILE AND PUNCH

Assuming that source statements are card input (SYSIPT) and job control statements are card input (SYSRDR), the job control cards required (and some helpful options) to compile and punch are:

```
// JOB SUBROTNE
// OPTION LOG,DECK,LIST,LISTX,ERRS        } Input from SYSRDR
// EXEC COBOL

SUBROTNE
SOURCE STATEMENTS                         } Input from SYSIPT

/*
/&                                        } Input from SYSRDR
// PAUSE REMOVE OBJECT DECK FROM HOPPER   } (Optional card)
```

The options selected specify:

LOG -- Requests a listing of all control statements on SYSLST.

DECK -- Requests that a deck (object module) be punched on SYSPCH.

LIST -- Causes the compiler to write source statements on SYSLST.

LISTX -- Causes the compiler to write a procedure division map on SYSLST in hexadecimal.

ERRS -- Causes the compiler to write all diagnostics related to the source program on SYSLST.

EXAMPLE 2--CATALOGING AN OBJECT MODULE IN RELOCATABLE LIBRARY

In this example, an object module generated by the compiler (see Example 1) is cataloged to the relocatable library.

Note: The relocatable library is on SYSRES.

The job control cards required to catalog an object module to an existing relocatable library are:

```
// JOB RELOCATE
// EXEC MAINT
      CATALR SUBROTNE
     (Object deck to be
     cataloged goes here.)
/*
/&
*          OBJECT MODULE 'SUBROTNE' IS
*          NOW CATALOGED TO THE RELOCATABLE
// PAUSE   LIBRARY ON SYSRES          (optional card)
```

EXAMPLE 3--COMPILE, LINKAGE EDIT, AND EXECUTE

This example illustrates how an object module cataloged to the relocatable library is included in a compilation, linkage edited with the main program, and executed.

```
// JOB CALLPROG
// OPTION LINK,LIST,LISTX,ERRS
   PHASE MAIN,*
// EXEC COBOL
   {COBOL SOURCE STATEMENTS}
/*
   INCLUDE SUBROTNE   {Retrieves SUBROTNE from relocatable library}
// EXEC LNKEDT
// EXEC
  {DATA DECK}
  { (if any)}
/*
/&
```

This program consists of one phase that includes the object module SUBROTNE and can be executed immediately. [The name provided in the PHASE statement (MAIN) has no relationship to the external-name given in the COBOL Program-ID statement.]

EXAMPLE 4--EXECUTING A PROGRAM

The job control statements required simply to execute a program, assuming it has been cataloged in the core image library, are:

```
// JOB CALL PROG
// ASSGN SYS006,X'00C'
// ASSGN SYS004,X'191'
// ASSGN SYS005,X'191'
// VOL SYS004,SYS004
// DLAB 'THIS IS THE JOB INPUT FILE etc,...
// XTENT  Enter track specification here ...
// VOL SYS005,SYS005
// DLAB 'THIS IS THE JOB OUTPUT FILE etc,...
// XTENT  Enter track specification here ...
// EXEC MAIN
   [DATA DECK]
/*
/&
// PAUSE  MESSAGE TO OPERATOR, IF ANY (optional card)
```

The example can be used for validating data, or for making test runs, where many runs might be made with different sets of data. Note that the VOL, DLAB, and XTENT statements specify areas in the disk pack (assigned to X'191') that are used by the job input and output files SYS004 and SYS005, respectively.

EXAMPLE 5--CATALOGING SOURCE MODULES IN SOURCE STATEMENT LIBRARY

The procedural steps and the job-control statements required to catalog two source statement modules in the source statement library follow.

Note: The source statement library is on the system residence volume SYSRES.

The job control statements are:

```
// JOB CATLSORC
// EXEC MAINT
   CATALS C.INOUT
   BKEND C.INOUT
       BEGIN.  OPEN INPUT FILEB, FILED OUTPUT FILEA.
       INFO.  READ FILEB AT END GO TO CYCLE.
       MASTER.  READ FILED AT END GO TO LABA.
           GO TO PROCESS.
       LABA.  CLOSE FILEA, FILEB, FILED, STOP RUN.
   BKEND C.INOUT
   CATALS C.DATAIN
   BKEND C.DATAIN
       FD FILEB, DATA RECORDS ARE CAPACITOR-RECORD1,
           INDUCTOR-RECORD1,
           LABEL RECORDS ARE STANDARD, BLOCK
           CONTAINS 12 RECORDS, RECORDING
           MODE IS F.
   BKEND C.DATAIN
/*
/&
```

The open and close routine is now cataloged to the source statement library under the name INOUT, and the file description under the name DATAIN.

EXAMPLE 6--COMPILE (USING SOURCE STATEMENT LIBRARY), LINKAGE EDIT, AND EXECUTE

This example illustrates:

1. How two previously written routines, that were cataloged in the source statement library, are utilized. In this example, the source statement library is on SYSRES.

2. How assignments can be made to process an inventory file using direct-access storage.

Assume an electronics firm stocks quantities of electrical components that are to be maintained at a minimum quantity level, and an input data file is used to check against a master file to determine stock item reorder points.

For the purposes of illustration, only two of its many components--capacitors and inductors--are treated here. They are:

CAPACITORS PART NUMBER	VALUE	QUANTITY ON HAND	REORDER POINT
C61	.010MFD	47	50
C62	.020MFD	60	50
C65	.050MFD	50	50
C121	.001MMFD	90	50
C122	.002MMFD	100	50
C125	.005MMFD	22	50

INDUCTORS PART NUMBER	VALUE	QUANTITY ON HAND	REORDER POINT
L10	.10H	18	35
L20	.20H	15	35
L40	.40H	30	35
L61	10.00MH	60	35
L62	20.00MH	70	35
L64	40.00MH	69	35

Assume further than an input update file called DATAIN (Example 5, ROUTINE 2), was created on disk and cataloged to the source statement library. Assume that the records are, as follows:

```
01 CAPACITOR-RECORD1.
   02 CAPACITOR OCCURS 6.
        03 PART-NUMBER PICTURE XXXX.
        03 VALUE1 PICTURE V999.
        03 VALUE2 PICTURE XXXX.
        03 QUANTITY-ON-HAND PICTURE IS S999.
        03 REORDER-PT PICTURE IS 99.


01 INDUCTOR-RECORD1.
   02 INDUCTOR OCCURS 6.
        03 PART-NUMBER PICTURE XXXX.
        03 VALUE1 PICTURE 99V99.
        03 VALUE2 PICTURE XX.
        03 QUANTITY-ON-HAND PICTURE IS S999.
        03 REORDER-PT PICTURE IS 99.
```

Also assume a program called ORDERPT (to be compiled) was written to process these records (against the master file) to reorder parts when their respective QUANTITY-ON-HAND falls below REORDER-PT.

The following source statements portray, in skeleton form, the program ORDERPT. Included is the Input-Output Section for the program.

```
IDENTIFICATION DIVISION.

PROGRAM-ID.  'ORDERPT'.
       .
       .
ENVIRONMENT DIVISION.
       .
       .
INPUT-OUTPUT SECTION.
FILE-CONTROL.

         SELECT FILEB ASSIGN TO 'SYS004' UTILITY 2400 UNITS.
         SELECT FILEA ASSIGN TO 'SYS005' UTILITY 2311 UNITS,
          RESERVE NO ALTERNATE AREA.
         SELECT FILEC ASSIGN TO 'SYS006' UNIT-RECORD 1403.
         SELECT FILED ASSIGN TO 'SYS007' UTILITY 2311 UNITS.
```

Notice that FILEC is assigned to an IBM 1403 Printer. This enables printing out the REORDER-PT, PART NUMBER of the component, and its VALUE (in MFD or MH) when the QUANTITY-ON-HAND falls below REORDER-PT.

In order to do this, a file description or FD must be written for FILEC in the data division:

```
DATA DIVISION.

FD FILEC....

   01 REORDER.
      02 REORDER-PT PICTURE IS 99 USAGE IS DISPLAY.
      02 VALUE-OF-PART PICTURE IS ZZ.999.
      02 PART-NUMBER PICTURE IS XXXX.
      02 QUANTITY PICUTRE IS 999.
```

Before printing out FILEC, the appropriate values are moved into REORDER-PT (50 or 35), VALUE-OF-PART (.999 MFD or ZZ.999H) PART-NUMBER (CXXX or LXXX), and QUANTITY (999).

Specifically, four files are required to process this problem:

FILEA	Updated master file.
FILEB	Updating input file (DATAIN).
FILEC	Output print file.
FILED	Master file.

The control cards to compile, linkage edit, and execute the problem are:

```
// JOB INVNTORY
// OPTION LINK,LIST,DUMP
   PHASE INVNTORY,*
// EXEC COBOL
            .
            .
            .
   DATA DIVISION.              (see
   FD FILEB COPY 'DATAIN'.     Example 5
            .                  for expansion.)
            .
            .
   PROCEDURE DIVISION.
            .
            .
            .

   START. INCLUDE 'INOUT'.     (see
               .               Example 5
               .               for expansion.)
               .
   PROCESS.  (Records on FILEB are processed)

/*
// LBLTYP TAPE
// EXEC LNKEDT
// ASSGN SYS004,X'284',X'90'      (DATAIN)
// ASSGN SYS005,X'190'            (OUTPUT FILE, NEW MASTER)
// ASSGN SYS006,X'00E'            (PRINT FILE)
// ASSGN SYS007,X'191'            (MASTER FILE)
*          MOUNT INPUT (SYS004) ON X'284',
// PAUSE   X'90'.
// TLBL SYS004
// DLBL SYS005, 'THIS IS THE NEW JOB MASTER FILE etc., ...'
// EXTENT Enter the track specification here ...
// DLBL SYS007, 'THIS IS THE JOB(OLD) MASTER FILE etc., ...'
// EXTENT Enter the track specification here ...
// EXEC
/*
/&
```

Note that the program that processes the files takes advantage of two previously written routines (Routines 1 and 2) that were cataloged in the source statement library.

Note also that the LBLTYP job control statement was used (for SYS004) because it is required when label information for tape files is processed.

The compiler, linkage editor, COBOL program phases, and other system components can produce output in the form of printed listings, punched card decks, diagnostic or informative messages, and data files directed to tape or direct-access devices. This section describes the output listings that can be used to document and debug programs. Included are explanations of compiler output, a list of conditions that can cause a dump, a brief discussion of how to use a dump, and an explanation of how diagnostic messages are determined. A complete list of diagnostic messages is contained in Appendix G.

COMPILER OUTPUT

The output of the compilation job step may include:

- A printed listing of the control statements
- A printed listing of the statements contained in the source module
- A printed listing of a data map
- A printed listing of a procedure map
- Compiler diagnostic messages
- An object module

All forms of output must be requested by means of the job control OPTION statement. For example, DECK specifies that the object module is to be punched. A complete list of the options for this statement is given in Section I. All output to be listed is printed on the device whose symbolic name is SYSLST.

SOURCE LISTING (LIST)

Figure 5 is an example of a source module listing. It is obtained when LIST is specified on the job-control OPTION statement. The listing is given on SYSLST. (The heading, GENERATED COBOL SOURCE LISTING, that appears at the top of the listing is explanatory only. It does not actually appear on the listing.)

The source listing consists of:

LINE NO. A compiler generated line number that is shown in the left-most column. This line number is used in diagnostic messages and LISTX references. The generated line numbers for the sample program are 1 through 39.

SEQ. NO The programmer provides the statement sequence numbers. They appear in the second column.

SOURCE STATEMENT All COBOL words and punctuation. Words, punctuation, and other groups of characters on each line are referenced as elements on the line in LISTX listings so that a specific entry may be defined.

S — Sequence numbers out of order. If columns 1 through 6 of the source statement are not blank, they are sequence checked. The character S is placed beside a number not in logical ascending order. Example: assume that in the sample listing statement number 26 (generated line number) was out of sequence. The compiler would list the source statement as:

```
S26   000250   WRITE A AFTER ADVANCING 3 LINES.
```

D — Debug packet card inserts. Cards inserted as part of a DEBUG packet are identified with the character D alongside the generated sequence number.

* — Library cards. Cards coming from the library as a result of a COPY or INCLUDE statement are noted with an asterisk.

```
                    GENERATED COBOL SOURCE LISTING

LINE NO.  SEQ. NO.          SOURCE STATEMENT        D 12MAR66 04/21/66

     1    000010      IDENTIFICATION DIVISION.
     2    000020      PROGRAM-ID.  'CARRRCTL'.
     3    000030      ENVIRONMENT DIVISION.
     4    000040      INPUT-OUTPUT SECTION.
     5    000050      FILE-CONTROL.
     6    000060          SELECT PRINTO ASSIGN TO 'SYS004'
     7    000070          UNIT-RECORD 1403 UNIT RESERVE
     8    000080          NO ALTERNATE AREAS.
     9    000090      DATA DIVISION.
    10    000100      FILE SECTION.
    11    000110      FD  PRINTO RECORDING MODE F LABEL RECORDS
    12    000120          ARE OMITTED DATA RECORD IS A.
    13    000130      01  A.
    14    000140          02 C-C PICTURE X.
    15    000150          02 GARB PICTURE X(20).
    16    000160          02 FULLER PICTURE X(112).
    17    000170      WORKING-STORAGE SECTION.
    18    000180      77  B PICTURE X(20) VALUE 'THIS IS A RECORD'.
    19    000190      01  D PICTURE S99.
    20    000200      01  E REDEFINES D.
    21    000210          02 FILLER PICTURE X.
    22    000220          02 F PICTURE X.
    23    000230      PROCEDURE DIVISION.
    24    000240      START. OPEN OUTPUT PRINTO. MOVE B TO GARB.
    25    000260          WRITE A AFTER ADVANCING 1 LINE.
   S26    000250          WRITE A AFTER ADVANCING 3 LINES.
    27    000270          WRITE A AFTER ADVANCING 2 LINES.
    28    000280          MOVE ' ' TO C-C. WRITE A AFTER ADVANCING C-C.
    29    000290          MOVE '0' TO C-C. WRITE A AFTER ADVANCING C-C.
    30    000300          MOVE '-' TO C-C. WRITE A AFTER ADVANCING C-C.
    31    000310          MOVE '+' TO C-C. WRITE A AFTER ADVANCING C-C.
    32    000320          MOVE '1' TO C-C. WRITE A AFTER ADVANCING C-C.
    33    000330          MOVE 'C' TO C-C. WRITE A AFTER ADVANCING C-C.
    34    000340          MOVE 'TRICK COMING UP' TO FULLER.
    35    000350          WRITE A AFTER ADVANCING C-C.
    36    000360          MOVE 'EOJ' TO A.
    37    000370          WRITE A AFTER ADVANCING 3 LINES.
    38    000380          CLOSE PRINTO.
    39    000390          STOP RUN.
```

Figure 5. Example of a COBOL Source Listing

Figure 6 is an example of a data map. It is a portion of the data map generated for the program given in Figure 5, and is obtained when SYM is specified on the job-control OPTION statement. The data map is printed on the SYSLIST unit.

The data map shows the name of each nonprocedure name defined in the program. File-names, record-names, and condition-names are identified in the column headed TYPE. (In this example, no condition-names were used; therefore, none are listed.) The relative location of each entry is shown (column headed LOCATION). Linkage and file entries are relative to the level 01 or 77. Working storage is relative to 0. The addresses given are 24-bit addresses.

The column headed DATA NAME gives the names of the nonprocedure name specified in the program.

If the load address is known, it may be used as the hexadecimal offset parameter in a CBL option card parameter (DMAP=h). This would result in adjusted addresses on the listing.

DATA DIVISION MAP

TYPE	LOCATION	DATA NAME
FILE		PRINTO
REC	0000000	A
	0000000	C-C
	0000001	GARB
	0000021	FULLER
	0000000	B
REC	0000024	D
REC	0000024	E
	0000025	F

Figure 6. Example of a Data Map

Figure 7 is an example of a procedure map. It is a portion of the procedure map generated for the program given in Figure 5 and is obtained when LISTX is specified on the job-control OPTION card. The listing is printed on the SYSLST unit. The details of LISTX are given for their debugging value.

LINE/POS — Contains the generated line number and the position of the COBOL verb on the line. (These numbers are decimal numbers.) The actual instruction(s) used to accomplish the COBOL statement is identified by the compiler-generated internal line number(s). If more than one instruction was generated, the compiler-generated line number for that COBOL statement would be repeated for each instruction listed. A look at source statement 28 shows that MOVE is the first COBOL verb on the line, hence, its location is 28 01. Counting each element in the line from left to right (for definition of an element, see "Error Messages (ERRS)"), it is found that the COBOL verb WRITE occupies position 6 on the line, hence, it is location 28 06. The MOVE verb required only one System/360 machine instruction to effect its action. However, the WRITE verb required five System/360 machine instructions to effect its action. This accounts for the fact that "28 06" appears five times in the listing. It should be noted that qualified words count as one element. The line counter cannot exceed 4095. At this point, it resets to 0.

ADDR — Contains the relative address of each instruction in the procedure division in hexadecimal. The addresses are relative to the program's load point. The address may be offset by specifying PMAP=h on the COBOL CBL option statement.

INSTRUCTION — Contains the machine language instruction (in hexadecimal) generated for the COBOL statement.

LINE/POS	ADDR	INSTRUCTION
00028 01	003270	D2 00 5 000 4 14D
00028 06	003276	D2 00 5 000 5 000
00028 06	003270	41 10 4 088
00028 06	003280	58 F0 1 010
00028 06	003284	45 E0 F 00C
00028 06	003288	58 50 4 088
00029 01	00328C	D2 00 5 000 4 14E
00029 06	003292	D2 00 5 000 5 000
00029 06	00329B	41 10 4 088
00029 06	00329C	58 F0 1 010
00029 06	0032A0	45 E0 F 00C
00029 06	0032A4	58 50 4 088

Figure 7. Example of a Procedure Map for a COBOL Program

Figure 8 is an example of a list of error messages that are obtained when ERRS is specified on the job-control OPTION card. These diagnostic messages were generated by the compiler for the program shown in Figure 5. The list is generated on SYSLST.

LINE/POS — Contains the internal line numbers of the source statements, and the position of the COBOL verb or element on the line where the error was detected. An element is a word, punctuation, picture, name, literal, or any other similar unit of COBOL syntax.

When the compiler cannot locate the item in error on the line, it identifies the line at fault by generating the SEQUENCE NUMBER X-0.

When the compiler generates the line number 0-0, it is referring to an entire section (the section may be missing).

ER CODE — Contains a message number and the severity level of the error:

MESSAGE NUMBER — The format of the message number, and the associated message is described in Appendix H.

Severity Code	Explanation
W = WARNING	This calls attention to a condition that can cause a problem, but should permit a successful run.
C = CONDITIONAL	The error statement is dropped or corrective action is taken. The compilation is continued as it may have debugging value, but the statement should not execute as intended.
E = ERROR	This condition seriously affects execution of the job. Execution is not attempted.

CLAUSE — This column identifies either the particular COBOL clause being processed at the time the diagnostic message was discovered or the basic area that was involved, such as ALIGNMENT, FD, or similar items.

MESSAGE — The actual message is given here. These messages are listed in Appendix G.

DIAGNOSTIC MESSAGES

LINE/POS	ER CODE	CLAUSE	MESSAGE
15-1	IJS063W	ALIGNMENT	TO ALIGN BLOCKED RECORDS ADD 3 BYTES TO THE 01 CONTAINING DATANAME FILLER.
18-1	IJS054W	ALIGNMENT	FOR PROPER ALIGNMENT, A 4 BYTE LONG FILLER ENTRY IS INSERTED PRECEDING D.

Figure 8. Example of Source Module Diagnostics

1. Handle the diagnostic messages in the order in which they appear on the source listing. It is possible to get compound diagnostic messages. Frequently, an earlier diagnostic indicates the reason for a later diagnostic message. For example, a missing quote for an alphabetic or alphameric literal could involve the inclusion of some clauses not intended in that particular literal. This could cause an apparently valid clause to be diagnosed as invalid because it is not complete, or because it is in conflict with something that preceded it.

2. Check for missing or extra punctuation, or other errors of this type.

3. Frequently, a seemingly meaningless message is clarified when the valid syntax or reference format is referenced. Diagnostic messages are coded directly from the reference format and are designed for use in conjunction with the particular type of reference.

How Diagnostic Messages Are Determined

The compiler scans the statement, element by element, to determine whether the words are combined in a meaningful manner. Based upon the elements that have already been scanned, there are only certain words or elements that can be correctly encountered.

If the anticipated elements are not encountered, a diagnostic message is produced. Some errors may not be uncovered until information from various sections of the program are combined and the inconsistency indicated. Errors uncovered in this manner can produce a slightly different message format than those uncovered when the actual source text is still available. The message that is made unique through that particular error may not have, for example, the actual source statement that produced the error. The position and sequence reference, however, indicates the place at which the error was uncovered.

Errors that appear to be identical are diagnosed in a slightly different manner, depending on where they were encountered by the compiler and how they fit within the context of valid syntax. For example, a period missing from the end of the Working-Storage Section clause, is diagnosed specifically as a period required. There is no other information that can occur at that point. However, if at the end of a Record Description entry, an element is encountered that is not valid at that point such as the digits 02, they are diagnosed as invalid. Any clauses associated with the clause at that entry, which conflict with the entries in the previous entry (the one that had the missing period), are diagnosed. Thus, a missing period produces a different type of diagnostic message in one case than in another.

If a given compilation produces more than 25 diagnostic messages, they are presented in a batched sequence. The first 25 messages are sorted in order, followed by the second series, which is also sorted in order.

If an error occurs after the 4095 source statement, the line sequence of the source statement in error can usually be determined by adding 4095 to the sequence number given in the diagnostic message. A message frequently suggests the divison of a COBOL source program in which the error occurred.

Examples of How Diagnostic Messages Are Generated

Each message has a general or skeleton form. Unique words for each message are inserted to identify the specific error that was encountered. The following two examples illustrate this form.

Example 1:

COBOL format is MOVE data-name TO data-name ...
literal

```
Error 1
023             MOVE FIELDA TOO FIELDB

                ERROR #178

                INSERT1 TO                  Information
                                            passed to
                INSERT2 TOO                 diagnostic
                                            out of phase I19
```

Skeleton Message #178 CSYNTAX REQUIRES WORD "Insert1". FOUND "Insert2".

REQUIRES WORD "TO". FOUND "TOO".

Example 2:

```
Error 2
023               NOVE FIELDA TO FIELDB

                 ERROR #549

                 INSERT1 NOVE
```

Skeleton Message #549 E WORD INSERT1 WAS EITHER INVALID OR SKIPPED DUE TO ANOTHER DIAGNOSTIC.

Message appears as: 23-1 IJS549E "NOVE" UNHANDLED. WORD NOVE WAS EITHER INVALID OR SKIPPED DUE TO ANOTHER DIAGNOSTIC.

LINKAGE EDITOR OUTPUT

The linkage editor produces diagnostic messages, console messages and a storage map. For a description of output and error messages from the linkage editor see the IBM publications IBM System/360 DOS System Control and System Service Programs, Form C24-5036, and IBM System/360 TOS System Control and System Service Programs, Form C24-5034.

EXECUTION TIME MESSAGES

When an error condition that is recognized by compiler-generated code occurs during execution, an error message is written on SYSLST or SYSLOG. Any messages normally written on SYSLST that result from an error

in the foreground program are written on SYS000. Messages that normally appear on SYSLOG are provided with a code indicating whether the message originated in a foreground or background program. These messages and their descriptions are listed in Appendix G.

PROGRAM PHASE DUMPS

Execution of a program phase may produce a dump as part of an abort procedure. A dump is caused by one of many errors. Several of these errors may occur at the COBOL language level while others can occur at the job-control level.

Examples of COBOL language errors that can cause a dump follow.

1. A GO TO statement with no procedure name following it may have been improperly initialized with an ALTER statement. The execution of this statement will cause an invalid branch.

2. Arithmetic calculations or moves on numeric fields that have not been properly initialized can cause an interrupt and a dump.

   For example, neglecting to initialize an OCCURS...DEPENDING ON clause, or referencing data fields prior to the first read may cause an interrupt and a dump.

3. Invalid data placed in a numeric field as a result of redefinition.

4. Input/output errors that are nonrecoverable.

5. Subscripts whose values exceed the defined maximum value will, when moved into the Procedure Division, destroy machine instructions in the program.

6. Attempting to execute an invalid operation code through a systems error or invalid program.

7. Generating an invalid address for an area that has address protection.

8. Subprogram linkage declarations that are not defined exactly as they are stated in the calling program.

9. Data or instructions can be modified by entering a subprogram and manipulating data incorrectly. A COBOL subprogram could acquire invalid information from the main program, e.g., a CALL using a procedure-name and an ENTRY using a data-name.

10. Incorrect tape record length. Causes the compiler to generate an invalid supervisor call SVC32. This inititates the dump terminating the job.

11. An input file contains invalid data such as a blank numeric field or data incorrectly specified by its data description.

    The compiler does not generate a test to check the sign position for a valid configuration before the item is used as an operand. The programmer can test for valid data by means of the numeric class test and, by use of the TRANSFORM statement, convert it to valid data under certain circumstances.

    For example, if the units position of a numeric data item described as USAGE IS DISPLAY contained a blank, the blank could be transformed to a zero, thus forcing a valid sign.

Information regarding the location of the error and the reason for an interrupt precedes the dump.

The instruction address can be compared to the Procedure Division map. Such a map is produced in the listing by the LISTX option. The load address of the module (which can be obtained from the map of main storage generated by the linkage editor) must be subtracted from the instruction address to obtain the relative instruction address as shown in the procedure map. The contents of LISTX provides a relative address for each statement. By use of the error address and LISTX, the programmer can locate a specific statement appearing within a line of the source program, if the interrupt was within the COBOL program. Examination of the statement and the fields associated with it may produce infromation as to the specific nature of the error. A more detailed analysis would involve a deeper knowledge of Disk and Tape Operating Systems and control programs.

Object Storage Layout

The relative position, in main storage, of all the components of a COBOL program is, as follows:

- COBOL subroutines
- Working storage data items
- Edit masks
- DTF tables
- Buffers
- Procedure literals
- Work area and global table
- Instructions
- Input/output subroutines
- Subprograms

The DEBUG option in the COBOL Disk and Tape Operating Systems language allows the programmer to use three new verbs for the purpose of debugging COBOL source programs. These verbs are EXHIBIT, TRACE, and ON. They can appear anywhere in the COBOL program or in a compile-time debugging packet. Their formats and a description of their use is contained in the publication IBM System/360 Disk and Tape Operating Systems: COBOL Language Specifications, Form C24-3433. However, this section is included in the publication to give the programmer an idea of when to use the debugging language, how to construct a debugging packet, and what job control cards are needed to use the debugging packet. A complete list of precompile error messages is included in Appendix F. These messages reflect errors in the debug packet(s) only. They are not associated with compiling.

TRACE STATEMENT

When a job does not execute properly and the diagnostic messages fail to indicate how to correct the error, a READY TRACE statement can be inserted at a point known to be prior to the trouble area. The TRACE displays each paragraph name as control is passed to that paragraph. To reduce the volume of such a trace, it is possible to turn on the trace with a READY TRACE statement and turn it off with a RESET TRACE if the area can be localized. The TRACE function can be used any number of times within the program. It would reduce the volume if RESET were issued upon entering a loop (containing a paragraph name) and READY were issued upon leaving the loop.

It is sometimes difficult to determine what the specific path of program logic is. This is especially true with a series of PERFORMS or nested conditions. A TRACE statement can be very beneficial as an aid to this problem. Also, if values are inconsistent, a TRACE statement will again aid in determining whether or not a program is actually going through a certain point.

EXHIBIT STATEMENT

To find out what specifically caused the error within the paragraph, additional data can be obtained from the fields within the specific paragraph by use of the EXHIBIT statement. The EXHIBIT statement displays the field and the source name for identification purposes. Its use may be restricted to display the field only if it has changed since the last time the program fell through that point. This permits the programmer to check on the value of the subscript name or other fields that are pertinent to a given field, and to check out logic errors. An example of the various forms of this statement follows.

```
DATA DIVISION.
     77 NO-CHANGE-NAME PICTURE XX VALUE 'AB'.
     77 SUB-SCRIPT-NAME PICTURE S999 COMPUTATIONAL VALUE 30.
```

```
PROCEDURE DIVISION.

TEST-LOOP.
     EXHIBIT NAMED NO-CHANGE-NAME.
     EXHIBIT CHANGED NAMED SUB-SCRIPT-NAME.
     EXHIBIT CHANGED SUB-SCRIPT-NAME.
     EXHIBIT CHANGED NO-CHANGE-NAME.

     ADD 10 TO SUB-SCRIPT-NAME.  IF SUB-SCRIPT-NAME = 100 NEXT SENTENCE
       ELSE GO TO TEST-LOOP.
```

The printout for this example is:

```
NO-CHANGE-NAME =AB
SUB-SCRIPT-NAME = 30
30
AB
NO-CHANGE-NAME =AB
SUB-SCRIPT-NAME = 40
40
NO-CHANGE-NAME = AB
SUB-SCRIPT-NAME = 50
50
.
.
.
.
```

ON STATEMENT

It is possible, where large volumes of data are involved, to sample specific portions of a program by use of the ON statement. The ON statement allows the programmer to perform a series of operations at certain times when a program passes a particular point. For example, a series of operations could be performed the 110th time through a loop and every fifth time thereafter until the 275th time. This allows the programmer to determine whether or not a given loop gets out of the expected range for a particular program.

There can be any number of these statements, and there is a compiler counter generated for each one. The counter starts at zero and is increased by one each time the path of program execution falls through that specific point. For example, if the programmer knows that the error occurs on the 500th record processed, the ON statement can be used to count records. Then a READY TRACE can be set as the counter approaches the point where the error occurred. This eliminates tracing each statement up to that point. This type of example could also have been done by a counter or a PERFORM statement, but this method is easier.

Note: An ON statement with an UNTIL or ELSE option cannot be used in an IF statement.

THE DEBUG PACKET

The debug packet can be used only in background type processing. It is a tool used for debugging COBOL object modules and is positioned in the job input stream before the COBOL source module. The packet is combined with the COBOL source module before compilation begins. The position of

the packet within the COBOL source module is determined by the Procedure Division name specified in the *DEBUG card of the packet.

JOB CONTROL SETUP FOR USING DEBUG PACKETS

Debug packets for a given compilation are processed as separate job steps immediately preceding the job step that executes the COBOL compiler program.

A number of debugging packets are permitted for a program depending on the size of the machine used. In practice, the number of packets required by a programmer should not exceed Disk and Tape Operating Systems storage facilities.

Each compile-time debugging packet is headed by the control card:

```
1_____8_________
*DEBUG location
```

An example of the deck setup for executing a debugging packet, including all the required job control cards, is given in Figure 9.

Note that the deck setup provides for the assignment of SYSIPT (for the COBOL compilation) to the drive currently assigned to SYS004 for the packet. This is required by job control, because SYSIPT is used as the input for the COBOL program.

If a disastrous error occurs, a message followed by RUN TERMINATED is displayed and listed. If the job runs to completion, a message saying that SYSIPT for the COBOL compilation should be assigned to the current SYS004 is displayed and listed.

At the conclusion of a compilation, SYSIPT should be reassigned to the original device if the job stream contains additional job steps.

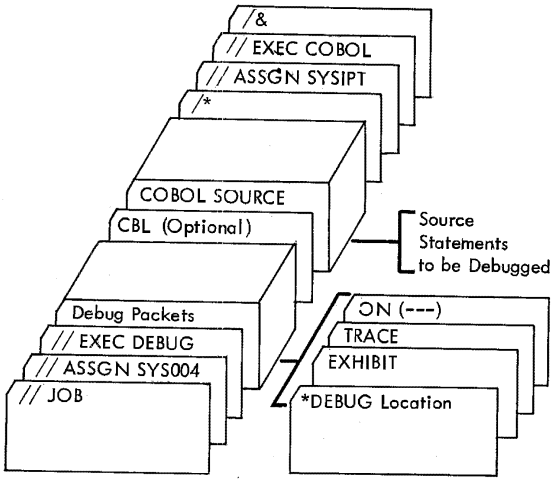


Figure 9. Example of a Debug Packet

This section is intended to aid the programmer in his efforts to produce efficient COBOL code. The suggestions offered here will optimize the compilation and/or execution of the program by reducing the time and/or storage which it requires.

The topics given consideration in this section include:

1. The effect of data format and organization on core storage

2. General coding hints, both arithmetic and non-arithmetic, for a more efficient program

3. A discussion of processing and aligning variable length records

4. Considerations for input/output error processing.

DATA ITEMS

A primary concern of programmers aiming at more efficient coding is the conservation of core storage. One means of using storage wisely is careful declaration and manipulation of data items. The manner in which data is defined affects the number of instructions generated in the Procedure Division. Saving one byte in the Data Division can cause a significant increase in the number of instructions generated in the Procedure Division. Conversely, a meaningful addition of one byte in the Data Division can result in a savings of 20 or more bytes of generated instructions for the Procedure Division.

The number of bytes occupied by a data item in main storage depends on the USAGE clause associated with it. Figure 10 illustrates the number of bytes required for each type of elementary item. Figure 11 provides additional information concerning the characteristics of numeric data.

The following section describes the various kinds of data items and illustrates machine representations of these data items. Because programs frequently deal with data in different formats, conversions between formats often occur. These conversions necessarily increase the amount of core storage needed. Therefore, this section includes a comparison of core storage required when data is in the same and in mixed formats. Finally, this section analyzes the effect on storage of ADD, MOVE, and relational statements when the items involved are of mixed format.

TYPE OF ITEM	CALCULATION OF REQUIRED BYTES FROM PICTURE		
DISPLAY			
Alphabetic	Bytes = Number of A's in picture		
Alphanumeric	Bytes = Number of X's in picture		
External Decimal	Bytes = Number of 9's in picture		
External Floating Point	Bytes = Number of characters in picture		
Report	Bytes = Number of characters in picture except P, V		
COMPUTATIONAL-3			
Internal Decimal	Bytes = (Number of 9's + 1 divided by 2, rounded up)		
COMPUTATIONAL		Size	Alignment
		2 if 1≤N≤4	Halfword Machine Address
Binary	Bytes =	4 if 5≤N≤9	Fullword Machine Address
		8 if 10≤N≤18	Fullword Machine Address
		Where N = Number of 9's in picture	
COMPUTATIONAL-1 or		4 if short precision (Computational-1)	Fullword Machine Address
	Bytes =		
COMPUTATIONAL-2			
Internal Floating Point		8 if long precision (COMPUTATIONAL-2)	Doubleword Machine Address

Figure 10. Bytes Required for each Class of Elementary Item

DATA USAGE

DISPLAY

DISPLAY is used for non-numeric and external decimal fields. Zeros and blanks are not inserted automatically by the logical instruction set; a move requires coding to insert zeros or blanks. On a compare, the smaller item must be moved to a work area where zeros or blanks are inserted before the compare.

Examples of external decimal items (usage DISPLAY) are shown in Figure 12.

COMPUTATIONAL-3

COMPUTATIONAL-3 is used for internal decimal fields. The System/360 decimal feature provides for the automatic insertion of high-order zeros on adds, subtracts, and compares.

Usage and Data Type	No. of Bytes Required	Typical Use	Converted in Arithmetic Calculation	Boundary Alignment Required	Special Characteristics
DISPLAY (External decimal)	1 per digit	Input from cards Output to cards Listings	Yes	No	May be used for numeric fields up to 18 digits long. Fields over 15 digits require extra instructions if used in computations.
COMPUTATIONAL-3 (Internal decimal)	1 byte per 2 digits after the first byte for byte for low-order digit	Input to a report item Arithmetic fields Work areas	Not normally	No	Requires less space than DISPLAY. Convenient form for decimal alignment. The natural form contains an odd number of digits.
COMPUTATIONAL (Binary)	2 if 1≤N≤4 4 if 5≤N≤9 8 if 10≤N≤18	Subscripting Arithmetic	Yes/No for mixed usage No for unmixed usage	Yes	Rounding and on size error tests are cumbersome. Fields over 8 digits require more handling. Must always be signed.
COMPUTATIONAL-1 COMPUTATIONAL-2 (Internal floating point)	4 (short precision) 8 (long preision)	Fractional exponentiation, or very large or very small numbers	No	Yes	Less accurate. COMPUTATIONAL-2 more accurate than COMPUTATIONAL-1 Requires floating-point feature.

Figure 11. Characteristics of Numeric Data

COMPUTATIONAL-3, or internal decimal usage, is also referred to as packed decimal. To conserve storage packed decimal should be used whenever the number of digits exceeds nine positions; its picture should begin with "S" and the field length should be an odd number. In general most commercial applications are safer with numeric fields in packed format, and fields which have decimal positions should always be packed.

When arithmetic operations using data fields and literals are performed, the literal is generated in the format of the receiving field. Programming efficiency is increased if the data fields involved are defined as COMPUTATIONAL-3. For example,

```
SEND PICTURE 9(5) USAGE COMPUTATIONAL-3.
TARGET PICTURE 9(5) USAGE COMPUTATIONAL.

ADD SEND 200 TO TARGET.
```

This statement will be performed by adding the sending field and the literal "200" together, and then adding the result to the target field. Since the literal takes the form of the receiving field, it is binary. This operation will take 32 bytes of core. If both fields had been defined as COMPUTATIONAL-3, execution of the ADD statement would require only 12 bytes.

Examples of internal decimal items (COMPUTATIONAL-3 usage) are shown in Figure 12.

COMPUTATIONAL

COMPUTATIONAL is used for binary numbers. Binary operations require one of the operands to be in a register where a halfword is automatically expanded to a fullword. Because System/360 contains a large number of halfword and fullword instructions, handling mixed halfword and fullword fields requires no additional operations.

An example of an item with COMPUTATIONAL usage is shown in Figure 12.

COMPUTATIONAL-1 AND COMPUTATIONAL-2

COMPUTATIONAL-1 and COMPUTATIONAL-2 are used for internal floating-point numbers. System/360 provides a full set of short and long-precision instructions which enables operations involving mixed precision fields to be handled without conversion. For maximum efficiency, floating-point usage should be limited to purely scientific applications.

Examples of items with COMPUTATIONAL-1 and COMPUTATIONAL-2 usage are shown in Figure 12.

MIXED DATA FORMATS

When data fields are used together in move, arithmetic or relational statements, their formats should be the same whenever possible to conserve storage and reduce execution time. Operations involving data items of different formats require conversion before the operation can be executed. For example, when comparing a DISPLAY field to a COMPUTATIONAL-3 field, the code generated by the COBOL compiler moves the DISPLAY field to an internal work area, and converts it to a COMPUTATIONAL-3 field. It then executes the compare. For maximum efficiency, a onetime conversion (using packed or binary modes where possible) is helpful; that is, move the data to a work area, convert it to the matching data format, and reference the work area in procedural statements.

The following example illustrates the conversions that take place when the components of a COMPUTE are defined:

```
A COMPUTATIONAL-1.
B PICTURE S99V9 COMPUTATIONAL-3.
C PICTURE S9999V9 COMPUTATIONAL-3.
```

and the following computation is specified:

```
COMPUTE C = A * B.
```

ITEM	VALUE	USAGE	INTERNAL REPRESENTATION
External Decimal	-1234	DISPLAY PICTURE 9999	|Z1|Z2|Z3|F4| BYTE
		DISPLAY PICTURE S9999	|Z1|Z2|Z3|-4| BYTE
Internal Decimal	+1234	COMPUTATIONAL-3 PICTURE 9999	|01|23|4F| BYTE
		COMPUTATIONAL-3 PICTURE S9999	|01|23|4+| BYTE
Binary	+1234	COMPUTATIONAL PICTURE S9999	|0000 0100|1101 0010| S BYTE
External Floating-Point	+12.34E+2	DISPLAY PICTURE 99.99E-99	|+|1|2|.|3|4|E|b|0|2| BYTE
Internal Floating-Point		COMPUTATIONAL-1	|S|Characteristic|Fraction| 0 1 7 8 31
		COMPUTATIONAL-2	|S|Characteristic|Fraction| 0 1 7 8 63

Note: The codes used within the INTERNAL REPRESENTATION column are as follows:
- Z=zone
- Hexadecimal F=non-printing plus sign
- S=the sign position of a numeric field: '1' indicates a negative number '0' indicates a positive number;
- b=a blank

• Figure 12. Internal Representation of Numeric Items

To perform this operation, the internal decimal data (COMPUTATIONAL-3) is converted to floating-point format and then the COMPUTE is executed. The floating-point result is converted to internal decimal. The conversion routines are time consuming and use storage unnecessarily.

TYPES OF CONVERSIONS

The following examples show what must logically be done when working with mixed data fields before the indicated operations can be performed.

DISPLAY to COMPUTATIONAL-3

To move data: No additional code is required (if proper alignment exists) because one instruction can both move and convert the data.

To compare data: Before a COMPARE is executed, DISPLAY data must be converted to COMPUTATIONAL-3 format.

To perform arithmetic operations: Before arithmetics are performed, DISPLAY data is converted to COMPUTATIONAL-3 format.

DISPLAY to COMPUTATIONAL

To move data: Before the MOVE is executed, DISPLAY data is converted to COMPUTATIONAL-3 format, which is then converted to COMPUTATIONAL data format.

To compare data: Before a COMPARE is executed, both DISPLAY data and COMPUTATIONAL data are converted to COMPUTATIONAL-3 data format.

To perform arithmetic operations: Before arithmetics are performed, DISPLAY data is converted to COMPUTATIONAL-3 format which is then converted to COMPUTATIONAL format.

COMPUTATIONAL-3 to COMPUTATIONAL

To move data: Before a MOVE is executed, COMPUTATIONAL-3 data is moved to a work area, and then converted to COMPUTATIONAL data format.

To compare data: Before a COMPARE is executed, COMPUTATIONAL data is converted to COMPUTATIONAL-3 format.

To perform arithmetic operations: Before arithmetics are performed, COMPUTATIONAL-3 data is converted to COMPUTATIONAL data format.

COMPUTATIONAL to COMPUTATIONAL-3

To move data: Before a MOVE is executed, COMPUTATIONAL data is converted to COMPUTATIONAL-3 data format.

To compare data: Before a COMPARE is executed, COMPUTATIONAL data is converted to COMPUTATIONAL-3 data format.

To perform arithmetic operations: Before arithmetics are performed, COMPUTATIONAL data is converted to COMPUTATIONAL-3 data format.

COMPUTATIONAL to DISPLAY

To move data: Before a MOVE is executed, COMPUTATIONAL data is converted to COMPUTATIONAL-3 data format, which is then converted to DISPLAY data format.

To compare data: Before a COMPARE is executed, both COMPUTATIONAL and DISPLAY are converted to COMPUTATIONAL-3 data format.

To perform arithmetic operations: Before arithmetics are performed, both COMPUTATIONAL and DISPLAY data are converted to COMPUTATIONAL-3 data format. The result is generated in a COMPUTATIONAL-3 work area, which is then moved to the DISPLAY result field.

COMPUTATIONAL-3 to DISPLAY

To move data: Before a MOVE is executed, COMPUTATIONAL-3 data is converted to DISPLAY data format.

To compare data: Before a COMPARE is executed, DISPLAY data is converted to COMPUTATIONAL-3 data format.

To perform arithmetic operations: Before arithmetics are performed, DISPLAY data is converted to COMPUTATIONAL-3 data format. The result is generated in a COMPUTATIONAL-3 work area, which is then converted and moved to the DISPLAY result field.

DISPLAY to DISPLAY

To perform arithmetic operations: Before arithmetics are performed, all DISPLAY data is converted to COMPUTATIONAL-3 data format. The result is generated in a COMPUTATIONAL-3 work area, which is then converted and moved to the DISPLAY result field.

Conversion of COMPUTATIONAL-1 or COMPUTATIONAL-2 Data

Because the conversion from internal to external floating-point and vice-versa is done by subroutine, use of floating-point (COMPUTATIONAL-1 or COMPUTATIONAL-2) numbers mixed with other usages should be held to a minimum. Fields used in conjunction with a floating-point number cause the object program to perform conversions. For example, assume a COMPUTE is specified as:

```
COMPUTE A = B * C + D + E.
```

Assume B is COMPUTATIONAL-1 or COMPUTATIONAL-2 and all other fields are defined as COMPUTATIONAL-3 data. Fields C, D and E are converted to COMPUTATIONAL-1 or COMPUTATIONAL-2 data format, the calculation performed, and the result converted back from COMPUTATIONAL-1 or COMPUTATIONAL-2 data format to COMPUTATIONAL-3 data. If field B is defined as COMPUTATIONAL-3, no conversion is necessary. If it is necessary to use floating-point data, special care should be taken not to mix data formats.

EXAMPLES SHOWING EFFECT OF DATA DECLARATIONS

Mixed mode operations involve transferring data between fields defined in different formats. The following examples illustrate the coding

necessary to perform mixed format operations. In order to isolate the effect of mixed formats the examples are based on the assumption that all fields are the same size, and that all decimals are aligned. If fields are unequal or decimal points are unaligned, time and storage will be wasted to modify field lengths and insure decimal alignment.

The following abbreviations will be used throughout the examples:

DISP: DISPLAY usage (external decimal).

COMP-3: COMPUTATIONAL-3 usage (internal, or packed decimal).

COMP: COMPUTATIONAL usage (binary).

Arithmetic operations can be performed on data in packed, binary or floating-point format. As a basis for analyzing mixed mode operations, these examples illustrate the core required to add fields of the same mode.

```
ADD COMP-3 to COMP-3      6 bytes
ADD COMP   to COMP       12 bytes
ADD DISP   to DISP       24 bytes
```

Compare the above core requirements with the following examples:

```
ADD DISP   to COMP-3     12 bytes
ADD DISP*  to COMP       20 bytes
ADD COMP-3 to COMP       20 bytes
ADD COMP-3 to DISP       18 bytes
ADD COMP   to COMP-3     20 bytes
ADD COMP   to DISP       32 bytes
```

*Note: The DISPLAY field must not exceed nine digit positions, or a subroutine would be required to handle the statement.

Mixed mode moves have a similar effect on efficiency. As a basis for analysis, the following examples illustrate moves in the same mode.

```
MOVE DISP   to DISP       6 bytes
MOVE COMP-3 to COMP-3     6 bytes
MOVE COMP   to COMP       8 bytes
```

Compare these core requirements with the following examples:

```
MOVE DISP   to COMP-3     6 bytes
MOVE DISP   to COMP      14 bytes
MOVE COMP-3 to COMP      14 bytes
MOVE COMP-3 to DISP       6 bytes
MOVE COMP   to DISP      20 bytes
MOVE COMP   to COMP-3    14 bytes
```

The cost in bytes of moving COMPUTATIONAL-3 data to a REPORT field is:

```
24 bytes for a simple move;
12 bytes for floating insertion character;
24 bytes for non-floating digit postion;
18 bytes for decimal alignment;
24 bytes for trailing characters;
12 bytes for unmatched digit positions.
```

Mixed format moves with decimals aligned will result in no extra core usage in moves between DISPLAY and COMPUTATIONAL fields. However, other mixed format moves involving binary fields will take from 6 to 14 extra bytes.

Group moves of 256 or fewer bytes cost less than a series of single moves of the elementary items within the group item. Any move of more

than 256 bytes causes a subroutine to be used, if the operands are unequal in length and one or both of them is greater than 256.

At present, arithmetics in mixed format require 6 to 22 bytes of extra core for each operation. This is sufficient reason to avoid it. Data files should have their arithmetic fields converted to packed or binary format for most efficiency.

For optimum use of storage when using relational statements, first make all computations, and then compare the results. Following is a list of the amount of storage required to perform various kinds of relational statements:

The cost in bytes to execute an IF statement when data is defined as DISPLAY and COMPUTATIONAL-3 is:

18 bytes for conversion and for the compare and branch instruction, and

18 bytes for decimal alignment.

The cost in bytes to execute an IF statement when all data is defined as COMPUTATIONAL-3 is:

6 bytes for the compare and branch instruction (no decimal alignment).

42 bytes for the compare and branch with decimal alignment.

The cost in bytes to execute an IF statement when all data is defined as COMPUTATIONAL is:

18 bytes for the compare and branch instruction, when the number of decimal digits is 1 to 9. The number of bytes required to execute the IF statement is unpredictable when the number of decimal digits is from 10 to 18.

GENERAL CODING TECHNIQUES

The remaining part of this chapter is devoted to specific programming techniques which, when incorporated in a COBOL program, will increase its efficiency. These techniques are divided into two broad categories: arithmetic and non-arithmetic. The text will point out suggested methods for using these techniques and provide examples to illustrate each suggestion.

Before beginning the specifics of efficient COBOL coding, the programmer should remember that, as a general rule, time and storage are reduced whenever statements are kept simple.

ARITHMETIC SUGGESTIONS

ARITHMETIC FIELDS

Before use, all data fields not containing a value clause should be initialized with numeric data or zeros by the problem program to insure accurate results. Using an uninitialized field may produce invalid results or cause an abnormal job termination.

INTERMEDIATE RESULTS IN A COMPLEX EXPRESSION

The compiler can process complex statements, but not always with the same efficiency of storage utilization that the programmer may obtain by breaking up a complex statement into several simple statements. The compiler handles complicated expressions as a series of simple operations, each producing an intermediate result. It is this result which is used in the next operation to obtain a new intermediate result until the final answer is calculated. Because truncation may occur during computations, unexpected intermediate results may be obtained, thus producing invalid results.

Intermediate results do not occur in arithmetic statements containing only a single pair of operands. However, intermediate results are possible in the following cases:

1. In an ADD or SUBTRACT statement containing multiple operands immediately following the verb.

2. In a COMPUTE statement specifying a series of arithmetic operations.

3. In arithmetic expressions contained in IF or PERFORM statements.

Because of concealed intermediate results, the final result is not always obvious. To avoid unexpected intermediate results make critical computations by assigning maximum (or minimum) values to all fields. Then analyze the results by testing specific computations for expected results. The COBOL Language Specifications Manual, Form C24-3433, provides detailed information on calculating intermediate results.

Splitting up the expression and controlling the intermediate results eliminates the necessity of computing for the worst or best case. Consider the following example:

```
COMPUTE B = (A + 3) / C + 27.600.
```

Define adequate intermediate result fields, i.e.:

```
02 INTERMEDIATE-RESULT-A PICTURE S9(6)V999.
02 INTERMEDIATE-RESULT-B PICTURE S9(6)V999.
```

Then, split up the expression as follows.

```
ADD A, 3 GIVING INTERMEDIATE-RESULT-A.
```

Then write:

```
DIVIDE C INTO INTERMEDIATE-RESULT-A GIVING
 INTERMEDIATE-RESULT-B.
```

Then, compute the final result by writing:

```
ADD INTERMEDIATE-RESULT-B, 27.600 GIVING B.
```

EXPONENTIATION

Exponentiation to a fractional power requires the use of the floating-point feature. This feature increases both the amount of storage used and the calculation time involved. Floating-point computations can be

avoided by separating the statements into individual computations. The first example given requires the use of the floating-point feature. The second example restates the problem, illustrating how to circumvent use of floating-point numbers.

Assume data is defined:

```
DATA DIVISION.
WORKING-STORAGE SECTION.
  77 FLD PICTURE S99V9, COMPUTATIONAL-3.
  77 EXPO PICTURE S99, COMPUTATIONAL-3.
  77 P PICTURE S99.
  77 N PICTURE S99.
  77 VALUE1 PICTURE S99.
```

Assume values used in the example were appropriately moved into their respective symbolic names as follows: VALUE1 = 5, P = 10, and N = 5.

Example 1:

```
COMPUTE FLD = VALUE1 ** (P / N).
```

Because (P / N) = 10/5=2.00 (with decimal places), the floating-point feature is required to solve this statement; it is not known whether decimal digits are present when the exponent is developed.

Example 2:

The statement in example 1 can be solved by writing:

```
COMPUTE EXPO = (P / N).
```

The result is truncated to two significant digits (S99).

Then write:

```
COMPUTE FLD = VALUE1 ** EXPO.
```

Thus, the statement written in example 1 can be solved by separating it into two distinct computations, avoiding the need for floating-point instructions.

Intermediate result truncation can affect final results. For example:

Example 3:

Assume that VALUE1 = 10, and N = 2.

If COMPUTE FLD = (VALUE1 ** N) - 2 is written, by substitution the result is:

```
  FLD = (VALUE1 ** N) - 2
S99V9 = (S99 ** S99) - 2
S99V9 = (10 ** 2) - 2
```

By the rule for truncation:

```
S99V9 = 100.0 - 2.
```

The most significant digit is truncated. The final result is then:

```
FLD =  00.0 - 2
Hence, FLD = -02.0, could be an unexpected result.
```

Example 4:

The situation can be corrected by expanding the target field (FLD) as follows:

```
77 FLD PICTURE S999V9
```

Then, when the statement is written (assuming VALUE1 = 10, and N = 2):

```
COMPUTE FLD = (VALUE1 ** N) - 2.
```

The result is:

```
 FLD = (VALUE1 ** N) - 2
S999V9 = (S99 ** S99) - 2
S999V9 = (10 ** 2) - 2.
```

By the rules for truncation:

```
S999V9 = 100.0 - 2.
```

The result is,

FLD = 098.0, which is the expected result.

DECIMAL POINT ALIGNMENT

Correction of non-aligned decimals requires compiler generated instructions for padding, sign movement and blanking-out results. Therefore, the programmer should specify identical decimal positions whenever possible. If it is not feasible to declare all items aligned, the item can be moved to a work area to insure alignment, before use in a multiple operation.

As a general rule, two or four additional instructions (12 to 18 bytes) are required in basic arithmetic statements and IF statements when decimal point alignment is necessary to process two COMPUTATIONAL-3 fields. For example,

```
77 A PICTURE S999V99 COMPUTATIONAL-3.
77 B PICTURE S999V9 COMPUTATIONAL-3.
```

By defining FIELD B like FIELD A, (PICTURE S999V99), the need for alignment instructions is eliminated, and no more bytes are required for FIELD B. (Remember, hardware requires an odd number of digits for internal decimal fields. By using an odd number of nines when defining data in COMPUTATIONAL-3 format, more efficient object code results without using additional storage for the item defined.)

To illustrate further:

```
ADD 1 to A.
```

The literal is compiled in internal decimal form, but decimal point alignment instructions are necessary (four instructions, 18 bytes). If, instead, the literal is written 1.00, only one byte is added in the literal area. The 18 bytes required for alignment of decimal points are eliminated.

SIGN CONTROL

For numeric fields specified as unsigned (no S in the picture clause of external or internal decimal items), the COBOL compiler attempts to ensure that a special positive sign (F) is present so that the values are treated as absolute.

The compiler inserts a hexadecimal F whenever the posibility of a change in sign exists. Examples are: subtracting unsigned fields, moving a signed field to an unsigned field, or an arithmetic operation on signed fields where an unsigned result field is specified. (The hexadecimal F, while treated as a plus, does not cause the digit to be printed or punched as a signed digit.) If the PICTURE associated with a dataname indicates the presence of an operational sign, the character D will appear when the value is negative, and the character C will appear when the value is positive.

The sign is not checked on input data nor on group level moves. Therefore, the programmer must know what type of data is being used under these circumstances.

The use of unsigned numeric fields increases the possibility of error (an unintentional negative sign could cause invalid results) and requires additional generated code to control the sign. The use of unsigned fields should be limited to fields that are to be treated as absolute values. The following example illustrates the additional instructions generated by the compiler each time an unsigned field is modified:

If data is defined as:

```
A PICTURE 999.
B PICTURE S999.
C PICTURE S999.
```

and the following moves are made,

```
MOVE B TO A.
MOVE B TO C.
```

moving B to A causes four more bytes of storage to be used than moving B to C, because an absolute value is specified for receiving field A.

Note: An S must be specified in the picture clause of a binary item, since a binary item is always treated as a signed item.

NON-ARITHMETIC SUGGESTIONS

UNEQUAL LENGTH FIELDS

When handling fields of unequal length, an intermediate operation may be required. For example, zeros may have to be inserted in numeric fields and blanks in alphabetic or alphanumeric fields in order to pad them out to the proper length. To avoid these operations, the number of integer digits in fields used together should be equal. Any increase in data field size is compensated for by the savings in generated object code.

For example, if data is defined as:

```
SENDFLD PICTURE S999.
RECEIVEFLD PICTURE S99999.
```

and SENDFLD is moved to RECEIVEDFLD, the cost of zeroing high-order positions (numeric fields are justified right) is 10 bytes. To eliminate these 10 bytes define SENDFLD as:

```
SENDFLD PICTURE S99999.
```

The overall length of a field can have a significant bearing on the most efficient format. Binary fields defined as having more than nine digits require a double word for storage. This exceeds the natural hardware limits for binary arithmetic, and results in extra processing steps. By defining fields that exceed nine digits as packed, both core and execution time will be saved.

Field lengths ranging from one to nine digits can usually be stored in fewer bytes in binary format than in packed format; however, it takes 8 bytes to add two aligned binary fields, and only six bytes to add two aligned packed fields.

The choice of which format to choose in this case will depend on considering a multitude of factors. Some of these factors are:

- Do the fields have to be rounded?
- Do the fields require print editing?
- Does your application require extensive calculating? (Binary arithmetic will normally run faster.)
- Have you considered slack bytes?
- Do your data fields require decimals?

CONDITIONAL STATEMENTS

The final result of an expression included in a conditional statement is limited to an accuracy of six decimal places. Therefore, computing arithmetic values separately and then comparing them may produce more accurate results than including arithmetic expressions in conditional statements. The following example shows how separating computations from the conditional can improve accuracy.

If data is defined as:

```
77 A PICTURE S9V9999 COMPUTATIONAL-3.
77 B PICTURE S9V9999 COMPUTATIONAL-3.
77 C PICTURE S999V99999999 COMPUTATIONAL-3.
```

and the following conditional statement is written,

```
IF A * B = C GO TO EQUALX.
```

the final result will be S99V999999. Although the receiving field for the final result (C) specifies eight decimal positions, the final result actually obtained in this example contains six decimal places. For increased accuracy, define the final result field as desired, perform the computation, and then make the desired comparison as follows.

```
77 X PICTURE IS S999V99999999 COMPUTATIONAL-3.

COMPUTE X = A * B.
IF X = C GO TO EQUALX.
```

Note: Because COMPUTATIONAL-3 format is the most efficient, numeric comparisons are usually done in this format. Note also, because compiler-inserted slack bytes can contain meaningless data, group compares should not be attempted when the group contains slack bytes unless the programmer knows the contents of these bytes.

SUBSCRIPTING

Using a constant subscript instead of a variable (data-name) subscript results in less core storage and faster execution time. For example, NAME (1, 23) is more efficient than NAME (S1, S2) where S1=1 and S2=23. The address of NAME (in the former case) is resolved at compile time, based on the given constant subscripts. However, when variable subscripting is used, the address of the field is computed each time a subscripted field is referenced.

For further efficiency, frequently referenced subscripted fields should be moved to a work area, manipulated and, if necessary, returned.

Example:

```
ADD D TO TAB-FIELD (A, B, C).
IF TAB-FIELD (A, B, C) = LIMIT-FLD GO TO ERR.
MOVE TAB-FIELD (A, B, C) TO F.
COMPUTE TAB-FIELD (A, B, C) = TAB-FIELD (A, B, C) + F/G
```

This coding could be improved by writing:

```
MOVE TAB-FIELD (A, B, C) TO WORK-FLD.  ADD
D TO WORK-FLD.  IF WORK-FLD = LIMIT-FLD GO TO ERR.
MOVE WORK-FLD TO F, COMPUTE TAB-FIELD
(A, B, C) = WORK-FLD + F / G.
```

Note: Because subscripting is done in the binary mode, data-name subscripts not in binary must be converted. Therefore, use of binary mode subscripts increases efficiency. If binary is used, the picture must begin with S and the field length should be four, nine, or 18 places with no decimal positions.

ALIGNMENT AND SLACK BYTES

If files and working storage are organized so that all halfwords, fullwords and doublewords are grouped together, no additional storage is wasted in satisfying boundary alignment requirements. However, if these items are not grouped together properly, the amount of additional wasted storage required for proper alignment is:

1 byte per halfword
1 to 3 bytes per fullword
1 to 7 bytes per doubleword.

The user need be concerned with slack bytes only when using binary or floating-point data. The number of bytes of main storage necessary for the Data Division must include bytes added to produce valid boundary alignment for binary and floating-point data fields.

The compiler generates both slack bytes to align data and a diagnostic message indicating it has done so.

Example:

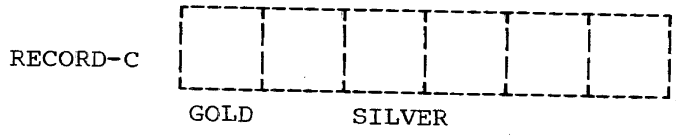
```
01 RECORD.
   02 FLD-1 PICTURE IS X(2).
   02 FLD-2 PICTURE IS S99999 COMPUTATIONAL.
```

Because FLD-2 is binary and five digits in length, the compiler sets aside one fullword which must be aligned on a fullword boundary. In this example, two slack bytes are required. The compiler inserts them automatically.

Since COBOL aligns computational fields on output files and expects that input files will contain slack bytes (where required), a problem could exist when reading or writing a file. A file to be read that contains computational fields without slack bytes must be coded with the knowledge that this is so. If the file contains computational data without slack bytes, the data will not be properly aligned when read from the file; thus it cannot be processed by the compiler.

The following is a technique for manipulating computational data not containing slack bytes so that it may be processed by the compiler.

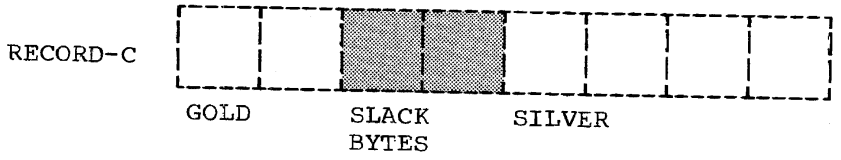
Assume a group record called RECORD-C exists on a file and consists of two bytes of alphanumeric data called GOLD, and a 4-byte binary data item called SILVER. The record on the file would appear as follows:



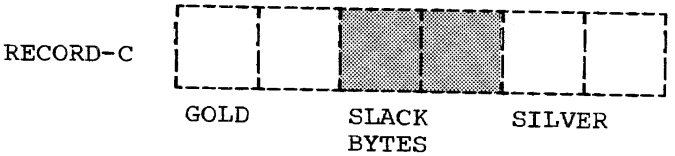
If an FD were defined:

```
01 RECORD-C.
   02 GOLD PICTURE XX.
   02 SILVER PICTURE S99999 COMPUTATIONAL.
```

the compiler assumes the following structure:



When the record on the file is read, it is placed in the area defined, left justified. The area thus contains the following:



(This is the compiler-generated address of SILVER.)

Thus, the first two bytes of the 02 SILVER are lost because of improper alignment. Hence, when the 02 SILVER is accessed, only the last two bytes are available. To circumvent this problem, define RECORD-C as follows:

```
01 RECORD-C.
   02 GOLD PICTURE XX.
   02 SILVER PICTURE XXXX.
```

and a GROUP item such as:

```
01 LEAD.
   02 DIAMOND PICTURE S99999 COMPUTATIONAL.
```

Now, access RECORD-C. This places it in the buffer, properly aligned.

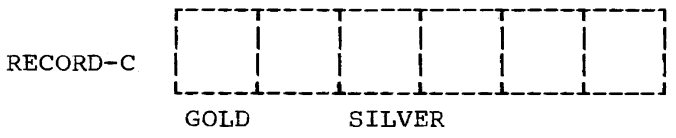
Then move the 4-byte elementary 02 SILVER (defined as alphanumeric but is actually binary data) to the record 01 LEAD. Because the 01 LEAD is a group item, the data moved retains its original form (no data conversion takes place) and the elementaries 02 SILVER and 02 DIAMOND are properly aligned. Thus, by accessing DIAMOND, the binary data can be operated on as desired.

There is an alternate method of obtaining proper alignment when reading the record.

Define a record in an FD as follows:

```
01 RECORD-C.
   02 GOLD PICTURE XX.
   02 SILVER PICTURE XXXX.
```

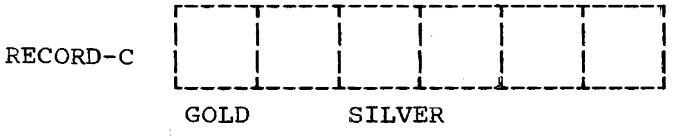
The area defined would appear:



Then define a record in the Working-Storage Section as:

```
01 BRASS.
   02 LEAD PICTURE XXXX.
   02 DIAMOND REDEFINES LEAD PICTURE S99999
        COMPUTATIONAL.
```

As before, when the record is accessed, it is placed in the buffer, properly aligned. Its structure in the buffer would be:



Now move the 4-byte elementary 02 SILVER to the elementary 02 LEAD. Because the 02 SILVER and 02 LEAD elementaries are both defined as display, the data retains its original form and the elementaries are properly aligned. By accessing the REDEFINES (DIAMOND) the binary data can be operated on as desired. The same problem could exist when reading or writing floating-point data.

For a complete discussion of slack bytes, refer to the publication, IBM System/360 Disk and Tape Operating Systems: COBOL Language Specifications, Form C24-3433.

REDUNDANT CODING

Using computational designators at the group level helps avoid redundant coding of usage designators. (This does not affect the object program.)

Example:

```
02 FULLER.
    03 A COMPUTATIONAL-3 PICTURE 99V9.
    03 B COMPUTATIONAL-3 PICTURE 99V9.
    03 C COMPUTATIONAL-3 PICTURE 99V9.
```

This coding could be improved by writing:

```
02 FULLER COMPUTATIONAL-3.
   03 A PICTURE 99V9.
   03 B PICTURE 99V9.
   03 C PICTURE 99V9.
```

REDEFINITION

Main storage can be used more efficiently by writing different data descriptions for the same data area. For example, the following coding shows how the same area can be used as a work area for the records of several input files that are not processed concurrently:

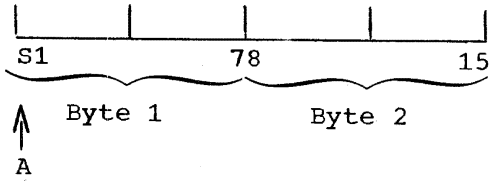
```
WORKING STORAGE SECTION.
   01 WORK-AREA-FILE1.
      Largest record description for FILE1.
           .
           .
           .

   01 WORK-AREA-FILE2 REDEFINES WORK-AREA-FILE1.
      Largest record description for FILE2.
           .
           .
           .
```

The REDEFINES clause can also be used to manipulate unusual data forms. For example, a technique for isolating one binary byte follows.

```
02 A PICTURE S99 COMPUTATIONAL.
02 FILLER REDEFINES A.
   03 FILLER PICTURE X.
   03 B PICTURE X.
```

Explanation:

COMPUTATIONAL sets up a binary halfword:



02 FILLER REDEFINES A., stating that A is to be redefined as follows:

Ignore first byte (03 FILLER PICTURE X).
Name second byte B. (03 B PICTURE X).

Now byte B can be moved to a work area, and operated on logically at the assembler level, or compared logically at the COBOL level. It can be stored on a file, and later moved back to its point in a similarly defined field. When using data in this manner, the programmer must be careful of signs and numeric values.

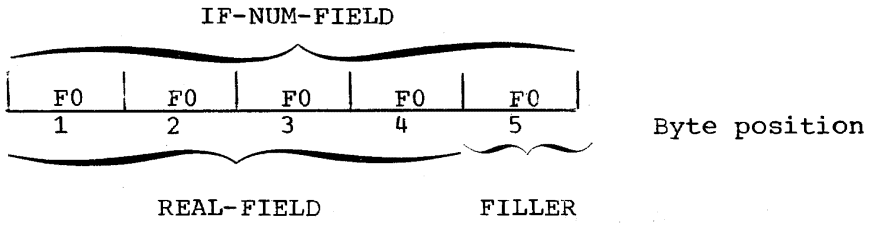
Another illustration of REDEFINES to manipulate data concerns the test IF NUMERIC. Under normal language usage, a field is considered numeric if all the positions of the field are numeric with the exception of the sign position. If a field is to be considered numeric only when it is unsigned, the sign position must be tested. A technique for relocating the sign (or "shifting") so that it can be tested as an unsigned numeric value follows:

Assume a field is defined:

```
02 IF-NUM-FIELD PICTURE X(5) VALUE '00000'.
02 CHANGE-FIELD REDEFINES IF-NUM-FIELD.
   03 REAL-FIELD, PICTURE S9(4).
   03 FILLER, PICTURE X.
```

IF-NUM-FIELD defines a 5-byte alphanumeric field.
REAL-FIELD redefines this field to be 4 bytes numeric.

The fields appear in storage as follows:

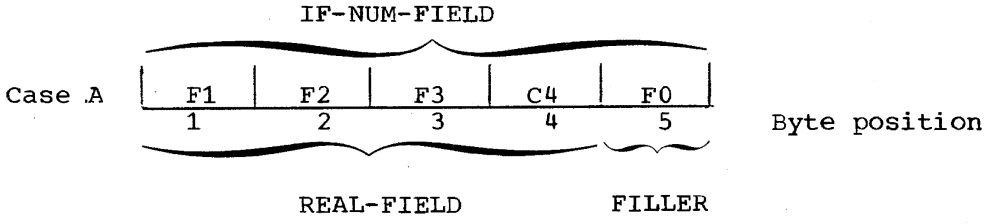


To make an IF NUMERIC test true for only unsigned fields:

1. Move the 4-byte value to be tested into REAL-FIELD. The value and its sign occupy bytes 1-4.

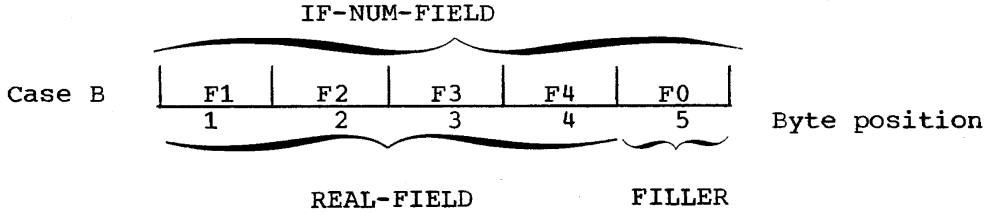
   Example:

   If +1234 is moved to REAL-FIELD, the resultant field appears in storage as follows:



   Note: the low-order byte (rightmost byte) of IF-NUM-FIELD retains its initial value of 0.

   If 1234 is moved to REAL-FIELD, the resultant field appears in storage as follows:



2. Test IF-NUM-FIELD for NUMERIC.

All four bytes of REAL-FIELD will be tested as an unsigned numeric value because the sign position was "shifted left one position," and is no longer in the units position of IF-NUM-FIELD. If the value is unsigned, a hexadecimal F appears in the sign position or fourth byte on the 4-byte field, and it appears as an unsigned numeric.

Thus in the preceding example, when the fourth byte is tested in case A, the numeric test is not true, but when tested in case B the numeric test is satisfied.

EDITING

Data fields should be in packed format (COMPUTATIONAL-3) prior to editing. If the arithmetic on such fields is done in packed rather than binary mode, a conversion will be saved.

In addition, careful use of editing symbols can increase a program's efficiency. For example, a high-order nonfloating digit position involves more instructions than a floating digit position.

Example:

nonfloating	vs	floating
999.99		$$$9.99

Furthermore, the blank-when-zero is implied in certain pictures. For example:

```
ZZZ.ZZ
```

If blank-when-zero is not required for low-order characters, more efficient coding is generated by pictures such as:

```
ZZZ.99
```

FILES

The COBOL OPEN requires a work area that cannot be recovered in a COBOL program. Less storage is used if multiple files are opened with one OPEN statement than when an OPEN is used for each file. A single OPEN for each file requires approximately 100 bytes of additional storage per file-name.

To conserve storage, use: OPEN INPUT FILEA, FILEB....

rather than: OPEN INPUT FILEA OPEN INPUT FILEB....

After opening the file, efficiency is increased by issuing only one read statement per input file and one write statement per output file.

Data should not be moved from an input file before the file has been opened and the first record has been read; data should not be moved from an input file after the file has been closed. Neither should data be moved to an output file before it has been opened nor after it has been closed. In addition, the contents of input/output buffers must be inserted by the problem program before each WRITE. If blanks or zeros

are not moved to unused areas of an output buffer, the output file will contain whatever was previously in the buffer.

ACCEPT VERB

The ACCEPT verb does not provide for recognition of the last card read from a card reader. When COBOL detects a /* card it drops through to the next statement. Because no indication of this is given by COBOL, an end of file detection requires special treatment. Thus, the programmer must provide his own end card (some card other than /*) which he can test to detect an end-of-file.

PARAGRAPH-NAMES

Paragraph-names are used to identify the range of a PERFORM verb (i.e. the paragraphs or procedures to be performed). To be meaningful a name should describe the function of the procedure. Since paragraph-names occupy storage relative to their lengths, long names should be avoided when the PERFORM verb is used. Instead a NOTE should be placed immediately preceding the paragraph to identify its function and a shortened name used as the paragraph-name.

Example: Avoid:

```
            MOVE A TO B.
            PERFORM ROUTINE-TO-COMPUTE-VALUE-OF-A.
                 .
                 .
                 .
ROUTINE-TO-COMPUTE-VALUE-OF-A.  COMPUTE A = D + E * F.
```

Recommended:

```
            MOVE A TO B,
            PERFORM ROUTINE.
                 .
                 .
                 .
            NOTE ROUTINE TO COMPUTE VALUE OF A
ROUTINE.    COMPUTE A = D + E * F.
```

A NOTE and/or a blank card can be used to identify in-line procedures where paragraph-names are not required.

TRAILING CHARACTERS

Pictures with a trailing period or comma require that punctuation follow, or the trailing picture character is treated as punctuation.

Example:

```
77 A PICTURE IS 999., USAGE IS DISPLAY.
```

VARIABLE LENGTH RECORDS

Variable length records can be specified for standard sequential files only. The OCCURS...DEPENDING ON clause describes the part of the record that is to be variable. An example of specifying a variable length record is, as follows:

```
01 VARIABLE-REC.
     05 FIXED.
        10 A PICTURE X(46).
        10 CONSTANT PICTURE 99.
     05 VARIABLE-PART OCCURS 10 TIMES DEPENDING ON CONSTANT.
        10 V-1 PICTURE X(38).
        10 V-2 PICTURE 9(10).
```

The record consists of a fixed portion and a variable portion. The variable portion must be the last part of the record. The variable portion in the example can occur a maximum of 10 times depending on CONSTANT. In this example, CONSTANT is part of the record but it need not be. However, the programmer is always responsible for initializing and updating the value of CONSTANT before referring to data items that are part of the variable portion of the record (such as V-1 and V-2 in the example). The value of CONSTANT may be 0, in which case only the fixed portion of the record exists. However, the value of CONSTANT cannot be negative.

References to the variable portion must always be subscripted. For example, V-1 (1) refers to the first occurrence of the field in the record. If the subscript is a data-name, for example V-1 (N), the programmer must be sure that N has the appropriate value. He may wish to initialize it to 1, increment it to refer to subsequent portions of the record, and check it for maximum size.

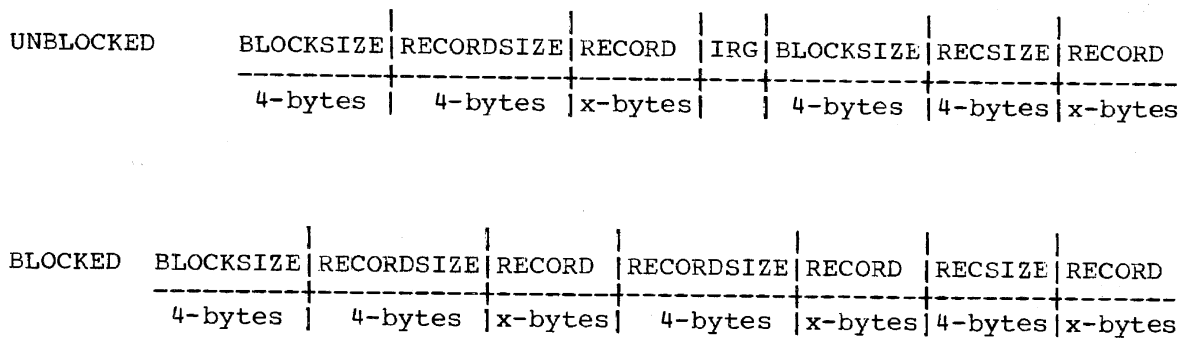
If a subscript is represented by a literal, the location of the subscripted data item is resolved at compile time. If a subscript is represented by a data name, the location is resolved at execution time for each occurrence of the data item. Thus, if a data item subscripted by a variable is to be used frequently, it is more efficient to move the data item to a work area. It is also more efficient to define subscripts as COMPUTATIONAL with pictures of not more than four integers.

When moving variable length records, the length attribute is determined by the receiving field. If the record to be moved contains an OCCURS...DEPENDING ON clause, the field on which the length depends should be moved to the receiving field before moving the entire record at the group or 01 level.

BLOCKING VARIABLE LENGTH RECORDS

When blocking variable length records, the programmer must consider how much the records will vary and the size of the buffer area. A buffer is a designated area in main storage used for input/output transactions. When file processing begins, a block is placed into a buffer where the records are directly addressed. Execution of a READ or WRITE statement directs a pointer to the appropriate record in the buffer. When writing a file, the buffer is filled and then written out as a block.

When a variable length record is written, it actually contains the record itself and a 4-byte control field indicating the record length. An additional 4-byte control field containing the block size precedes each block. The following illustration shows the layout of both blocked and unblocked records.



These control fields are supplied by the system and are not available to the programmer. However, they are a consideration when determining the buffer size which is specified by means of the BLOCK CONTAINS clause. If the BLOCK CONTAINS integer CHARACTERS form of the clause is used, integer must equal the size of the largest record defined for the file (RECORD CONTAINS) plus an additional four bytes for each record for the control field that precedes each record. (The compiler adds the 4-byte block count field. The programmer does not include this field in his count.) Note that if the file contains records with COMPUTATIONAL, COMPUTATIONAL-1, or COMPUTATIONAL-2 entries, it is the programmer's responsibility to add necessary intra-record slack bytes. These slack bytes are part of the record description and must be included in the value of the integer.

Thus, if two types of records are to be written, one of 400 characters in length and the other 200 characters in length (RECORD CONTAINS 200 TO 400 CHARACTERS), the minimum integer that can be specified is 404 (BLOCK CONTAINS 404).

However, if a record 200 characters long was placed in the block specified, there would not be enough space allocated for another record even if the next record was also 200 characters long, because the 4-byte count field preceding each variable length record could not be accommodated. Therefore, given the above facts, the programmer should at least specify BLOCK CONTAINS 408 and use the APPLY WRITE-ONLY option. This option is specified to make optimum use of buffer space. When it is specified, the length of the next record to be written is checked against the space remaining in the buffer. If the space is sufficient, the record is written. If APPLY WRITE-ONLY is not specified, the buffer is truncated and the block is written out whenever the space remaining in the buffer is not sufficent for the maximum record (400 characters in the above example) defined for the file plus its 4-byte count field.

The programmer can use the RECORDS option instead of the CHARACTERS option in the BLOCK CONTAINS clause to specify how many maximum size records are to fit into a block. The compiler then computes the buffer size by multiplying the length of the maximum size record by the number of records specified and adding four bytes for the block count field and four bytes for a count field for each record. This option is more efficient if the records do not vary in size considerably. However, if the following is specified:

```
RECORD CONTAINS 200 TO 400 CHARACTERS
BLOCK CONTAINS 3 RECORDS
```

the compiler reserves a buffer area of 1216 characters. Depending on the actual size of the records, more records could probably be contained in the buffer area. Given the above facts, it is possible for a block to contain five 200-character records (5*204+4<1216).

PROCESSING BUFFERS

Files can be processed using multiple buffers. Logical records are referenced in the proper block by adjusting registers (using them as pointers).

This technique elimates the need for moving a record from the buffer area to a separate record work area, as well as the record work area itself. The record can be operated on directly in the buffer area.

When processing records in a buffer, the next read results in the previous record not being available. Because the previous record is no longer available, the technique of moving a high value to the control field of the last record (to force the processing of records remaining on the other file) cannot be used.

Here are several alternatives:

1. A GO TO statement, prior to the compare, can be altered during the AT END procedure to GO TO the low compare procedure, thus bypassing the compare.

2. A dummy record having a high value in its control field can be provided as the last logical record. This automatically causes the associated files to compare low. However, this can result in the AT END condition never occurring.

3. The control field can be moved to a separate work area following the read, and compared in the work area. The control field is then available in the work area following an AT END condition. The AT END procedure can move a high value into the control field.

VARIABLE RECORD ALIGNMENT CONTAINING OCCURS...DEPENDING ON CLAUSE

Records are processed in the file's buffer area. The first record starts on a doubleword boundary. If there is no OCCURS...DEPENDING ON clause, a diagnostic message is given indicating the padding to be added to the record to assure proper alignment of succeeding records.

To align blocked V-type records containing an OCCURS...DEPENDING ON clause in the buffer:

1. Determine the largest alignment factor with the record.

Alignment factor is	For
2	COMPUTATIONAL (1-4 digits)
4	COMPUTATIONAL-1 or COMPUTATIONAL (5-18 digits)
8	COMPUTATIONAL-2
0	OTHER

2. For alignment factors of four or less, pad both the fixed and the variable portions of the record to an even multiple of the alignment factor.

3. For an alignment factor of eight, move the record, as a group, to 01 in the Working-Storage Section.

INPUT/OUTPUT ERROR PROCESSING CONSIDERATIONS

The USE AFTER STANDARD ERROR clause provides the programmer with a means for investigating input/output processing errors. Depending upon the presence or absence of the declarative section, IOCS provides certain error processing procedures when an input/output error occurs. The following points should be considered when the USE AFTER STANDARD ERROR clause is used with the various types of file organization.

SEQUENTIAL TAPE FILE ORGANIZATION

1. If the declarative section is not included in the program and a wrong length record occurs, the program is abnormally terminated and a storage dump is produced.

   If the the declarative section is not included in the program and a parity error is detected when a block of tape records is read, the tape is backspaced and reread 100 times. If the parity error persists, the tape block within which the error occurred is considered a tape error block, and the block is added to the block count found in the DTF table. IOCS indicates an input/output error (by a diagnostic message) and cancels the job.

2. If the declarative section is included in the program and a parity error is detected when a block of tape records is read (described in 1 above), the tape is backspaced and reread 100 times. If the error persists, the tape block is considered a tape error block, and the block is added to the block count found in the DTF table. However, instead of canceling the job (this occurs when a declarative section is not included in the program), IOCS transers control to the declarative section procedures to be followed on an error condition.

3. The address of the tape error block is stored by COBOL in register 3 + 192, and is accessible through an assembler subprogram.

   Normal return (to the main program) from the declarative section is through the IOCS subroutine invoked, thus bringing the next sequential block into main storage and permitting continued processing of the file (the bad block is bypassed).

   The programmer can interrogate the DTF table further, and display any pertinent data desired (such as block number) by using a CALL statement USING filename.

   A return through the use of GO TO does not bring the next block into main storage, therefore continued processing of the file is impossible.

4. In the case of tapes, the error declarative is entered only for read errors. For write errors, IOCS automatically retries 15 times (including skips and erases) and then cancels the job.

SEQUENTIAL DISK FILE ORGANIZATION

1. If the declarative section is not included in the program and a parity error occurs when a block of records is read, the disk block is reread 10 times. If the read error persists, the disk block, within which the error occurred is considered a disk error block, and the job is terminated. If a parity error occurs when a block of records is written, IOCS attempts to write the block on an alternate track, and continued processing of the file is permitted.

If the declarative section is not included in the program and a wrong length record occurs, IOCS issues an invalid supervisor CALL of 32 which causes a storage dump.

2. If the declarative section is included in the program, and a read or write error occurs, the declarative section is entered.

   If a parity error occurs when a block of records is read (described in 1 above), the disk block is reread 10 times. If the read error persists, the disk block within which the error occurred is considered a disk error block and a READ operation cannot be issued to the error block. IOCS transfers control to the declarative section procedures to be followed on an error condition.

   In the case of a READ operation, normal return from the declarative is to the IOCS subroutine invoked, thus bringing the next sequential block into storage and permitting continued processing of the file.

   If a parity error occurs when a block of records is written, IOCS transfers control to the declarative section procedures to be followed on an error condition.

   In the case of a WRITE operation, normal return from the declarative is to the next instruction in the problem program. The disk block that was to be written is bypassed.

3. In the case of a READ error, a return from the declarative through the use of GO TO does not bring the next block into main storage. Continued processing of the file is impossible and the file must be closed.

   In the case of a WRITE error, a return from the declarative through the use of GO TO permits continued processing of the file. A normal return from the declarative results in the record to be written being bypassed.

Refer to "Section VIII: Processing COBOL Files on Direct-Access Devices" for information on error processing for other direct-access organizations.

This section describes the accepted linkage conventions for calling and called programs and discusses linkage methods when using an assembler language program. In addition, this section contains a description of the overlay facility which enables different called programs to occupy the same area in main storage at different times. It also contains a suggested assembler language program for use in conjunction with the overlay feature.

CALLING AND CALLED PROGRAMS

A COBOL source program which passes control to another program is a calling program. The program which receives control from the calling program is referred to as a called program. Both programs must be compiled (or assembled) in separate job steps, but the resulting object modules must be linkage edited together in the same phase.

A called program can also be a calling program; that is, a called program can, in turn, call another program. In Figure 13, for instance, program A calls program B; program B calls program C. Therefore:

1. A is considered a calling program by B.
2. B is considered a called program by A.
3. B is considered a calling program by C.
4. C is considered a called program by B.

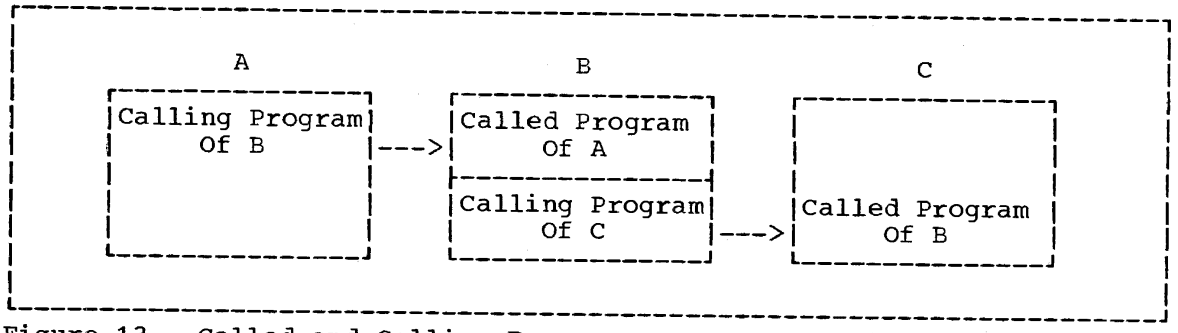


Figure 13. Called and Calling Programs

By convention, a called program may call to an entry point in any other program, except one on a higher level in the path of that program. That is, A may call to an entry point in B or C, and B may call C; however, C should not call A or B. Instead, C transfers control only to B by issuing the RETURN statement in COBOL (or its equivalent in another language). B then returns to A.

LINKAGE

Whenever a program calls another program, a link must be established between the two. The calling program must state the entry point of the called program, and must specify any arguments to be passed. The called

program must have an entry point and must be able to accept the arguments. Further, the called program must establish the linkage for the return of control to the calling program.

LINKAGE IN A CALLING PROGRAM

A calling COBOL program must contain the following statements at the point where another program is to be called:

```
ENTER LINKAGE.
CALL entry-name [USING argument-list].
ENTER COBOL.
```

"Entry-name" is the paragraph-name of the entry point in the called program to which control is to be transferred. The Program-ID should not be the same as the name in an ENTRY statement within that source module because the Program-ID produces an external reference defining an entry point. The external references for the entry-point and the Program-ID must be unique, which would not happen if the entry point and Program-ID are identical.

"Argument-list" is one or more data-names that are to be passed to the called program. If the called program is an assembler language program, the argument-list may also include file-names and procedure names. A file-name may be used in the argument-list when calling a COBOL program, for the purpose of modifying the DTF. If no arguments are to be passed, the USING clause is omitted.

LINKAGE IN A CALLED PROGRAM

A called COBOL program must contain two sets of statements. The following statements must appear at the point where the program is to be entered:

```
ENTER LINKAGE.
ENTRY entry-name [USING parameter-list].
ENTER COBOL.
```

"Entry-name" is the name of the entry point in the called program. It is the same name that appears in the CALL statement of the program that calls this program.

"Parameter-list" is one or more data-names that correspond to the arguments of the CALL statement of the calling program. Each data-name of the parameter list must be defined in the Linkage Section of the Data Division and must have a level number of 01 or 77.

The following statements must be inserted where control is to be returned to the calling program:

```
ENTER LINKAGE.
RETURN.
ENTER COBOL.
```

The RETURN statement enables restoration of necessary registers, and it returns control to the point in the calling program immediately following the calling sequence.

ENTRY POINTS

Each time an entry point is specified in a called program, an external name is defined. An external name is a name that can be referenced by another separately compiled or assembled program. Each time an entry name is specified in a calling program, an external reference is defined. An external reference is a symbol that is defined as an external name in another separately compiled or assembled program. The linkage editor resolves external names and references and combines calling and called programs into a format suitable for execution together, i.e., as a single phase.

Note: Several different entry points may be defined in one COBOL source module. Different CALL statements in any module of the phase may specify the same entry point, but each definition of an entry point must be unique in the same phase.

CORRESPONDENCE OF ARGUMENTS AND PARAMETERS

The number of data-names in the parameter list of the called program must be the same as the number of data-names in the argument-list of the calling program. There is a one-for-one correspondence.

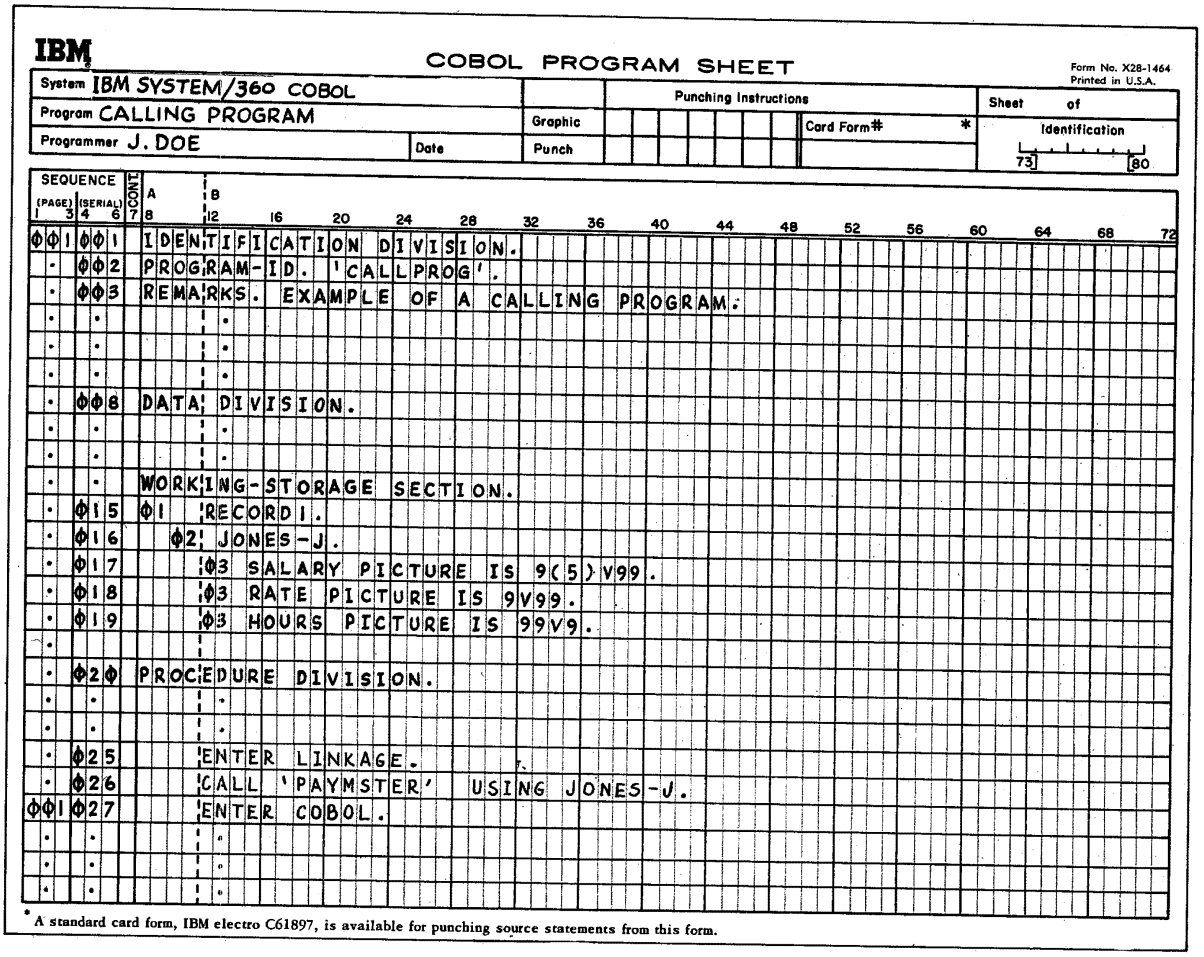
Only the address of an argument is passed. Consequently, the data-name that is an argument and the data-name that is the corresponding parameter both refer to the same location in main storage. The pair of data-names need not be identical, but the data descriptions must be equivalent. For example, if an argument is a level 77 data-name with a picture size of 30 characters, its corresponding parameter could also be a level 77 data-name of 30 characters, or it could be a level 01 data-name with subordinate items whose combined picture sizes are equal to 30 characters.

Although all parameters in the ENTRY statement must be described with level numbers of 01 or 77, there is no such restriction made for arguments in the CALL statement. An argument may be a qualified name or a subscripted name. When a group item with a level number other than 01 is specified as an argument, proper word-boundary alignment is required if subordinate items are described as COMPUTATIONAL, COMPUTATIONAL-1 or COMPUTATIONAL-2. If the argument corresponds to a 01 level parameter, doubleword alignment is required.

Figure 14 illustrates how a program is called and what data definitions are required to support the CALL.

The calling program 'CALLPROG' calls program 'PAYROLL' at the entry point 'PAYMSTER' and passes the argument 'JONES-J'. The elementary data items subordinate to 'JONES-J' (i.e.,'SALARY', 'RATE', 'HOURS'), are processed by 'PAYMSTER' through its using statement parameter 'PAYOFF' because, in effect, 'JONES-J' is equated with 'PAYOFF'. Any processing specified for data items subordinate to 'PAYOFF' is actually performed on those items subordinate to 'JONES-J'.

Note that the entry-name (ENTRY 'PAYMSTER') is not the same as the Program-ID ('PAYROLL').



IBM

COBOL PROGRAM SHEET

Form No. X28-1464
Printed in U.S.A.

System: IBM SYSTEM/360 COBOL
Program: CALLING PROGRAM
Programmer: J. DOE
Date:
Graphic
Punch
Punching Instructions
Card Form# *
Sheet of
Identification 73 80

SEQUENCE (PAGE) 1 3 (SERIAL) 4 6 CONT 7 A 8 B 12 16 20 24 28 32 36 40 44 48 52 56 60 64 68 72

```
00100001 IDENTIFICATION DIVISION.
      0002 PROGRAM-ID. 'CALLPROG'.
      0003 REMARKS. EXAMPLE OF A CALLING PROGRAM.
      0008 DATA DIVISION.
           WORKING-STORAGE SECTION.
      0015 01 'RECORD1.
      0016    02 JONES-J.
      0017       03 SALARY PICTURE IS 9(5)V99.
      0018       03 RATE PICTURE IS 9V99.
      0019       03 HOURS PICTURE IS 99V9.
      0020 PROCEDURE DIVISION.
      0025       'ENTER LINKAGE.
      0026       'CALL 'PAYMSTER' USING JONES-J.
00010027       'ENTER COBOL.
```

* A standard card form, IBM electro C61897, is available for punching source statements from this form.

Figure 14. Example of a Calling Program (Part 1 of 3)

IBM

COBOL PROGRAM SHEET

Form No. X28-1464
Printed in U.S.A.

System IBM SYSTEM/360 COBOL | Punching Instructions | Sheet of

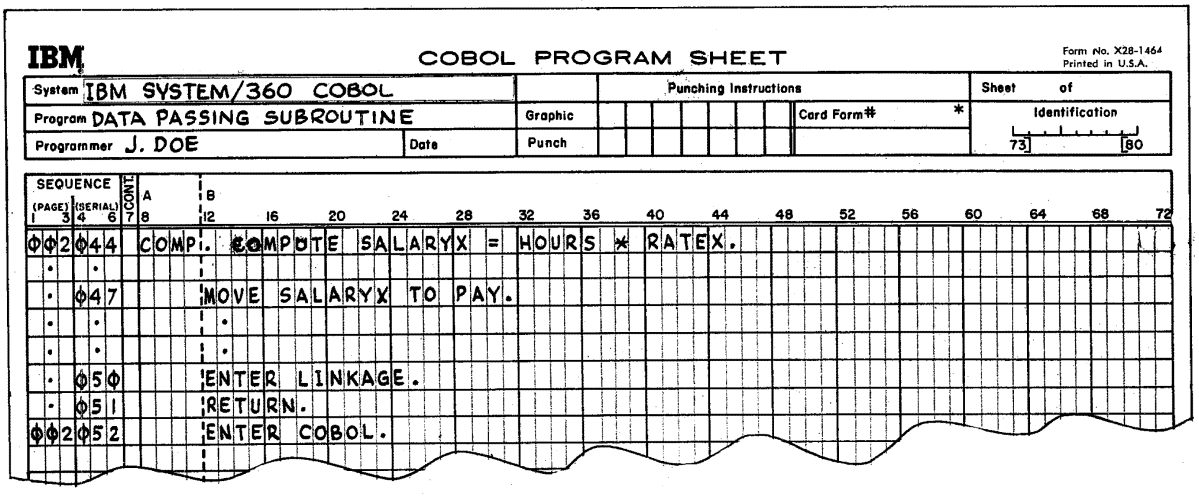
Program DATA PASSING SUBROUTINE | Graphic | Card Form# * | Identification 73 80

Programmer J. DOE | Date | Punch

SEQUENCE (PAGE) 1 3	(SERIAL) 4 6	CONT 7	A 8	B 12 16 20 24 28 32 36 40 44 48 52 56 60 64 68 72
00	001			IDENTIFICATION DIVISION.
	002			PROGRAM-ID. 'PAYROLL'.
	005			DATA DIVISION.
	008			77 'SALARYX PICTURE IS 9(5)V99 VALUE IS 00000000.
	012			LINKAGE SECTION.
	015			01 PAYOFF.
	016			02 PAY PICTURE IS 9(5)V99.
	017			02 RATEX PICTURE IS 9V99.
				02 HOURS PICTURE IS 99V9.
	025			PROCEDURE DIVISION.
	040			ENTER LINKAGE.
	041			ENTRY 'PAYMSTER' USING PAYOFF.
00	042			ENTER COBOL.

* A standard card form, IBM electro C61897, is available for punching source statements from this form.

Figure 14. Example of a Calling Program (Part 2 of 3).



IBM

COBOL PROGRAM SHEET

Form No. X28-1464
Printed in U.S.A.

System IBM SYSTEM/360 COBOL | Punching Instructions | Sheet of

Program DATA PASSING SUBROUTINE | Graphic | Card Form# * | Identification 73 80

Programmer J. DOE | Date | Punch

SEQUENCE (PAGE) 1 3	(SERIAL) 4 6	CONT 7	A 8	B 12 16 20 24 28 32 36 40 44 48 52 56 60 64 68 72
00	044			COMP. COMPUTE SALARYX = HOURS * RATEX.
	047			MOVE SALARYX TO PAY.
	050			ENTER LINKAGE.
	051			RETURN.
00	052			ENTER COBOL.

Figure 14. Example of a Calling Program (Part 3 of 3).

LINKAGE EDITING WITHOUT THE OVERLAY FEATURE

Assume a COBOL main program exists, called COBMAIN, that contains calls at one or more points in its logic to COBOL programs: SUBPRGA, SUBPRGB, SUBPRGC and SUBPRGD. Also assume that the module sizes for the main program and the subprograms given are:

PROGRAM	MODULE SIZE (in bytes)
COBMAIN	20,000
SUBPRGA	4,000
SUBPRGB	5,000
SUBPRGC	6,000
SUBPRGD	3,000

Through the linkage mechanism (ENTER LINKAGE, CALL SUBPRGA...), all called programs plus COBMAIN must be linkage edited together to form one module 38,000 bytes in size. Therefore, COBMAIN would require 38,000 bytes of storage in order to be executed. No overlay structure need be specified at linkage edit time if 38,000 bytes of core storage are available.

Following is an example of the job control statements needed to linkage edit these calling and called programs without specifying an overlay structure. The object decks for COBMAIN and SUBPRGA are included in the job; whereas SUBPRGB, SUBPRGC, and SUBPRGD are included from the relocatable library.

```
// JOB NOVERLAY
// OPTION LINK,LIST,DUMP
   ACTION MAP
   PHASE EXAMP1,*
   INCLUDE


   {Object Module COBMAIN}


/*
   INCLUDE SUBPRGB
   INCLUDE SUBPRGC
   INCLUDE SUBPRGD
   INCLUDE


   {Object Module SUBPRGA}

/*
   ENTRY
// EXEC LNKEDT
// EXEC

   {Data for program}

/*
/&
```

Figure 15 is an example of the data flow logic of this call structure where all the programs fit into main storage.

Note: For the example given, it is assumed that SYSLNK is a standard assignment. The flow diagram illustrates how the various program segments are linkage edited into storage in a sequential arrangement.

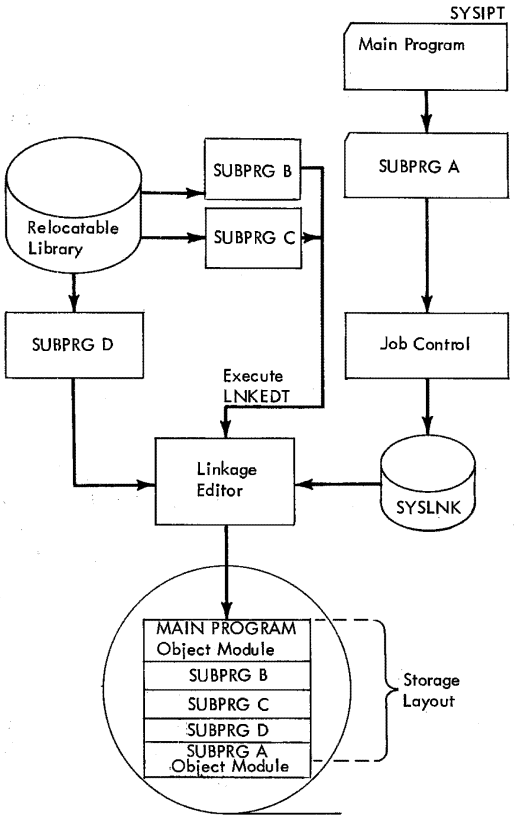


Figure 15. Example of Data Flow Logic in a Call Structure.

ASSEMBLER LANGUAGE SUBROGRAMS

A main program written in COBOL can call programs written in other languages. Whenever a COBOL program calls an assembler language program, certain conventions and techniques must be used.

There are three basic ways to use assembler-written called programs with a main program written in COBOL:

1. A COBOL main program or called program calling an assembler-written program.
2. An assembler-written program calling a COBOL program.
3. An assembler-written program calling another assembler-written program.

From these combinations, more complicated structures can be formed.

In a COBOL program the expansions of the ENTER LINKAGE statement provide the save and return coding that is necessary to establish linkage between the calling and called programs. Assembler language programs must be prepared in accordance with the basic linkage conventions of the operating system. These conventions include:

1. Using the proper registers to establish linkage.

2. Reserving, in the calling program, an area that is used by the called program to refer to the argument list.

3. Reserving, in the calling program, a save area in which the contents of the registers may be saved.

REGISTER USE

The disk and tape operating systems have assigned functions to certain registers used in linkages. Figure 16 shows the conventions for use of general registers as linkage registers. The calling program must load the address of the return point into register 14, and it must load the address of the entry point of the called program into register 15.

Register Number	Register Name	Function
1	Argument List Register	Address of the argument list passed to the called program.
13	Save Area Register	Address of the area reserved by the calling program in which the contents of certain registers are stored by the called program.
14	Return Register	Address of the location in the calling program to which control is returned after execution of the called program.
15	Entry Point Register	Address of the entry point in the called program.

Figure 16. Linkage Registers

SAVE AREA

A calling assembler language program must reserve a save area of 18 words, beginning on a fullword boundary, to be used by the called program for saving registers, and it must load the address of this area into register 13. Figure 17 shows the layout of the save area and the contents of each word.

A called COBOL program does not save floating-point registers. The programmer is responsible for saving and restoring the contents of these registers in the calling program.

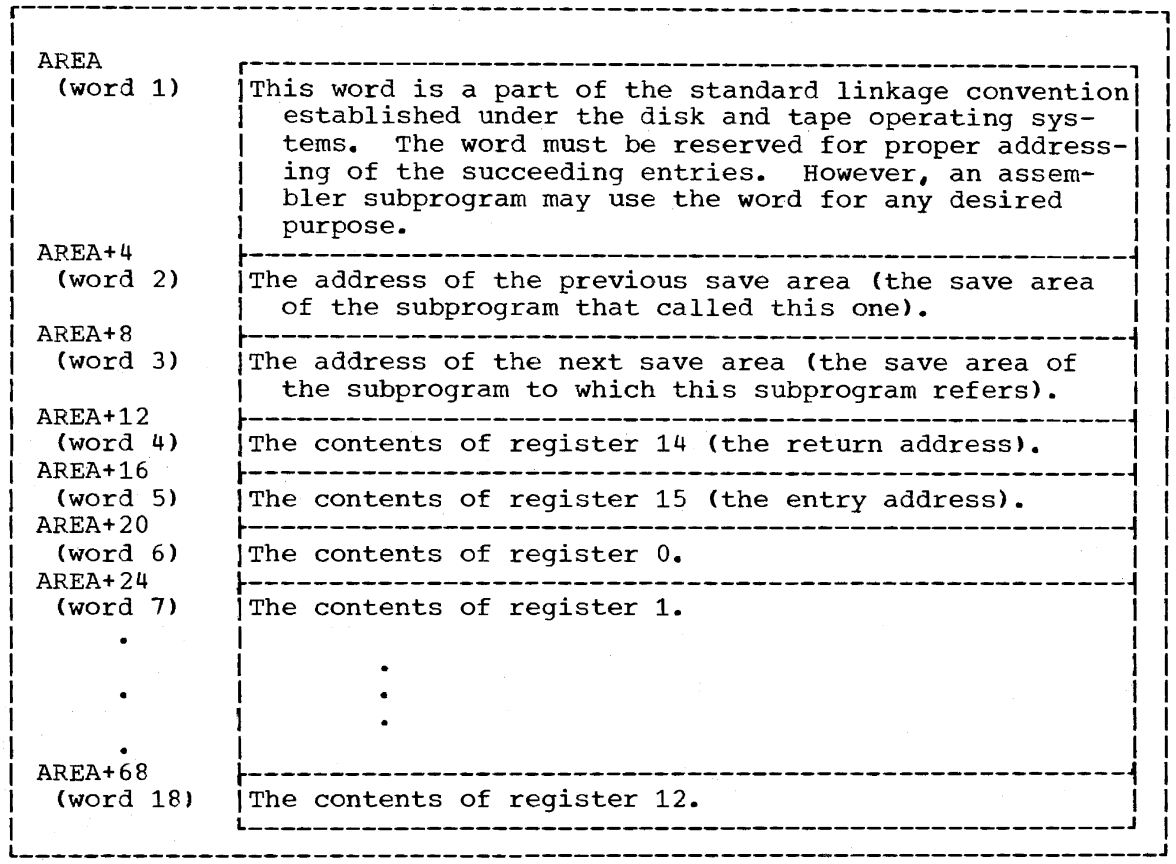


Figure 17. Save Area Layout and Word Contents

ARGUMENT LIST

The argument list is a group of contiguous fullwords, beginning on a fullword boundary, each of which is an address of a data item to be passed to the called program. If the program is to pass arguments, an argument list must be prepared and its address loaded into register 1. The high order bit of the last argument, by convention, is set as a flag of one to indicate the end of the list.

Any assembler-written program must be coded with a detailed knowledge of the data formats of the arguments being passed. Most coding errors probably occur because of the data format discrepancies of the arguments.

If one programmer writes both the calling program and the called program, the data formats of the arguments should not present a problem when passed as parameters. However, when the programs are written by different programmers, the data format specifications for the arguments must be clearly defined for the user.

The linkage conventions used by an assembler program that calls another program are shown in Figure 18. The linkage should include:

1. The calling sequence.
2. The save and return routines.
3. The out-of-line parameter list. (An in-line parameter list may be used).
4. A save area on a fullword boundary.

```
deckname    START    0                initiates program assemblage
                                        at first available loca-
                                        tion.  Entry point to the
                                        program.
            ENTRY    name1
            EXTRN    name2
            USING    name1,15
*  Save Routine
name        STM      14,r1,12(13)     The contents of registers 14,
*                                       15, and 0 through r1 are
*                                       stored in the save area of
*                                       the calling program (pre-
                                        vious save area).  r1 is
                                        any number from 0 through
                                        12.
            LR       r3,15
            DROP     15
            USING    name1,r3         where r3 and r2 have been
                                        saved
            LR       r2,13            Loads register 13, which
*                                       points to the save area of
*                                       the calling program, into
                                        any general register, r2,
                                        except 0 and 13.
            LA       13,AREA          Loads the address of this
*                                       program's save area into
                                        register 13.
            ST       13,8(0,r2)       Stores the address of this
*                                       program's save area into
*                                       word 3 of the save area of
                                        the calling program.
            ST       r2,4(0,13)       Stores the address of the
*                                       previous save area (i.e.,
*                                       the same area of the call-
*                                       ing program) into word 2 of
                                        this program's save area.
            BC       15,prob1
AREA        DS       18F              Reserves 18 words for the
*                                       save area.  This is last
                                        statement of save routine.
prob1       User-written program statements
*  Calling Sequence
            LR       1,ARGLST         First statement in calling
                                        sequence.
            L        15,ADCON
            BALR     14,15
*           Remainder of user-written program statements
```

Figure 18. Sample Linkage Routines Used with a Calling Subprogram (Part 1 of 2)

```
*  Return Routine
               L         13,4(0,13)       First statement in return
*                                           routine.  Loads the address
*                                           of the previous save area
*                                           back into register 13.
               LM        2,r1,28(13)      The contents of registers 2
*                                           through r1, are restored
*                                           from the previous save area
               L         14,12(13)        Loads the return address,
*                                           which is in word 4 of the
*                                           calling program's save
*                                           area, into register 14.
               MVI       12(13),X'FF'     Sets flag FF in the save area
*                                           of the calling program to
*                                           indicate that control has
*                                           returned to the calling
*                                           program.
               BCR       15,14            Last statement in return
                                           routine.
ADCON          DC        A(name2)         Contains the address of sub-
                                           program name2.
*  Parameter List
ARGLST         DC        AL4(arg1)        First statement in parameter
                                           area setup.
               DC        AL(arg2)
               DC        X'80'            First byte of last argument
                                           sets bit 0 to 1.
               DC        AL3(argn)        Last statement in parameter
                                           area setup.
```

Figure 18. Sample Linkage Routines Used with a Calling Subprogram (Part 2 of 2)

In-Line Parameter List

The assembler programmer may establish an in-line parameter list instead of an out-of-line list. In this case, he may substitute the calling sequence and parameter list shown in Figure 19 for that shown in Figure 18.

```
ADCON          DC        A(prob1)
                 .
                 .
                 .
               LA        14,RETURN
               L         15,ADCON
               CNOP      2,4
               BALR      1,15
               DC        AL4(arg1)
               DC        AL4(arg2)
                 .
                 .
                 .
               DC        X'80'
               DC        AL3(argn)

RETURN         BC        0,X'isn'
```

Figure 19. Sample In-line Parameter List

If an assembler-called program does not call any other program (i.e.,if it is at the lowest level), the programmer should omit the save routine, calling sequence, and parameter list shown in Figure 18. If the assembler called program uses any registers, it must save them. Figure 20 shows the appropriate linkage conventions used by an assembler program at the lowest level.

```
deckname        START           0
                ENTRY           name

                USING           *,15
name            STM             14,r1,12(13)
                  .
                  .
                  .
User-written program statements
                  .
                  .
                  .
                LM              2,r1,28(13)
                MVI             12(13),X'FF'
                BCR             15,14
```

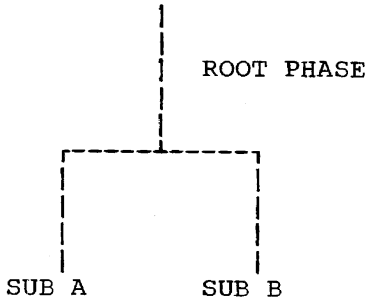
Note: If registers 13 and/or 14 are used in the called subprogram, their contents should be saved and restored by the called subprogram.

Figure 20. Sample Linkage Routines Used with a Lowest Level Subprogram.

OVERLAYS

If a program is too large to fit into the number of bytes available in main storage, it can still be executed by means of an overlay structure. An overlay structure permits the reuse of storage locations previously occupied by another program. In order to use an overlay structure, the programmer must plan his program so that one or more called programs need not be in main storage at the same time as the rest of the program phase.

Following is a diagram of the basic form of a program to be overlaid:



The root phase consists of the COBOL main program and an assembler language subroutine which handles the overlays. SUB A and SUB B are the called programs which overlay each other in core.

In using the overlay technique the programmer specifies to the linkage editor which programs are to overlay each other. These programs are processed by the linkage editor so they can be placed automatically in main storage for execution when called by the main program. The resulting output by the linkage editor is called an overlay structure.

SPECIAL CONSIDERATIONS WHEN USING OVERLAY STRUCTURES

There are three areas of special concern to the programmer who wishs to use the overlay feature. These problems concern the use of the assembler language subroutine, proper linkage editing and job control statements.

ASSEMBLER LANGUAGE SUBROUTINE FOR EFFECTING OVERLAYS

The CALL in IBM System/360 COBOL is used for "direct" linkage; that is, the assistance of the supervisor is not required (as it is when loading or fetching a phase). There are no COBOL statements that will generate the equivalent of the LOAD or FETCH assembler macros. For this reason, one must call an assembler program to effect an overlay of a COBOL program. This routine must be linkage edited as part of either a ROOT or permanently resident phase.

The following overlay subroutine is an example and is governed by the following restrictions:

1. The example is a suggested technique, and not the only technique.

2. It can be used for assembler overlays if the user has a desired entry point in his end card, and the first statement at that entry point is 'STM 14,12,12(13)'(90ECDOOC).

3. The subroutine cannot be used for entry points other than at the first instruction of the Procedure Division. A suggested technique for diverse entry points is a table lookup employing V-type constants.

```
STMNT           SOURCE STATEMENT

0001            OVRLAY START 0
0002                  ENTRY OVRLAY
0003            * AT ENTRY TIME
0004            *     R1= POINTER TO ADCON LIST OF USING ARGUMENTS
0005            *         FIRST ARGUMENT
0006            *         IS PHASE OR SUBROUTINE NAME, MUST BE 8 BYTES
0007            *     R13=ADDRESS OF SAVE AREA
0008            *     R14=RETURN POINT OF CALLING PROGRAM
0009            *     R15=ENTRY POINT OF OVERLAY PROGRAM
0010            * AT EXIT
0011            *     R1= POINTER TO SECOND ARGUMENT OF ADCON LIST
0012            *         OF USING ARGUMENTS
0013            *     R14=RETURN POINT OF CALLING PROGRAM--NOT THIS PROG
0014            *     R15=ENTRY POINT OF PHASE OR SUBPROGRAM
0015            *
0016                  USING *,15
0017            STM   0,1,20(13)        SAVE REG 0 AND 1
0018            L     1,0(1)            R1=ADDRESS OF PHASE NAME
0019            CLC   0(8,1),CORSUB     IS IT IN CORE
0020            BE    SUBIN             YES
0021            MVC   CORSUB(8),0(1)    NO,CORSUB = PHASE NAME
0022            SR    0,0               R0 = 0
0023 *                                  LOAD REQUIRES R0 = 0 IF LOAD
0024 *                                  ADDRESS
0025 *                                  ISN'T SPECIFIED, R1=ADDRESS OF
0026 *                                  PHASE NAME.  R1=PHASE ENTRY
0027 *                                  UPON RETURN.
0028            SVC   4                 LOAD PHASE
0029            SH    1,=H'2'
0030 ENTRY     LA    1,2(1)            STEP SEARCH POINTER
0031            CLC   0(4,1),STMINS     IS THIS THE ENTRY POINT
0032            BNE   ENTRY             NO, LOOP BACK
0033            ST    1,ASUB            YES, SAVE IT
0034 SUBIN      LM    0,1,20(13)        RESTORE REG 0 AND 1
0035            LA    1,4(1)            STEP PAST PHASE NAME ADCON
0036            L     15,ASUB           LOAD ENTRY POINT ADDRESS
0037            BR    15
0038 ASUB       DS    IF
0039 CORSUB     DC    8X'FF'
0040 STMINS     DC    X'90ECD00C'
0041            END
```

LINKAGE EDITING WITH OVERLAY

In a linkage editor job step, the programmer specifies the overlay points in a program by using PHASE statements. In the Working-Storage Section a 77-level constant must be set up for each phase to be called at execution time. These constants have a picture of X(8) and a value clause containing the same name as will be on the PHASE card for that segment in the linkage edit run.

In addition, each argument to be passed to the called program must have an entry in the linkage section. Remember, also, the ENTRY statement should not refer to the Program-ID but to the paragraph-name in the Procedure Division where control is to be passed on entering the called program. (Use of the Program-ID will result in incorrect execution).

When setting up the control cards for the linkage editor, be certain to include the assembler language subroutine with the main (root) phase. Also, to achieve maximum overlay, the phase names for the called programs should be different from the Program-ID names of the called programs.

Figure 21 is a flow diagram of the overlay logic. PHASE cards reorigin C and D overlays at the same origin as OVERLAYB. The sequence of events is:

1. The main program calls the overlay routine.

2. The overlay routine fetches the particular COBOL subprogram and places it in the overlay area.

3. Control is then transferred to the first instruction of the called program.

4. The called program returns to the COBOL calling program (not to the assembler language overlay routine).

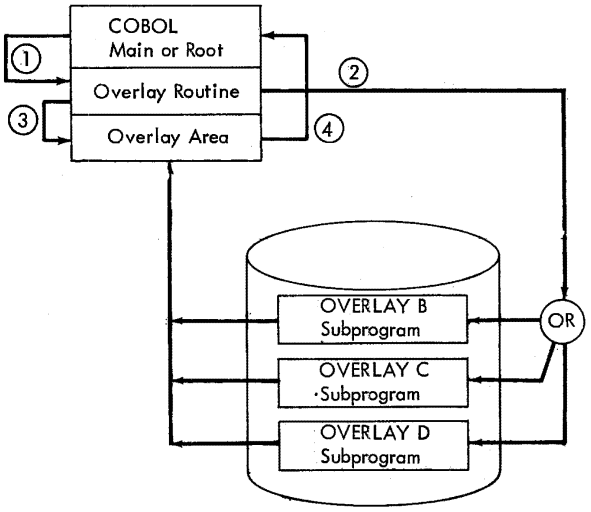


Figure 21. Flow Diagram of Overlay Logic.

If OVERLAYB were known to be in storage, the CALL would be:

```
CALL 'OVERLAYX' USING PARAM-1  PARAM-2.
```

But when using the assembler language overlay routine, it becomes:

```
CALL 'OVRLAY' USING PROCESS-LABEL, PARAM-1, PARAM-2.
```

where PROCESS-LABEL contains the external name 'OVERLAYB' of the called program.

However, the ENTRY statement of the called program is the same for both cases, i.e. ENTRY 'OVERLAYX' USING PARAM-10, PARAM-20, whether it is called indirectly by the main program through the overlay program or called directly by the main program.

Note: An ENTRY which is to be called by OVRLAY must precede the first executable statement in the called program.

The job control statements required to accomplish overlay follow. The PHASE statements specify to the linkage editor that the overlay structure to be established is one in which called programs OVERLAYB, OVERLAYC and OVERLAYD overlay each other when called during execution.

```
// JOB OVERLAYS
// OPTION LINK
   PHASE OVERLAY,ROOT
// EXEC COBOL

   {COBOL Source for Main Program 'OVERLAY'}

/*
// EXEC ASSEMBLY

   {Source deck for Assembler Language Routine OVRLAY}

/*
   PHASE OVERLAYB,*
// EXEC COBOL

   {COBOL Source for Called Program 'OVERLAYB'}

/*
   PHASE OVERLAYC,OVERLAYB
// EXEC COBOL

   {COBOL Source for Called Program 'OVERLAYC'}

/*
   PHASE OVERLAYD,OVERLAYC

   {COBOL Source for Called Program 'OVERLAYD'}

/*
// EXEC LNKEDT
// EXEC
/*
/&
```

Note: The phase name specified in the PHASE card must be the same as the value contained in the first argument for CALL 'OVRLAY', i.e. PROCESS-LABEL, COMPUTE-TAX etc. contain OVERLAYB, OVERLAYC respectively, which are the names given in the PHASE card.

It is the programmer's responsibility to write the entire overlay procedure i.e., the COBOL main (or calling) program and an assembler language subroutine (although a sample program is given in this chapter) that fetches and overlays the called programs. A calling sequence to obtain an overlay structure between two COBOL programs follows.

COBOL Program Main (Root or Main Program):

```
IDENTIFICATION DIVISION.
PROGRAM-ID.  'OVERLAY'.
        .
        .
        .
ENVIRONMENT DIVISION.
        .
        .
        .
DATA DIVISION.
WORKING-STORAGE SECTION.
     77 PROCESS-LABEL PICTURE IS X(8) VALUE IS 'OVERLAYB'.
     77 PARAM-1 PICTURE IS X.
     77 PARAM-2 PICTURE IS XX.
     77 COMPUTE-TAX PICTURE IS X(8) VALUE IS 'OVERLAYC'.
     01 NAMET.
        02 EMPLY-NUMB PICTURE IS 9(5).
        02 SALARY PICTURE IS 9(4)V99.
        02 RATE PICTURE IS 9(3)V99.
        02 HOURS-REG PICTURE IS 9(3)V99.
        02 HOURS-OT PICTURE IS 9(2)V99.
     01 COMPUTE-SALARY PICTURE IS X(8) VALUE IS 'OVERLAYD'.
     01 NAMES.
        02 RATES PICTURE IS 9(6).
        02 HOURS PICTURE IS 9(3)V99.
        02 SALARYX PICTURE IS 9(2)V99.
        .
        .
        .
PROCEDURE DIVISION.
        .
        .
        .
     ENTER LINKAGE.
     CALL 'OVRLAY' USING PROCESS-LABEL, PARAM-1, PARAM-2.
     ENTER COBOL.
        .
        .
        .
     ENTER LINKAGE.
     CALL 'OVRLAY' USING COMPUTE-TAX, NAMET.
     ENTER COBOL.
        .
        .
        .
     ENTER LINKAGE.
     CALL 'OVRLAY' USING COMPUTE-SALARY, NAMES.
     ENTER COBOL.
        .
        .
        .
     ENTER LINKAGE.
     CALL 'OVRLAY' USING COMPUTE-TAX, NAMET.
     ENTER COBOL.
        .
        .
        .
```

COBOL Subprogram B:

```
IDENTIFICATION DIVISION.
PROGRAM-ID.  'OVERLAY1'.
        .
        .
        .
ENVIRONMENT DIVISION.
        .
        .
        .
DATA DIVISION.
        .
        .
        .
LINKAGE SECTION.
01 PARAM-10  PICTURE IS X.
01 PARAM-20  PICTURE IS XX.
PROCEDURE DIVISION.
     ENTER LINKAGE.
     ENTRY 'OVERLAYX' USING PARAM-10, PARAM-20.
     ENTER COBOL.
        .
        .
        .
     ENTER LINKAGE.
     RETURN.
     ENTER COBOL.
```

COBOL Subprogram C:

```
IDENTIFICATION DIVISION.
PROGRAM-ID  'OVERLAY2'.
        .
        .
        .
ENVIRONMENT DIVISION.
        .
        .
        .
DATA DIVISION.
LINKAGE SECTION.
01 NAMEX.
     02 EMPLY-NUMBX PICTURE IS 9(5).
     02 SALARYX PICTURE IS 9(4)V99.
     02 RATEX PICTURE IS 9(3)V99.
     02 HOURS-REGX PICTURE IS 9(3)V99.
     02 HOURS-OTX PICTURE IS 9(2)V99.
PROCEDURE DIVISION.
        .
        .
        .
     ENTER LINKAGE.
     ENTRY 'OVERLAYY' USING NAMEX.
     ENTER COBOL.
        .
        .
        .
     ENTER LINKAGE.
     RETURN.
     ENTER COBOL.
```

COBOL Subprogram D:

```
IDENTIFICATION DIVISION.
PROGRAM-ID.  'OVERLAY3'.
        .
        .
        .
ENVIRONMENT DIVISION.
        .
        .
        .
DATA DIVISION.
LINKAGE SECTION.
01 NAMES.
     02 RATES PICTURE IS 9(6).
     02 HOURS PICTURE IS 9(3)V99.
     02 SALARYX PICTURE IS 9(2)V99.
PROCEDURE DIVISION.
     ENTER LINKAGE.
     ENTRY 'OVERLAYZ' USING NAMES.
     ENTER COBOL.
        .
        .
        .
     ENTER LINKAGE.
     RETURN.
     ENTER COBOL.
```

PROGRAMMING CONSIDERATIONS WHEN USING OVERLAY STRUCTURES

When SYSLST is assigned to disk, and either EXHIBIT or DISPLAY (to SYSLST) is used in any segment other than the root phase, at least one DISPLAY must be included in the root phase (or subroutine IHD2800 must be included in the root phase).

SECTION VIII: PROCESSING COBOL FILES ON DIRECT-ACCESS DEVICES

The data management facilities of the Disk Operating System are provided by routines that are referred to as the input/output control system (IOCS). A distinction is made between two types of routines:

1. Physical IOCS (PIOCS) -- Input/output routines that are included in the supervisor.

   Physical IOCS controls the actual transfer between the external medium and main storage. It performs the functions of initiating the execution of channel commands and handling associated input/output interrupts.

2. Logical (LIOCS) -- Input/output routines that are linked with a COBOL program.

   LIOCS performs those functions that a programmer needs to locate and access a logical record for processing. A logical record is one unit of information in a file of similar units -- for example, one employee's record in a master payroll file, one part-number record in an inventory file, or one customer account record in an account file. One or more logical records may be included in one physical record. LIOCS refers to the routines that perform the following functions:

   a. Blocking and deblocking records.

   b. Switching between input/output areas when two areas are specified for a file.

   c. Handling end-of-file and end-of-volume conditions.

   d. Checking and writing labels.

An understanding of how LIOCS functions may be of help to a COBOL programmer preparing files. Briefly, certain input/output statements and file description entries in the Data Division of the COBOL program such as ACCESS IS, RECORD KEY IS, etc., are used to build a unique DTF (Define the File) table for each file. The information in this table will be different based on what is stated in the COBOL program; or basically, it will contain the information particular to the file for processing input/output and a series of constants that describe the characteristics of a particular file, such as record size, block size, record format, etc.

One of the constants in the DTF table names a logic module that is to be used at execution time to process that file. A logic module is a generalized routine that modifies itself based on the constants stored in the DTF tables. It contains the coding necessary to perform data management functions required by the file such as blocking and deblocking, initiating label checking, etc.

Generally, these logic modules are separately assembled and cataloged in the relocatable library under a standard name. Then, at linkage editing time, the linkage editor searches the relocatable library using the name in the DTF table to find the logic module. The logic module is then included as part of the program phase. Note that the autolink feature of the linkage editor takes care of including the logic modules. The COBOL programmer does not specify any INCLUDE statements.

The type of DTF table prepared by the compiler depends on the data organization of the file. COBOL provides two types of data organization that are used for direct-access files only.

- Indexed sequential
- Direct

The rest of this section provides information on preparing files with indexed sequential and direct data organizations. Included for both are general descriptions of the organization, the COBOL statements that must be specified in order to build the correct DTF tables, error recovery techniques, how to modify the DTF tables, and coding examples.

INDEXED SEQUENTIAL

Files having indexed sequential organization may be processed randomly or sequentially. Indexed sequential files may be created, added to, read from, or updated.

The records of an indexed sequential file are organized on the basis of a collating sequence determined by control fields called keys. A key precedes the data portion of a record and is from 1 to 255 bytes in length.

An indexed sequential file exists in space allocated on direct-access volumes as prime areas, overflow areas, and index areas.

Prime Areas and Overflow Areas

Prime areas are areas on a cylinder allotted for data records which consist of a key and the actual data. The track format for the 2311 or 2314 Disk Storage Drive and the 2321 Data Cell Drive shown in Appendix D may be helpful in visualizing the formats of the records for an indexed sequential file. (PAGE 169)

A new record added to an indexed sequential file is placed into a location on a track determined by the value of its key field. If records were inserted in precise physical sequence, insertion would require shifting all records of the file with keys higher than that of the one inserted. However, because an overflow area exists, indexed sequential file organization allows a record to be inserted into its proper position with only the records on the track in which the insertion is made being shifted.

Overflow areas are areas on the disk reserved to accommodate additions to the file. When a record is to be inserted, the records already on the track that are to follow the new record are written back on the track after the new record. The last record on the track is written onto an overflow track. Track index entries (see the next discussion) are adjusted to indicate records in an overflow area. The COBOL programmer may choose among three options in determining where records will be placed. They are:

1. Cylinder Overflow Area Only -- When creating an indexed sequential file, two 2311 tracks or four 2314 or 2321 tracks will automatically be reserved by the COBOL compiler for cylinder overflow. These tracks will accommodate overflow records that occur within the specified cylinder. To decrease or increase the number of tracks reserved for overflow, the user must modify a DTF table entry (see

"Modifying the DTF Table" and the coding examples at the end of this section).

2. Independent Overflow Area -- An additional extent for the exclusive purpose of storing overflow records can be implemented by submitting the proper job control EXTENT cards. IOCS will then create this independent overflow area. No COBOL entry is needed to implement it. If, however, the programmer wishes an independent overflow area only (that is, no cylinder overflow area), the DTF table must be modified to specify no cylinder overflow (see "Modifying the DTF Table" and the coding examples at the end of this section).

3. Both Cylinder and Independent Overflow Areas -- In this case, the cylinder overflow will be used until it becomes full. At that time, further additions to the file will result in overflow records being placed in the independent overflow area. This option again can be implemented by specifying job control EXTENT cards.

The advantage of the cylinder overflow area is that of time. Arm motion is minimized during sequential or random retrieval and when making additions to the file.

The advantage of the independent overflow area is that of space. The number of tracks allocated to an independent overflow area may justifiably be less than the total number of tracks allocated by the cylinder overflow option. This alternative would then minimize the total disk pack area obligated for overflow records.

Index Areas

The ability to read and write records from anywhere in a file with indexed-sequential organization is provided by indexes that are part of the file itself. There are always two types of indexes: a cylinder index for the whole file, and a track index for each cylinder. A third type of index, the master index, can be created and used if desired.

Cylinder Index: For each cylinder of data, an entry is made to the cylinder index. This entry consists of the address of the track index for that cylinder and the highest key of a record on the entire cylinder.

The cylinder index will have its own extents that must be defined by job control EXTENT cards. These extents must be outside the limits of any data extents. (Note that at least two sets of extent information must be defined. They are a data extent and a cylinder index extent. If the file exceeds one disk pack, additional data extents will be provided and, at the user's option, an independent overflow area extent may be defined.) The cylinder extent must be on-line when the file is processed. It may be on the same pack as the data file, or it may be on a separate pack.

Track Index: A track index exists for each cylinder of the file. The track index always begins on track 0. For each track of data, an entry is made to the track index. The entry consists of two parts: (1) for the prime area, the entry is the address of the lowest record on that track and the highest key of a record on that track; (2) for the overflow area, the entry consists of the highest key associated with that track and the address of the lowest record in the overflow area. If no overflow entry has been made, the address is X'FF'.

Master Index: If a file occupies many cylinders, a search of the cylinder index for a key is inefficient. Thus, the user can create a master index (by specification on the EXTENT card) that indexes the cylinder index. An entry for the master index consists of the address

of the cylinder index track and the highest key of a data record on that cylinder index track. One entry is made to the master index for each track of data on the cylinder index. It is advantageous to construct a master index if the cylinder index occupies four or more tracks. Refer to Table 3 for modifying the DTF table for indexed sequential files containing a master index.

Figure 22 shows an indexed sequential file with two levels of indexing and no overflow records. The entries for track 1 of the cylinder are shown. The address of the first record on the track is track 1, record-0 at the beginning of track 1. The highest key on track 1 is 8. The address of the lowest record in the overflow area is FF because there are no overflow records. The entry to the cylinder index for track 1 shows the address of the track index and the highest key on the cylinder which is 32. The COCR (cylinder overflow control record), which is maintained in the data portion of record zero, indicates that no records are in the cylinder overflow area after loading. (Note that if the track index does not occupy all of track 0, track 0 will also contain data records).

Figure 23 shows what happens when another record, record 7, is added, and forces record 8 into an overflow area. In this case, the key of the normal entry is changed to 7 and the address of the overflow entry indicates the location of record 8, which is on track 8, record 1. No other changes to the indexes are required. The COCR will be updated to indicate that the last record in the cylinder overflow area is on track 8, record 1.

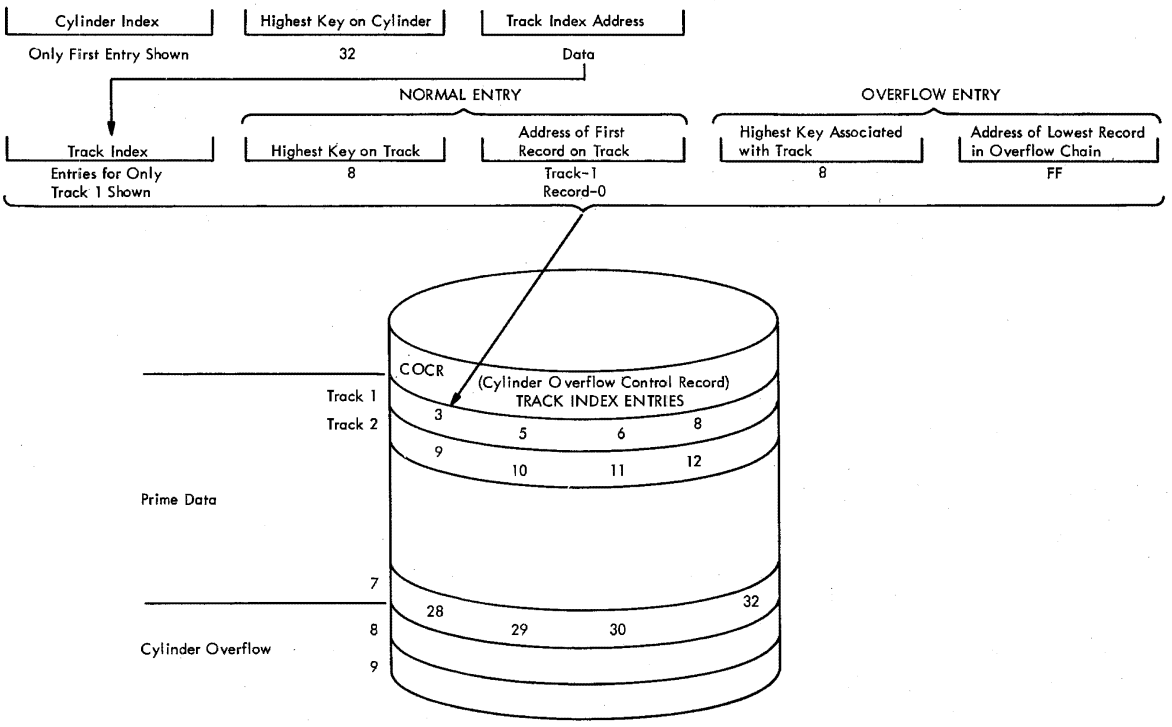


Figure 22. Indexed Sequential File Without Overflow

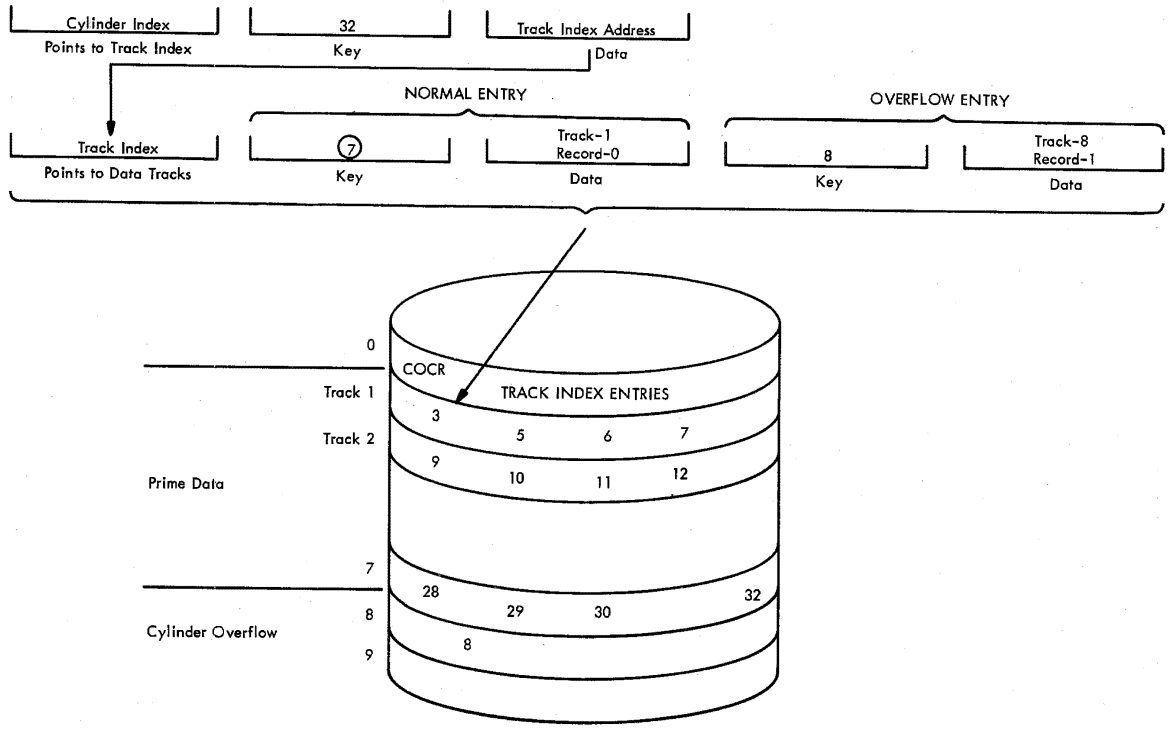


Figure 23. Indexed Sequential File With Overflow

The indexed sequential organization enables the programmer to:

1. Read or write (in a manner similar to that for sequential organization) logical records whose keys are in ascending collating sequence.

2. Read or write individual logical records randomly.

3. Add logical records with new keys. The system locates the proper position in the file for the new record and makes all necessary adjustments to the indexes.

The important advantages are the ability to retrieve records randomly as well as sequentially, and to make additions to the file without having to sort and merge the additions while copying the entire file.

These advantages are possible because overflow areas are available to provide the additional space required when additions are made to the file and to the indexes, which are built and maintained by LIOCS.

COBOL STATEMENTS USED TO SPECIFY AN INDEXED SEQUENTIAL FILE

The following is a list of the COBOL statements required for creating, adding to, or updating an indexed sequential file. In addition, the list is followed by a brief explanation of the functions IOCS performs as a result of executing these statements.

Creating an Indexed Sequential File

To create a sequential, indexed sequential file, the following clauses are required:

- ORGANIZATION IS INDEXED
- ACCESS IS SEQUENTIAL
- ASSIGN TO DIRECT-ACCESS
- RECORD KEY IS data-name

  (The SYMBOLIC KEY may be specified.)

The programmer must then specify:

- OPEN OUTPUT file-name
- WRITE record-name [INVALID KEY]
- CLOSE file-name

OPEN Statement

The OPEN statement causes the label information for the file to be recorded in a Volume Table of Contents (VTOC). It then initiates a checking procedure that prevents writing on an existing file that might still be active. In addition, the OPEN statement establishes the area that is to be written on the disk as specified in the EXTENT statement by the LOWER and UPPER parameters. Finally, the OPEN statement initializes the cylinder and track index tables, which are eventually filled with the record keys provided by the programmer when the file is being created.

WRITE Statement

The WRITE statement enters the record keys specified by the programmer into the track and cylinder index tables and writes the actual data on the portion of the track defined by the EXTENT parameters. The records are placed on the track sequentially in the prime data area.

If the programmer specifies INVALID KEY, control is given to the invalid key routine whenever a duplicate record or a record out of sequence is detected. The programmer is responsible for writing the invalid key routine (see the coding examples).

The CLOSE statement removes the reference to the labels in the VTOC, updates indexes (track and cylinder), and writes the end-of-file record. Once the reference to the labels is removed from the VTOC, the file must be opened again to be accessed. The index tables are updated each time a block is written out (in the case of blocked records) or each time a record is written (in the case of unblocked records). For a short block, the CLOSE statement results in truncation of the area not used in the block and in updating of the indexes with the record keys of those records in the block.

Key Handling: During the creation of an indexed sequential file, the programmer can control the RECORD KEY with certain restrictions:

- The RECORD KEY must be provided before execution of the WRITE statement. It is part of the record and identifies the particular record in the file.
- The RECORD KEY values must be given in ascending collating sequence.
- No two keys can be the same.

To extend a file previously created, the same clauses and control statements (DLBL, EXTENT) used to create the file are required, with the following exception: the parameter ISE should be used for the 'type' code in the DLBL statement instead of ISC used for creating the file.

Note that the record to be added must fit within the limits originally specified for the file by the EXTENT statement. If it does not fit, the file must be recreated.

The SYMBOLIC KEY is not required when creating an indexed sequential file.

Sequential Retrieval of an Indexed Sequential File

To retrieve an indexed sequential file sequentially, the following clauses are required:

- ORGANIZATION IS INDEXED
- ACCESS IS SEQUENTIAL
- RECORD KEY IS data-name

  (The SYMBOLIC KEY may be specified.)

To simply read the file, the programmer must specify:

- OPEN INPUT file-name
- READ file-name AT END
- CLOSE file-name

OPEN Statement: The OPEN statement checks the labels of the files to be opened and initializes the VTOC to indicate an active file. It also establishes the area to be read as specified by the LOWER and UPPER limit parameters of the EXTENT statement. This initializes processing of the file, as follows:

- If the SYMBOLIC KEY is omitted, processing begins with the first record of the file, and progresses sequentially.
- If the SYMBOLIC KEY is used and binary zeros are specified therein, processing begins with the first record of the file, and progresses sequentially.
- If the SYMBOLIC KEY is used and other than binary zeros are specified, processing begins with the specified key and progresses sequentially.

READ Statement: The READ causes sequential retrieval of logical records from the file until the end-of-file record is detected. At this time, control is given to the user routine specified by the AT END statement.

CLOSE Statement: The file is reset for future use.

Updating Sequentially

The same clauses used to create and retrieve a file (ORGANIZATION IS INDEXED, ACCESS IS SEQUENTIAL, RECORD KEY IS) are required to update an existing indexed sequential file.

The programmer must then specify:

- OPEN I-O file-name
- READ file-name AT END
- REWRITE record-name [INVALID KEY]
- CLOSE file-name

The OPEN and CLOSE statements function in the same manner for updating as they do for retrieving an indexed sequential file. The READ statement also functions in the same manner (as for sequential retrieval) but must be used in conjunction with the REWRITE statement, as follows.

REWRITE Statement: The REWRITE statement writes the logical record read by a preceding READ statement back into the same physical location from which it was originally retrieved. Thus, the REWRITE statement provides the facility to update records in a file. Under no circumstances should the user modify the RECORD KEY of the record being updated. Because the INVALID KEY check is not exercised for sequential retrieval of an indexed sequential file, results caused by modification of the RECORD KEY prior to return of the record to the file are unpredictable.

Key Handling: During sequential retrieval of a file, limited control of the SYMBOLIC KEY and RECORD KEY is permitted. Thus, the SYMBOLIC KEY can be set before the OPEN statement is executed, allowing processing to begin with any record within the file. Once the OPEN statement is completed, the SYMBOLIC KEY is not needed. The RECORD KEY, which must not be modified when updating a file, can be referred to when retrieving a record for the purpose of recognizing a particular record in the file.

Random Retrieval of an Indexed Sequential File

To retrieve, update, or add to an indexed sequential file randomly, the following clauses are required.

- ORGANIZATION IS INDEXED
- ACCESS IS RANDOM
- SYMBOLIC KEY IS data-name
- RECORD KEY IS data-name

To retrieve an indexed sequential file randomly, the following clauses must be specified:

- OPEN INPUT file-name
- READ file-name INVALID KEY
- CLOSE file-name

The OPEN and CLOSE statements function in the same manner for updating as they do for retrieving an indexed sequential file. The clauses specified allow random retrieval only. Before retrieval of each record, the SYMBOLIC KEY must be provided.

Updating Randomly

To update an indexed sequential file randomly, the following clauses must be specified:

- OPEN I-O file-name
- READ file-name INVALID KEY
- REWRITE record-name
- CLOSE file-name

The OPEN and CLOSE statements function in the same manner as for sequential retrieval of an indexed sequential file. The READ statement retrieves the record identified by the SYMBOLIC KEY. This key must be specified for every READ statement and must be within the limits of the file; otherwise, a 'NO RECORD FOUND' condition results. If this occurs, control is given to the user's INVALID KEY routine.

The REWRITE clause permits random updating of records in a file. It must be preceded by a READ, and the SYMBOLIC KEY and RECORD KEY must not be modified before the REWRITE is executed. NO INVALID KEY check is available for the update function.

Adding Randomly

To add to an indexed sequential file randomly, the following clauses are required.

- OPEN I-O file-name
- WRITE record-name [INVALID KEY]
- CLOSE file-name

The OPEN and CLOSE statements function in the same manner as for sequential retrieval of an indexed sequential file. Records can be added to an existing file by means of the WRITE statement. The WRITE requires that the RECORD KEY be initialized before the operation.

A duplicate key error results when a record that is being added has the same RECORD KEY value as a record already in the file. This condition causes control to be given to the programmer's INVALID KEY routine.

Key Handling: The programmer must initialize the SYMBOLIC KEY with a key value prior to every READ statement. The value must be equal to the record key within the record to be retrieved. This key must be within the file limits; otherwise, a 'NO RECORD FOUND' error condition results. The RECORD KEY can be used only for record reference during the retrieve and update functions. When adding to the file, this key must be initialized before each write.

ERROR RECOVERY TECHNIQUES FOR INDEXED SEQUENTIAL FILES

Recovery from input/output error conditions raised for an indexed sequential file may be attempted in three ways. They are:

1. The INVALID KEY clause in the COBOL program.
2. A COBOL library subroutine (IHD03500).
3. The USE AFTER STANDARD ERROR clause in the COBOL program.

The relationship among these three types of recovery attempts is shown in the flowchart that follows. If the user has specified INVALID KEY and an INVALID KEY error is raised, the INVALID KEY routine is executed. If the user does not have an INVALID KEY routine, the COBOL subroutine will analyze the error indicators. If no USE AFTER STANDARD ERROR is specified, the job is terminated after printing a message that identifies the type of error. If a user declarative section does exist, control is given to that routine. The COBOL programmer can prepare such a routine to make a further analysis of the DTF table to determine further information about the error status. Note that program execution can continue only if an INVALID KEY or USE AFTER STANDARD ERROR clause exists.

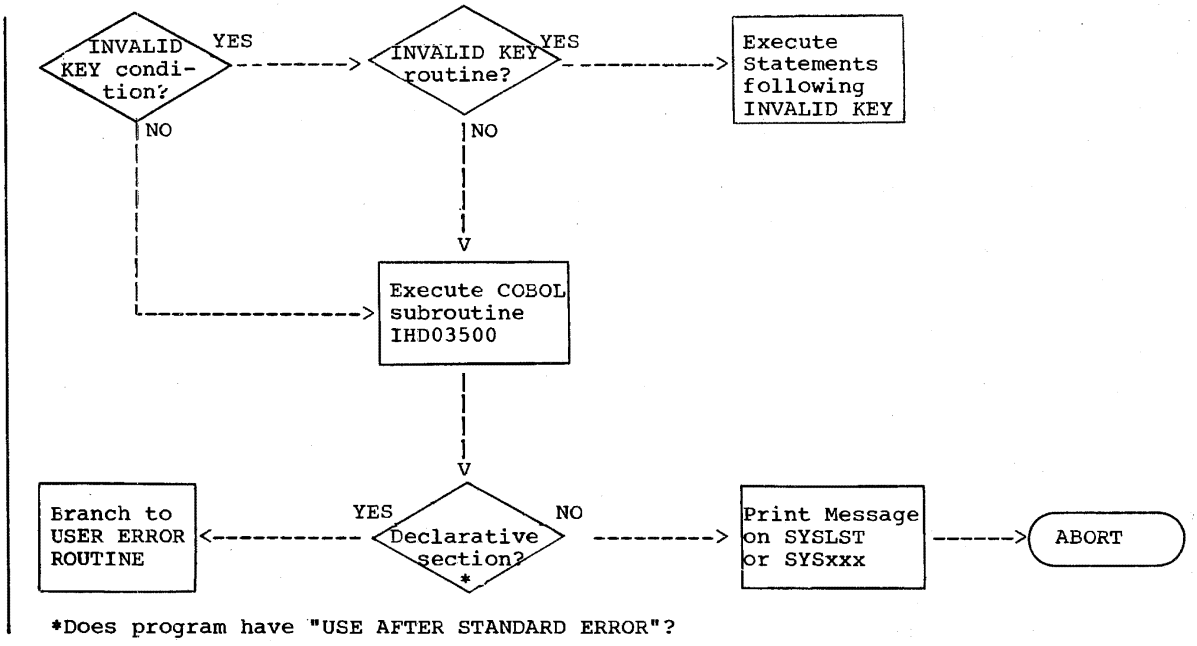


Table 1 summarizes the error conditions by function and indicates which errors will raise an INVALID KEY, which will be analyzed by the subroutine, IHD03500, and which errors could be profitably analyzed by a USE AFTER STANDARD ERROR routine (see the publications IBM System/360 Disk or Tape Operating System: Supervisor and Input/Output Macro Instructions, Forms C24-5037 and C24-5035, respectively, for a complete list of error conditions).

Table 1. Error Functions

Error Function	Create	Add	Random Retrieval	Sequential Retrieval
Duplicate Record	INVALID KEY	INVALID KEY		
Sequence Check	INVALID KEY			
DASD error	USE AFTER STANDARD ERROR			
Wrong length Record	USE AFTER STANDARD ERROR			
Prime data Area Full	USE AFTER STANDARD ERROR			
Cylinder Index Full	USE AFTER STANDARD ERROR			
Master Index Full	USE AFTER STANDARD ERROR			
No Record Found			INVALID KEY	USE AFTER STANDARD ERROR
Overflow Area Full Area Full		USE AFTER STANDARD ERROR		

INVALID KEY Errors

The INVALID KEY is raised when:

1. A duplicate record exists (duplicate key) (WRITE).
2. When building a file, a record is out of sequence (sequence check) (WRITE).
3. No record is found during retrieval (READ).

These are the conditions from which the programmer can most logically recover. In almost all other cases, the only choice is to abort the job; therefore, most programmers should be able to handle almost all of their error recovery procedures within the INVALID KEY routines.

When creating the file, the program will execute the imperative statements following the INVALID KEY clause for either a duplicate record or sequence check. In either case the record is not added to the file. The INVALID KEY routine could identify the error record, and either close the files, or continue with the next transaction.

When adding to the file, the INVALID KEY is raised for a duplicate record. In this case, the record will not be added. The user could identify the error record and continue with the next transaction in his INVALID KEY routine.

For random retrieval, the INVALID KEY is raised if the record cannot be found on the file. The INVALID KEY routine could identify the missing record and continue with the next transaction.

During sequential retrieval no INVALID KEY IS raised. The user must specify the AT END option to branch to end-of-job steps when the end of file is encountered.

USE AFTER STANDARD ERROR Routines

When creating a file, Prime Data Area Full would be indicated if the user did not reserve a large enough extent for all data records. In this case, the user could close the file in his USE AFTER STANDARD ERROR routine. He could then submit new job control EXTENT cards reserving more room for prime data, and extend the file with the remaining data cards by resubmitting the same program.

DASD errors and wrong-length records could be bypassed, if feasible, in the USE AFTER STANDARD ERROR routine. However, in most cases, the job must be terminated.

When adding to the file, if the cylinder overflow area cannot contain the overflow record, an Overflow Area Full error will be indicated. The record will not be added. The user could continue with the next transaction in his STANDARD ERROR routine by going to a routine to read the next input transaction, since it may be possible to add records that will be located on a different cylinder. However, the best procedure would be to close the file and stop the run.

Note that a programmer may elect to start sequential retrieval at a specified key rather than at the beginning of the file. If the key specified is not in the file, and if there is no error declarative section, the COBOL subroutine will print a message indicating this and abort the job.

In general, a declarative section may be included in a program in order to find out more information about an error condition that occurs. Such a routine can interrogate byte 30 of the DTF table to determine the type of error that exists. (For more information and a coding example, see "Modifying the DTF Table.") The error indicator can be passed to a subprogram by specifying the CALL statement including USING file-name. The programmer is responsible for writing the error checking subprogram. The error indicators are shown in Table 2. Normal return from the declarative is to the next sequential instruction in the program following the input/output operation. Return by means of a GO TO statement may be made to any location. Note that the programmer must realize that the record of the last input/output operation was not located.

Table 2. Error Indicators

BYTE 30	Add, Retrieve, or Both	Create
X'80'	Direct Access Device Error	Direct Access Device Error
X'40'	Wrong Length Record	Wrong Length Record
X'20'	End of File	Prime Data Area Full
X'10'	No Record Found	Cylinder Index Area Full
X'08'		Master Index Area Full
X'02'	Overflow Area Full	

The following example illustrates a declarative routine when combining random retrieval and additions. Assuming that INVALID KEY clauses were written, control will be given to the declarative section in this example only when DASD, wrong-length record, or Overflow Area Full error indicators are raised. The purpose of the routine is to continue processing in the case of an Overflow Area Full indicator and to close the file and end the job for DASD and wrong-length record indicators.

MAIN PROGRAM

```
WORKING-STORAGE SECTION.
01  INDICATOR PICTURE 9.
              .
              .
              .
PROCEDURE DIVISION.
DECLARATIVES.
ERR-TEST SECTION.  USE AFTER STANDARD ERROR PROCEDURE
       ON IS-FILE.
       ENTER LINKAGE.
       CALL 'ERRSUB' USING IS-FILE, INDICATOR.
       ENTER COBOL.

       IF INDICATOR IS EQUAL TO 1 GO TO READ-ROUTINE.
       GO TO END-JOB.
END DECLARATIVES.
```

SUBPROGRAM

```
WORKING-STORAGE SECTION.
77 FULL PICTURE 9 USAGE COMPUTATIONAL VALUE 2.

LINKAGE SECTION.
    01  DTF-FOR-DISK.
        02 BYTE PICTURE 9 OCCURS 31 TIMES.
    01  INDICATOR PICTURE 9.

PROCEDURE DIVISION.
    ENTER LINKAGE.
    ENTRY 'ERRSUB' USING DTF-FOR-DISK, INDICATOR.
    ENTER COBOL.
    MOVE LOW-VALUE TO INDICATOR.
    IF BYTE (31) IS NOT EQUAL TO FULL GO TO EXT.
    MOVE 1 TO INDICATOR.
EXT.
    ENTER LINKAGE.
    RETURN.
    ENTER COBOL.
```

When a DASD error, wrong-length record, or Overflow Area Full error occurs on the IS-FILE, control is given to the first instruction after the USE AFTER STANDARD ERROR clause. The subprogram is called. The address of the IS-FILE DTF table and the working storage indicator are passed to the subprogram.

The subprogram sets the indicator in working storage to zeros. If byte 30 contains an X'02' indicating an Overflow Area Full error, a 1 is moved to the working storage indicator. Return is made to the main program. The main program checks to see if the indicator is a 1. If it is, a branch is made to read the next transaction. If the indicator is not a 1, a DASD error or wrong-length record error has occurred, and the program branches to the end-of-job routine to close the files and stop the run.

Note that the COBOL subroutine will also print out an error message that provides another source of information about the type of error that has occurred. (See "Modifying the DTF Table" for more information about using COBOL and assembler language subprograms to modify the DTF table.)

MODIFYING THE DTF TABLE FOR INDEXED SEQUENTIAL ORGANIZATION FILES

The Disk Operating System COBOL compiler builds a skeleton DTF table. At execution time when the file is opened, a transient routine is called to construct the complete table. The programmer may wish to change the contents of the skeleton DTF table prior to execution of the OPEN statement in order to change the overflow tracks, suppress the verify option, etc. The contents of the skeleton DTF table are shown in Table 3.

The COBOL programmer can change the contents of a certain byte in the DTF table in one of two ways, as follow:

1. By writing statements in the main COBOL program to refer to the DTF table and by writing a COBOL subprogram to change the DTF table.

2. By writing statements in the COBOL main program to refer to the DTF table and by writing an assembler language subprogram to change the DTF table.

The following are examples of the options in the DTF table that can be changed. (Note that the byte count of a DTF table begins with zero; thus, for example, byte 22 actually is the 23rd byte of the table.)

1. Byte 3 (the fourth byte) of the DTF table controls the verify option. Changing the value of the fourth byte to X'00' suppresses record written out is correct. Suppression of the verify option can result in improved program performance.

2. The presence of a master index can be indicated by changing the value of byte 20 (the 21st byte) to X'F2' for the 2311, X'82' for the 2314, and X'02' for the 2321.

3. Byte 21 (the 22nd byte) of the DTF can be altered to change the number of overflow tracks assumed per cylinder. The number of overflow tracks assumed by the compiler is 2 for the 2311 or 4 for the 2321 or the 2314. The programmer may change this to a maximum of 8 for the 2311, 16 for the 2314, or 18 for the 2321. If the value is changed to LOW VALUE, cylinder overflow is suppressed.

4. By replacing the contents of byte 20 (the 21st byte) with X'F0' the user can locate his indexes on the 2311 or the 2314 when the prime data is on the 2321.

Table 3. Contents of Skeleton DTF Table

```
COBOL TRANSIENT PREPHASE TO OPEN.  THIS ROUTINE WILL
      BUILD THE DTFIS TABLES AT OPEN-TIME

INPUT TO THIS ROUTINE IS AS FOLLOWS
SPACE MUST BE RESERVED FOR THE BIGGEST POSSIBLE TABLE
THIS IS DEPENDING ONLY ON THE KEYSIZE, THE TOTAL NUMBER OF
BYTES USED BY THE TABLE IS 600&KEYSIZE.  THE CONTENTS OF
THIS TABLE IS BEFORE THIS ROUTINE

BYTE 0      X'00'=RANDOM              X'F0'=SEQUENTIAL
BYTE 1      X'00'=2311 and 2314       X'F0'=2321        (PRIME DATA)
BYTE 2      X'00'=UNBLOCKED           X'F0'=BLOCKED
BYTE 3      X'00'=NO VERIFY           X'F0'=VERIFY
BYTE 4-5    RECORD SIZE
BYTE 6-7    NUMBER OF RECORDS IN BLOCK
BYTE 8-9    KEYLOCATION %FIRST BYTE IN RECORD 31
BYTE 10-11  RECORD KEY-LENGTH
BYTE 12-15  ADDRESS OF IOAREAL
BYTE 16-19  ADDRESS OF WORKL
BYTE 20     X'00'=INDEX ON 2321 or 2314 X'F0'=INDEX ON 2311
BYTE 21     NUMBER OF OVERFLOW-TRACKS IN CYLINDER
BYTE 22-29  FILENAME
BYTE 30-31  DUMMY
BYTE 32-35  ADDRESS OF KEYARG  (SYMBOLIC KEY)
BYTE 36-37  TRACK-AREA LENGTH  (OPTION)
BYTE 38-39  CORE-INDEX LENGTH  (OPTION)
BYTE 40-43  CORE-INDEX ADDRESS (OPTION)
THE REST OF THE TABLE MUST BE SET TO X'00'
NOTICE THAT BYTES 3,20,21 MAY BE CHANGED BY THE USER
BEFORE THE OPEN STATEMENT IS EXECUTED
```

Example of COBOL Main Program and COBOL Subprogram Modifying DTF

In the COBOL main program, define and call the subprogram, as follows:

1. Data Division

```
FD ISFILE
```

2. Procedure Division

```
ENTER LINKAGE.
CALL 'CHGDTF' USING ISFILE.
ENTER COBOL.
OPEN OUTPUT ISFILE.
```

When the call is executed, the address of the skeleton DTF is passed to the subprogram. Note that COBOL permits only data-names to be passed to a COBOL subprogram. In this case, a file-name is passed, but only to use the address of the DTF for the file. No input/output operations can be performed on the file in the subprogram.

The subprogram could move an appropriate value into one or more bytes that the programmer wishes to modify. For example, the following subprogram will eliminate the verify option.

```
DATA DIVISION.
LINKAGE SECTION.
01 DTF-FOR-DISK.                                    DUMMY DTF TABLE
    02 BYTE PICTURE X OCCURS 35 TIMES.

PROCEDURE DIVISION.
  ENTER LINKAGE.
  ENTRY 'CHGDTF' USING DTF-FOR-DISK.
  ENTER COBOL
  MOVE LOW-VALUE TO BYTE (4).
  ENTER LINKAGE.
  RETURN.
  ENTER COBOL.
```

The LINKAGE SECTION in the subprogram defines a DTF table. Control is passed to byte 3 to eliminate the verify option and then control is returned to the main program at the OPEN statement.

Note that an assembler language subprogram can be called by using the same coding in the main COBOL program.

CODING EXAMPLES USING INDEXED SEQUENTIAL FILES

The following examples illustrate how a COBOL program can be prepared in order to create and retrieve an indexed sequential file. The job control cards specifying label information for these examples follow. They define a cylinder index located on cylinder 196, and a small prime data extent located on cylinders 197 and 198.

```
// ASSGN SYS004,X'192'
// DLBL SYS004,'INDEXED SEQ FILE', 67/365,ISC
// EXTENT SYS004,111111,4,1,01960,00010
// EXTENT SYS004,111111,1,2,01970,00020
// EXEC
```

Creating an Indexed Sequential File

This program example shows how to create an indexed sequential file from the card reader. The file consists of records of 100 characters, five records in a block.

When the file is opened, the labels are checked, the track indexes are formed, and the extents are reserved for the cylinder index.

After the files are opened, cards are read and data is moved to the print file and disk file. Movement of the KEY-ID in the cards to the REC-ID of disk is mandatory since the REC-ID is the data name specified by the RECORD KEY clause.

A branch to the INVALID KEY routine will occur on sequence errors or duplicate records. This routine identifies the error type and error record, and then gets the next transaction.

The COBOL error subroutine identifies all other errors and aborts the job. If the INVALID KEY routine were not present, it would also identify and abort the job for sequence errors. It would identify the error and continue with the next sequential instruction for duplicate records.

At end-of-job, the files are closed and the job terminated.

```
01 001001 IDENTIFICATION DIVISION.
02       1 PROGRAM-ID.  'LOADIS'.
03       3 AUTHOR.
04       4 INSTALLATION.
05       5 DATE WRITTEN.
06       6 REMARKS.  ILLUSTRATE CREATING OF INDEXED SEQUENTIAL FILE.
07       8 ENVIRONMENT DIVISION.
08       9 CONFIGURATION SECTION.
09      10 SOURCE-COMPUTER.  IBM-360.
10      11 OBJECT-COMPUTER.  IBM-360.
11 002001 INPUT-OUTPUT SECTION.
12       2 FILE-CONTROL.
13       3    SELECT IS-FILE ASSIGN TO 'SYS004' DIRECT-ACCESS 2311
14       4      ACCESS IS SEQUENTIAL ORGANIZATION IS INDEXED
15       5      RESERVE NO ALTERNATE AREA
16       7      RECORD KEY  IS REC-ID.
17      10    SELECT CARD-FILE ASSIGN TO 'SYS005' UNIT-RECORD 2540R
18      11      RESERVE NO ALTERNATE AREA.
19      12    SELECT PRINT-FILE ASSIGN TO 'SYS006' UNIT-RECORD 1403
20      13      RESERVE NO ALTERNATE AREA.
21 003001 DATA DIVISION.
22    002 FILE SECTION.
23       4 FD IS-FILE      DATA RECORD IS DISK
24       5                 RECORDING MODE IS F
25       6                 LABEL RECORDS ARE STANDARD
26       7                 BLOCK CONTAINS 5 RECORDS.
27      10 01 DISK.
28      11    02  DISK-FLD1    PICTURE  X(10).
29      12    02  REC-ID       PICTURE  X(10).
30      13    02  DISK-NAME    PICTURE  X(20).
31      14    02  DISK-BAL     PICTURE  99999V99.
32      15    02  FILLER       PICTURE  X(53).
33 004001 FD CARD-FILE    DATA RECORD IS CARDS
34       2                RECORDING MODE IS F
35       3                LABEL RECORDS ARE OMITTED.
36       5 01 CARDS.
37       6    02  KEY-ID       PICTURE  X(10).
38       7    02  CD-NAME      PICTURE  X(20).
39       8    02  CD-BAL       PICTURE  99999V99.
40 005001 FD PRINT-FILE  DATA RECORD IS PRINTER
```

```
41       2                 RECORDING MODE IS F
42       3                 LABEL RECORDS ARE OMITTED.
43       6 01 PRINTER.
44       7    02  PRINT-ID     PICTURE  X(10).
45       8    02  FILLER       PICTURE  X(10).
46       9    02  PRINT-NAME   PICTURE  X(20).
47      10    02  FILLER       PICTURE  X(10).
48            02  PRINT-BAL    PICTURE  ZZZ,ZZZ.99-.
49 006001 PROCEDURE DIVISION.
50       3 START.
51       4    OPEN INPUT CARD-FILE OUTPUT PRINT-FILE IS-FILE.
52       6 RD.
53       7    READ CARD-FILE AT END GO TO END-JOB.
54       9    MOVE KEY-ID TO PRINT-ID  REC-ID.
55      10    MOVE CD-NAME TO PRINT-NAME  DISK-NAME.
56      11    MOVE CD-BAL TO PRINT-BAL  DISK-BAL.
57            WRITE DISK INVALID KEY GO TO ERR.
58      13    WRITE PRINTER.
59      17    GO TO RD.
60          ERR.
61            DISPLAY 'DUPLICATE OR SEQ-ERR' UPON CONSOLE.
62            DISPLAY KEY-ID UPON CONSOLE.
63            GO TO RD.
64      19 END-JOB.
65      20    CLOSE CARD-FILE PRINT-FILE IS-FILE.
66      21    DISPLAY 'END JOB' UPON CONSOLE.
67      22    STOP RUN.
```

This program illustrates random retrieval and updating for the IS-FILE created in the previous example.

The Data Division is basically the same as in loading the file except for the ACCESS IS RANDOM clause. Both the SYMBOLIC KEY and the RECORD KEY clause are required.

The IS-FILE is opened as I-O. This allows both retrieval and updating. The OPEN verb does label checking, and it also stores statistic fields from the format 2 label into the DTF table.

The SYMBOLIC KEY clause data-name (KEY-ID) is defined in the Working-Storage Section. Reading the IS-FILE causes a search of the indexes for a record matching the KEY-ID. If the record is found, data is moved to the print-file and printed, the IS-FILE is updated, and a branch is made to the next transaction.

If a matching record is not found, the COBOL subroutine turns control to the INVALID KEY routine (NO-RECORD). This routine identifies the error and branches to the next transaction.

The end-of-job routine closes the files and terminates the job. The CLOSE verb also returns the updated statistics in the DTF table back to the format 2 label.

```
01          IDENTIFICATION DIVISION.
02 001002   PROGRAM-ID.  'RANDOMIS'.
03        3 AUTHOR.
04        4 INSTALLATION.  360 PROGRAMMING CENTER.
05        5 DATE WRITTEN.
06 001006   REMARKS.  ILLUSTRATE RANDOM RETRIEVAL FROM  IS-FILE.
07        8 ENVIRONMENT DIVISION.
08        9 CONFIGURATION SECTION.
09       10 SOURCE-COMPUTER.  IBM-360.
10       11 OBJECT-COMPUTER.  IBM-360.
11 002001   INPUT-OUTPUT SECTION.
12        2 FILE-CONTROL.
13        3     SELECT IS-FILE ASSIGN TO 'SYS004' DIRECT-ACCESS 2311
14 002004         ACCESS IS RANDOM ORGANIZATION IS INDEXED
15        5         RESERVE NO ALTERNATE AREA
16        6         SYMBOLIC KEY IS KEY-ID
17        7         RECORD KEY   IS REC-ID.
18       10     SELECT CARD-FILE ASSIGN TO 'SYS005' UNIT-RECORD 2540R
19       11         RESERVE NO ALTERNATE AREA.
20       12     SELECT PRINT-FILE ASSIGN TO 'SYS006' UNIT-RECORD 1403
21       13         RESERVE NO ALTERNATE AREA.
22 003001   DATA DIVISION.
23      002 FILE SECTION.
24        4 FD IS-FILE      DATA RECORD IS DISK
25        5                 RECORDING MODE IS F
26        6                 LABEL RECORDS ARE STANDARD
27        7                 BLOCK CONTAINS 5 RECORDS.
28       10 01 DISK.
29       11     02  DISK-FLD1    PICTURE  X(10).
30       12     02  REC-ID       PICTURE  X(10).
31       13     02  DISK-NAME    PICTURE  X(20).
32       14     02  DISK-BAL     PICTURE  99999V99.
33       15     02  FILLER       PICTURE  X(53).
34 004001   FD CARD-FILE    DATA RECORD IS CARDS
35        2                 RECORDING MODE IS F
36        3                 LABEL RECORDS ARE OMITTED.
37        5 01 CARDS.
38        6     02  KEY-ID1      PICTURE  X(10).
```

```
39       7    02  CD-NAME      PICTURE  X(20).
40       8    02  CD-AMT       PICTURE  99999V99.
41  004009    02  CD-CODE      PICTURE  X.
42          FD PRINT-FILE  DATA RECORD IS PRINTER
43                         RECORDING MODE IS F
44                         LABEL RECORDS ARE OMITTED.
45  005006 01 PRINTER.
46  005007    02  PRINT-ID     PICTURE  X(10).
47  005008    02  FILLER       PICTURE  X(10).
48  005009    02  PRINT-NAME   PICTURE  X(20).
49  002010    02  FILLER       PICTURE  X(10).
50  005011    02  PRINT-BAL    PICTURE  $ZZZ,999.99-.
51  005012    02  FILLER       PICTURE  X(10).
52  005013    02  PRINT-AMT    PICTURE  $ZZZ,ZZZ.99-.
53  005014    02  FILLER       PICTURE  X(10).
54  005015    02  PRINT-NEW-BAL PCITURE  $ZZZ,ZZZ.99-.
55  005016 WORKING-STORAGE SECTION.
56  005017    77  KEY-ID PICTURE X(10).
57  006001 PROCEDURE DIVISION.
58  006003 START.
59  006004    MOVE 48 TO NEW-AREA.
60  006004    OPEN INPUT  CARD-FILE I-O IS-FILE
61  006006 RD.
62  006007    READ CARD-FILE AT END GO TO END-JOB.
63  006008    MOVE KEY-ID1 TO KEY-ID.
64  006009    READ IS-FILE  INVALID KEY GO TO NO-RECORD.
65  006010    MOVE REC-ID      TO PRINT-ID.
66  006011    MOVE DISK-NAME   TO PRINT-NAME.
67  006012    MOVE DISK-BAL    TO PRINT-BAL.
68  006013    MOVE CD-AMT      TO PRINT-AMT.
69  006014    ADD CD-AMT       TO DISK-BAL.
70  006015    MOVE DISK-BAL    TO PRINT-NEW-BAL.
71  006017    WRITE PRINTER.
72  006019    REWRITE DISK.
73  006021    GO TO RD.
74  007001 NO-RECORD.
75  007002    DISPLAY 'NO RECORD FOUND' UPON CONSOLE.
76  007003    DISPLAY KEY-ID UPON CONSOLE.
77  007004    GO TO RD.
78  007017 END-JOB.
79  007018    CLOSE CARD-FILE PRINT-FILE  IS-FILE.
80  007019    DISPLAY 'END JOB' UPON CONSOLE.
81  007020    STOP RUN.
```

This program illustrates a sequential retrieval of the IS-FILE in order to print its contents.

The Data Division is basically the same as before. The file is opened as input. To update, it would have been opened as an INPUT-OUTPUT file.

Prior to opening the file, the program requests the operator to enter the starting key. The information he types will enter the KEY-ID data name specified by the SYMBOLIC KEY clause.

The OPEN verb will then open the file and start sequential retrieval based on the entered key. If the operator enters blanks or zeros, retrieval will start at the beginning of the file. If he enters a key that is not on the file, the COBOL error subroutine will identify the error and abort the job.

During execution of the job, the COBOL error subroutine will identify any DASD error or WLR indication and abort the job.

When the end-of-file indicator is detected, a branch is made to the END-JOB procedures.

```
01 001001 IDENTIFICATION DIVISION.
02 001002 PROGRAM-ID.  'SEQIS'.
03      3 AUTHOR.
04      4 INSTALLATION.  360 PROGRAMMING CENTER.
05      5 DATE WRITTEN.
06 001006 REMARKS.  ILLUSTRATE SEQUENTIAL RETRIEVAL FROM IS-FILE.
07      8 ENVIRONMENT DIVISION.
08      9 CONFIGURATION SECTION.
09     10 SOURCE-COMPUTER.  IBM-360.
10     11 OBJECT-COMPUTER.  IBM-360.
11 002001 INPUT-OUTPUT SECTION.
12      2 FILE-CONTROL.
13      3    SELECT IS-FILE ASSIGN TO 'SYS004' DIRECT-ACCESS 2311
14 002004      ACCESS IS SEQUENTIAL ORGANIZATION IS INDEXED
15      5      RESERVE NO ALTERNATE AREA
16      6      SYMBOLIC KEY IS KEY-ID
17      7    RECORD KEY   IS REC-ID.
18     12    SELECT PRINT-FILE ASSIGN TO 'SYS006' UNIT-RECORD 1403
19     13      RESERVE NO ALTERNATE AREA.
20 003001 DATA DIVISION.
21    002 FILE SECTION.
22      4 FD IS-FILE      DATA RECORD IS DISK
23      5                 RECORDING MODE IS F
24      6                 LABEL RECORDS ARE STANDARD
25      7                 BLOCK CONTAINS 5 RECORDS.
26     10 01 DISK.
27     11    02  DISK-FLD1    PICTURE  X(10).
28     12    02  REC-ID       PICTURE  X(10).
29     13    02  DISK-NAME    PICTURE  X(20).
30     14    02  DISK-BAL     PICTURE  99999V99.
31     15    02  FILLER       PICTURE  X(53).
32 005001 FD PRINT-FILE  DATA RECORD IS PRINTER
33      2                 RECORDING MODE IS F
34      3                 LABEL RECORDS ARE OMITTED.
35      6 01 PRINTER.
36      7    02  PRINT-ID     PICTURE  X(10).
37      8    02  FILLER       PICTURE  X(10).
38      9    02  PRINT-NAME   PICTURE  X(20).
39     10    02  FILLER       PICTURE  X(10).
40     11    02  PRINT-BAL    PICTURE  $ZZZ,ZZZ.99-.
```

```
41          WORKING-STORAGE SECTION.
42        6     77  KEY-ID      PICTURE  X(10).
43          PROCEDURE DIVISION.
44  001000  START.
45              DISPLAY 'ENTER STARTING KEY' UPON CONSOLE.
46              ACCEPT KEY-ID FROM CONSOLE.
47  001002
48  001003      OPEN OUTPUT PRINT-FILE
49  001004          INPUT   IS-FILE.
50  001006  RD.
51  001007      READ IS-FILE AT END GO TO END-JOB.
52  001008
53  001009      MOVE REC-ID     TO PRINT-ID.
54  001010      MOVE DISK-NAME  TO PRINT-NAME.
55  001011      MOVE DISK-BAL   TO PRINT-BAL.
56  001013      WRITE PRINTER.
57  001015      GO TO RD.
58  001017  END-JOB.
59  001018      CLOSE PRINT-FILE  IS-FILE.
60  001019      DISPLAY 'END JOB'  UPON CONSOLE.
61  001020      STOP RUN.
```

DIRECT ORGANIZATION

When files are created using direct organization, the positioning of the logical records in a file is determined by keys.

The two important characteristics of direct files are:

1. Records are stored at a physical address on disk that has some mathematical relationship to the record key (in COBOL this is supplied by the SYMBOLIC KEY clause).

2. The records are not arranged in any logical sequence by key.

   Some tracks may be only partially filled, or they may have no records at all.

SPECIFYING KEYS

Both the SYMBOLIC KEY clause and the ACTUAL KEY clause must be specified for files having direct organization.

The SYMBOLIC KEY must be specified for every record and actually becomes part of that record. The ACTUAL KEY specifies the physical track address. It must be specified as an eight-byte field, and it must be defined before a record can be processed. The structure and examples of code for the 8-byte ACTUAL KEY field for both the 2311 and 2321 direct access devices follow.

The elements of the field for the 2311 are:

M	M indicates the relative number of a disk pack. It will be 0 for the first disk pack, 1 for the second disk pack, etc. It corresponds to the symbolic address (SYS000-SYSxxx), which is specified on the EXTENT card for the file. Thus, if three EXTENT cards with SYS011, SYS012, and SYS013, respectively, are specified, M can range from 0 to 2.
BB	This 16-bit field will always be zero for the 2311 or 2314. It refers to the cell number when addressing the data cell (2321).
CC=0-199	This 16-bit field must contain the cylinder number in binary notation.
HH=0-9 for 2311 =0-19 for 2314	This 16-bit field must contain the head number in binary notation.
R=0	R refers to the record number or sector number. When using COBOL, this field will always be zero.

An example of a method of coding the 8-byte ACTUAL KEY in binary using COBOL for the 2311 disk pack is, as follows:

```
01 BINARY-KEY-RECORD.
   02 MM USAGE IS COMPUTATIONAL PICTURE IS S999 VALUE IS 0.
   02 BB USAGE IS COMPUTATIONAL PICTURE IS S9   VALUE IS 0.
   02 CC USAGE IS COMPUTATIONAL PICTURE IS S999 VALUE IS 10.
   02 HH USAGE IS COMPUTATIONAL PICTURE IS S9   VALUE IS 0.
   02 REC-R PICTURE IS X VALUE IS LOW-VALUE.
01 KEY-AS-ACTUAL REDEFINES BINARY-KEY-RECORD.
   02 FILLER PICTURE IS X.
   02 THE-ACTUAL-KEY  PICTURE IS X(8).
```

Although the ACTUAL KEY field really consists of eight bytes, nine bytes are defined by the given code for BINARY-KEY-RECORD. The 02 MM defines 2 bytes, the first byte of which is then disposed of by the 02 FILLER PICTURE IS X in the redefinition statement. Thus, the code defines an 8-byte binary field named THE-ACTUAL-KEY, which is used by IOCS to access records. A pictorial structure of the THE-ACTUAL-KEY field defined by the code is, as follows:

	Pack Number (M)	Cell (BB)	Cylinder (CC)	Head (HH)	Record (R)
Byte	0	1 2	3 4	5 6	7
	0	0 0	0 10	0 0	0

The elements of the field are the same for the 2311 Data Cell except that CC (bytes 3 and 4) is divided into subcell and strip, and HH (bytes 5 and 6) is divided into headbar and head element.

An example of a method of coding the 8-byte ACTUAL KEY in binary using COBOL for the 2321 Data cell is, as follows:

```
01 BINARY-KEY-RECORD.
   02 MM USAGE IS COMPUTATIONAL PICTURE IS S999 VALUE IS 0.
   02 BB USAGE IS COMPUTATIONAL PICTURE IS S9   VALUE IS 0.
   02 CC USAGE IS COMPUTATIONAL PICTURE IS S999 VALUE IS 1.
   02 HH USAGE IS COMPUTATIONAL PICTURE IS S999 VALUE IS 0.
   02 REC-R PICTURE IS X VALUE IS LOW-VALUE.
01 KEY-AS-ACTUAL REDEFINES BINARY-KEY-RECORD.
   02 FILLER PICTURE IS X.
   02 THE-ACTUAL-KEY PICTURE IS X(8).
```

Notice that just as for the 2311, nine bytes are defined and then redefined to eliminate the first byte, leaving eight bytes. Thus, the code defines the ACTUAL KEY that is used by IOCS to access records. A pictorial structure of THE-ACTUAL-KEY field as defined by the code is, as follows:

	Pack Number (M)	Cell (BB)	Cylinder (CC)		Head (HH)		Record (R)
			Sub Cell	Strip	Head Bar	Head Element	
Byte	0	1 2	3	4	5	6	7
	0	0 0	0	1	0	0	0

As records are processed, IOCS automatically updates Record (R) (in the example, it is defined by REC-R). When the desired number of records is processed within the defined area of a strip, or no more room is available in a strip area, the next head element must be accessed in order to continue processing on that strip. When all head elements have been used, the next head bar must be accessed, thus making 20 new head elements available.

Space is allocated on the 2321, as follows:

- 256 records per head element
- 20 head elements per head bar
- 5 head bars per strip
- 10 strips per subcell
- 10 subcells per pack
- 255 packs are available

The examples in the foregoing discussion may be used to specify the fields of the actual key. Another point of consideration is how to determine what the value of the ACTUAL KEY should be and then how to update it. One method is to prepare what is called a directly addressed file. With direct addressing, every symbolic key must convert to a unique address that is used as the value of the actual key. To use this method, records must be of fixed length and the symbolic key must be a numeric character.

Direct addressing saves disk time when processing is random. It is also convenient when processing is sequential because the records are written in key sequence. A possible disadvantage is that there may be a large amount of unused direct-access storage, because a location must be reserved for every key in the file's range even though many of the possible keys may not be used.

Another method of determining the value of the ACTUAL KEY is called indirect addressing. Indirect addressing generally is used when the range of keys for a file includes a high percentage of unused ones so that direct addressing is not feasible. For example, employee numbers may range from 0001 to 9999, but only 3000 of the possible 9999 numbers are actually assigned. Indirect addressing is also used for nonnumeric keys.

Indirect addressing means that the symbolic key is converted to a value for the actual key by use of some algorithm intended to compress the range of addresses. Such an algorithm is usually called a randomizing technique. Randomizing techniques need not produce a unique address for every record and, in fact, such techniques usually produce synonyms. Synonyms are records whose symbolic keys randomize to the same address.

Two objectives must be considered in selecting a randomizing technique:

1. Every possible key in the file must randomize to an address in the allotted range.
2. The addresses should be distributed evenly across the range so that there are as few synonyms as possible.

Note that one way to minimize synonyms is to allot more space for the file than is actually required to hold all the records. For example, the percentage of locations that are actually used might be 80%-85% of the allotted space.

A RANDOMIZING TECHNIQUE

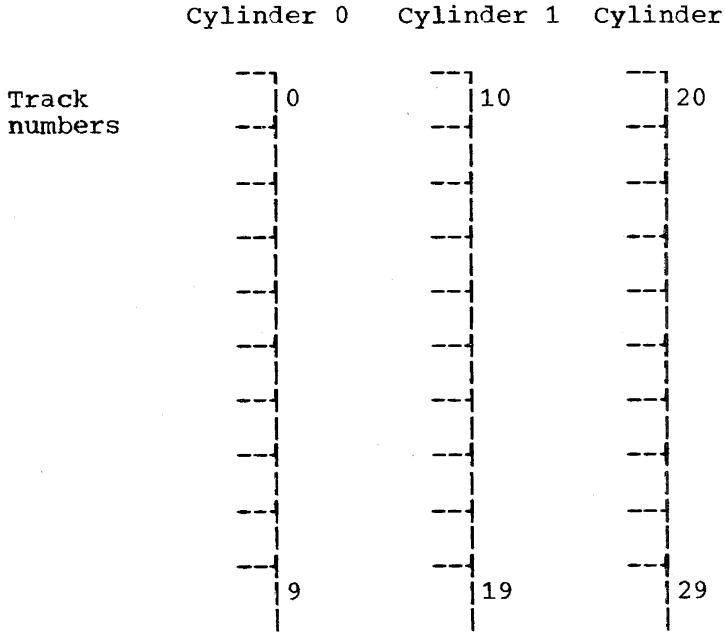
This randomizing technique is sometimes referred to as the division/remainder method. For examples of other randomizing techniques, refer to the publication Introduction to IBM System/360 Direct Access Storage Devices and Organization Methods, Form C20-1649.

The ACTUAL KEY field can be thought of as a "discontinuous binary address." This is important to the programmer because it describes two conditions of which he must be aware. First, the cylinder and head number must be in binary notation, so the results of the randomizing formula must be in binary format. Second, the address is "discontinuous" because a mathematical overflow from one element (e.g., head number) does not increment the adjacent element (e.g., cylinder number).

Randomizing for the 2311 Disk Pack

When randomizing to a 2311, it is possible to circumvent the discontinuous binary address, by coding the randomizing formula in decimal arithmetic, and then converting the results to binary. This can be done by setting aside a decimal field with the low-order byte reserved for head number, and the high-order bytes reserved for cylinder number. A mathematical overflow from the head number will now increment the cylinder number and produce a valid address. The low-order byte should then be converted to binary and stored in the HH field, and the high-order bytes converted to binary and stored in the CC field of the ACTUAL KEY field.

Randomizing to the 2311 should present no significant problems if the programmer using direct organization is completely aware that the cylinder and head number gives him a unique track number. To illustrate, the 2311 could be thought of as consisting of tracks numbered as follows:

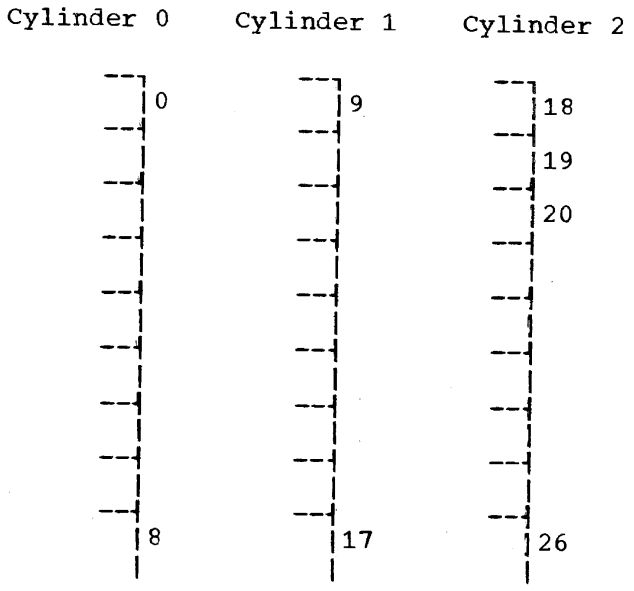


Now if the randomizing formula resulted in an address of Cylinder 001, Head 9:

```
    0  0  1  9

  Cylinder  Head
     #      #
```

this would be a reference to track 19. This fact allows the programmer to ignore the discontinuous cylinder and head number. If his formula resulted in an address of 0 0 2 0, this would result in accessing cylinder 2, head 0, and this is where track 20 is located.

The programmer can make another use of this decimal track address. He may wish to reserve the bottom track of each cylinder for synonyms. If this is the case, he is, in effect, redefining the cylinder to consist of nine tracks rather than 10 tracks. The 2311 cylinder could then be thought of as consisting of tracks numbered, as follows:



If he randomizes to relative track number 20, he can access it by dividing the track address by the number of tracks in a cylinder.

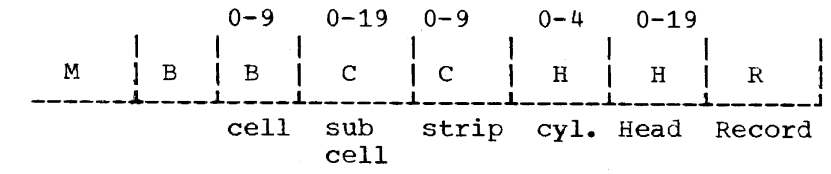
```
      2=Cylinder number
   ┌----
 9 | 0020
     18
     --
      2=Head number
```

The quotient now becomes the cylinder number, and the remainder becomes the head number. As can be seen from the illustration, relative track number 20 is on cylinder 2, head 2.

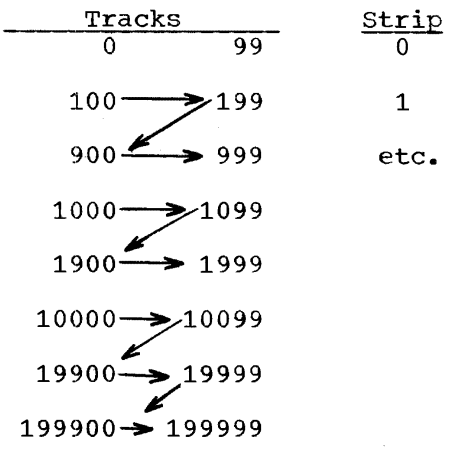
To simplify randomizing, an algorithm must be developed to generate a decimal track address. This track address can then be converted to a binary cylinder number and head number. In addition, tracks can be reserved by dividing the track address by the number of tracks in a cylinder. The same concepts will hold true for devices such as the 2314. For example, an algorithm can be developed using 20 tracks per cylinder and dividing by an approximate prime number.

Randomizing for the 2321 Data Cell

The track reference field for the data cell is composed of the following discontinuous binary address:



At first glance, this presents an almost impossible randomizing task, but since each strip comprises 100 tracks that are accessible through cylinder and head number, the 2321 can be considered to be composed of consecutively numbered tracks.



On inspection, it can be seen that relative track 20 is located on cylinder 1, head 0 of some particular strip. Its address can be calculated by dividing by 20.

```
     1=Cylinder #
   ┌---
20 |20
   20
   --
    0=Head #.
```

Thus, relative track number 120 will be located on strip 1, cylinder 1, head 0 of some subcell. Note that the strip number is given by the hundreds digit, and the cylinder and head number is derived by dividing the low-order two digits by 20.

The same relationship holds true for relative track number 900. It is located on strip 9, cylinder 0, track 0. Again the hundreds digit gives the strip number, and dividing the low-order two digits by 20 results in a quotient and remainder of zero.

This relationship holds true through a relative track number of 19999, which is the number of tracks that can be contained on one cell of a data cell array. By applying the foregoing rules, an address of subcell 19, strip 9, cylinder 4, Head 19 is derived.

```
19          9          99
subcell     strip        4=Cylinder #
                      ┌---
                   20 |99
                      80
                      --
                      19=Head #
```

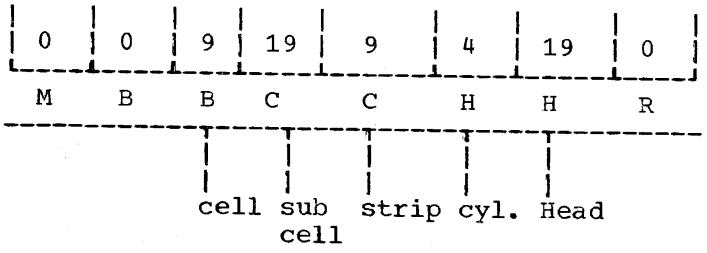
Thus, by randomizing to a 5-digit decimal track number, the programmer will be able to access the 20,000 tracks (40,000,000 characters) contained in a cell.

The thousands digits would represent the subcell number, the hundreds digit, the strip number, and the quotient and remainder of the two low-order digits divided by 20 would represent the cylinder and head number. Each one of these resulting decimal digits would then be converted to binary and placed in the appropriate place in the track reference field.

There is a total of 200,000 tracks per data cell array. To derive valid addresses that cross cell boundaries, the user should randomize to a 6-digit decimal track address. The highest address possible should be 199,999. To convert this to a data cell address, similar rules apply. In this case, the user must divide the three high-order digits by 20:

```
      9=Cell
    ┌---
20  |199
    180
    ---
     19=Subcell
```

The quotient becomes the cell number and the remainder becomes the subcell number. The hundreds digit is still the strip number, and the cylinder and head number can be derived as before. The resulting address would be:



Randomizing to the data cell can be accomplished by developing an algorithm to generate decimal track addresses. The use of the foregoing rules makes it possible to convert these generated track addresses to the appropriate discontinuous binary address.

COBOL STATEMENTS USED TO SPECIFY DIRECT ORGANIZATION FILES

The following discussions show the COBOL statements required to create, retrieve, or update a direct organization file. Also included are discussions of what functions the operating system performs when each statement is executed.

Creating a Direct Organization File

To create a direct file, the following clauses are required:

- ORGANIZATION IS DIRECT
- [ACCESS IS SEQUENTIAL]
- SYMBOLIC KEY IS data-name
- ACTUAL KEY IS data-name

The programmer must then specify:

- OPEN OUTPUT file-name
- WRITE record-name [INVALID KEY]
- CLOSE file-name

OPEN Statement: The OPEN statement initializes the VTOC to indicate the presence of the labels and checks the label area for a valid output file. It also establishes the limits of the file as defined in the EXTENT statement. It checks to be sure that the file limits specified do not overlap with an existing file and completes the DTF (Define the File) table for the file that was opened. Thus, it enters the system logical unit specified for the file into the table. In addition, the OPEN statement initializes the capacity records (R0) over the entire area of the EXTENT for the output file.

WRITE Statement: The WRITE statement transfers the record to the DASD address specified in the ACTUAL KEY. The specified SYMBOLIC KEY becomes a part of the record in the file.

Key Handling: When handling keys, the following restrictions are imposed:

1. The programmer must provide the SYMBOLIC KEY for every record loaded.
2. When creating a file, no provision is made to prevent the addition of a duplicate record.

CLOSE Statement: The CLOSE statement returns the track address of the end-of-file record to the ACTUAL KEY.

Sequential Retrieval of a Direct Organization File

To retrieve a direct file sequentially, the following clauses are required:

- ORGANIZATION IS DIRECT
- ACCESS IS SEQUENTIAL
- SYMBOLIC KEY IS data-name
- ACTUAL KEY IS data-name

The programmer must then specify:

- OPEN INPUT file-name
- READ file-name AT END
- CLOSE file-name

READ Statement: The READ statement retrieves the file sequentially beginning with the lower EXTENT.

OPEN and CLOSE Statements: The OPEN statement checks labels on the label track and initializes the VTOC. The limits of the extents are established at this time. The CLOSE statement is a no-operation.

Key Handling: For sequential retrieval of a direct file, the actual key must be initialized to binary zeros. After each READ, COBOL will return the symbolic key to the data-name specified in the SYMBOLIC KEY clause.

Random Retrieval, Updating, and Adding to a Direct File

To retrieve a direct file randomly, the following clauses are required:

- ORGANIZATION IS DIRECT
- ACCESS IS RANDOM
- SYMBOLIC KEY IS data-name
- ACTUAL KEY IS data-name

The programmer must then specify:

- OPEN INPUT file-name
- READ file-name INVALID KEY
- CLOSE file-name

Random Retrieval

The READ statement retrieves a record from the information given in the SYMBOLIC KEY. The search begins at the DASD address specified in the ACTUAL KEY.

Updating Randomly

To update randomly, the programmer must specify:

- OPEN I-O file-name
- READ file-name INVALID KEY
- REWRITE record-name [INVALID KEY]
- CLOSE file-name

When updating a file, the keys must not be modified.

Adding Randomly

The WRITE statement allows new records to be added to the file. When adding records to an existing file, both the ACTUAL KEY and SYMBOLIC KEY must be supplied. The record is written into the specified location. When adding randomly to a direct file, no provision is made to prevent the addition of a duplicate record.

OPEN, CLOSE Statements: For random retrieval, the OPEN and CLOSE functions are the same as for sequential retrieval of a direct file.

Key Handling: When a file is accessed randomly, both the ACTUAL KEY and SYMBOLIC KEY must be initialized by the user before the READ or WRITE statement is specified. The ACTUAL KEY contains the DASD address and the SYMBOLIC KEY identifies the record within the file.

When more than one type of retrieval is specified for direct-access files in a program, an indication of duplicate entry points may be given at linkage edit time. If duplicate entry points occur, the programmer must construct and include a supersetted LIOCS module that contains the individual modules.

Table 4 shows how (1) the module containing the duplicate entry point can be identified and (2) the supersetted module is built and included in the COBOL object module in place of the individual modules.

If a number of direct files are defined to be used by the same program, the linkage editor diagnostic messages shown in Table 4 might be obtained. (They are included in the DISK LINKAGE EDITOR DIAGNOSTIC OF INPUT.)

Note that the LIOCS modules are separately included in the program (see AUTOLINK IJ... entries near the top of the listing). When the modules are linkage edited with the COBOL program, an indication of a duplicate entry point may be given. The duplicate entry point is included in the line of print identified by the message number 2143I and belongs to the module IJHZRBZZ. This message number is listed in the operating guide for the system and indicates an invalid duplication of an entry point label.

The programmer can identify the module containing the duplicate entry point and build a supersetted module, as follows:

Compare the IJH... (entry points) given in the line next to the message number the ENTRY points given in the LABEL column part of the listing.

In this example, the duplicate ENTRY point is ENTRY IJHZRRZZ (the second one in the 2143I line of print, and the third one from the bottom in the LABEL column listing). Thus, this duplicate entry point is in the module CSECT IJHUARZZ (see the entry just above IJHZRRZZ in the LABEL column listing). The module should also be among those given in the AUTOLIST list.

From this module (IJHUARZZ) and module IJHZRBZZ, a supersetted module must be formed, as follows:

Use the first three characters of the module name for the functions used. In this case, they would be IJH. Then use the lowest letter, between the two modules, for each of the next five character positions, as follows:

```
I J H U A R Z Z
      ↓ ↓
I J H U A B Z Z    Supersetted module
        ↑
I J H Z R B Z Z
```

Thus, the name of the supersetted LIOCS module that contains the individual modules (IJHUARZZ and IJHZRBZZ) is IJHUABZZ.

The supersetted module can then be included with the COBOL object module at linkage edit time instead of the individual modules (IJHUARZZ and IJHZRBZZ) by inserting an INCLUDE card before the linkage edit function, as follows:

```
   INCLUDE IJHUABZZ

// EXEC LNKEDT
```

Table 4. Linkage Editor Diagnostic Output

```
JOB  CEFI1002  10/27/66   DISK LINKAGE EDITOR DIAGNOSTIC OF INPUT

ACTION TAKEN    MAP
LIST     PHASE COMPLDG0,*)
LIST   INCLUDE IHD02800  )
LIST   INCLUDE IJJCPD1   }Information supplied by COBOL compiler      CEFI0001
LIST   INCLUDE IHD03500  )                                            CEFI0002
LIST   INCLUDE IHD03700  )                                            CEFI0003
LIST   AUTOLINK   IJFFBCZZ)
LIST   AUTOLINK   IJHUARZZ}  Information supplied by Linkage Editor
LINK   AUTOLINK   IJHZLZZZ)
LINK   AUTOLINK   IJHZRBZZ)

2143I  IS050021 ESD 404040 0010 0001 IJHZRBZZ 0 000000 0095D0 IJHZRRZZ 1 000000
         000010 IJHZRSZZ 1 000000 000001

LIST   AUTOLINK   IJHZRSZZ                          Duplicate entry point
LIST   ENTRY
```

```
10/27/66   PHASE   XFR-AD  LOCORE  HICORE  DSK-AD  ESD TYPE  LABEL     LOADED  REL-FR
        COMPLDGO  007000  005080  00A07F  3A 7 2  CSECT     IJJCPD1   005080  005080
                                                    ENTRY   IJJCPD1N  005080
                                                  * ENTRY   IJJCPD3   005080

                                                  CSECT     IHD02800  005240  005240
                                                    ENTRY   IHD02801  005240
                                                    ENTRY   IHD02802  005270

                                                  CSECT     IHD03500  0053A8  0053A8
                                                    ENTRY   IHD03501  0053A8
                                                    ENTRY   IHD03502  00538C

                                                  CSECT     IHD03700  005680  005680
                                                    ENTRY   IHD03701  005680
                                                    ENTRY   IHD03702  005690
                                                                      00
                                                  CSECT     CEFI1002  0057A0  0057A0

                                                  CSECT     IJFFBCZZ  0084F0  0084F0
                                                  * ENTRY   IJFFBZZZ  0084F0
                                                  * ENTRY   IJFFZCZZ  0084F0
                                                  * ENTRY   IJFFZZZZ  0084F0

                                                  CSECT     IJHZRSZZ  009C70  009C70

                                                  CSECT     IJHZRBZZ  0095D0  0095D0
Module containing duplicate entry point ------>   CSECT     IJHUARZZ  008820  008820
                                                    ENTRY   IJHZRRZZ  008820
Duplicate entry point ------------------------>   * ENTRY   IJHUIZZZ  008820

                                                  CSECT     IJHZLZZZ  0092A0  0092A0
```

ERROR RECOVERY TECHNIQUES FOR DIRECT FILES

As with indexed sequential files, error recovery may be attempted in one of three ways, as follows:

1. The INVALID KEY clause
2. COBOL error subroutine (IHD03400)
3. The USE AFTER STANDARD ERROR clause

Table 5 summarizes, by function, the conditions that cause control to be passed to the INVALID KEY, which error conditions are analyzed by the COBOL subroutine, and, optionally, those error conditions for which a USE AFTER STANDARD ERROR routine can be useful.

INVALID KEY

When creating or adding to a file, the INVALID KEY is raised if the track does not contain room enough for the record to be written. A user routine could contain coding to place the synonym on some other track based on the randomizing technique being used.

During random retrieval, an INVALID KEY error is raised if the record is not found. Depending upon how the file was created, this condition could mean that the record may be located on some other track or cylinder, or it could mean that the record is truly missing. The INVALID KEY routine could determine this.

During sequential retrieval, there is no INVALID KEY. The AT END option after the READ statement is used to determine when the end-of-file condition is reached.

USE AFTER STANDARD ERROR

For data check and wrong-length record error conditions, the user may wish to have control passed to him by writing a USE AFTER STANDARD ERROR routine in the declarative section of his program. This routine can interrogate bytes 244 and 255 of the DTF in a subprogram to determine the type of error that has occurred. These error indicators are:

Byte 254

X'40'	wrong-length record
X'08'	no room found

Byte 255

X'80'	data check in count
X'10'	data check in key or data
X'08'	no record found

Note that the "no room found" and the "no record found" conditions should normally be handled by INVALID KEY routines.

Normal return from the declarative section is to the next sequential instruction following the input/output operation (which caused the interrupt). Return by means of a GO TO statement may be made to any location within the program. It is important to remember that the last input/output operation was not completed.

Table 5. Error Functions

Error Function	Create or Add	Random Retrieve	Sequential Retrieve
No Room Found	INVALID KEY		
No Record Found		INVALID KEY	
Wrong Length Record	USE AFTER STANDARD ERROR		
Data Check	USE AFTER STANDARD ERROR		
End of File			AT END

Refer to the "Use After Standard Error" discussion under indexed sequential for an example showing how to interrogate the DTF table. Also, see the following discussion "Modifying the DTF Table for Drect Files."

MODIFYING THE DTF FOR DIRECT FILES

The COBOL compiler builds a skeleton DTF table for files having direct organization. When the OPEN statement is executed, a transient routine uses this information to build a complete DTF table. The contents of the skeleton DTF table are illustrated in Table 6.

The programmer may modify the skeleton DTF table prior to execution of the OPEN statement in one of two ways.

1. By writing statements in the main COBOL program to access the DTF table and by writing a COBOL subprogram to modify the DTF table.

2. By writing statements in the COBOL main program to access the DTF table and by writing an assembler language subprogram to change the DTF table.

See the discussion "Modifying the DTF Table" under indexed sequential for an example of a COBOL main program and COBOL subprogram that modifies the DTF table.

Byte 3 (the fourth byte) can be changed to X'00' to suppress the verify option. Verification consists of IOCS checking to be sure that a record written out is correct. Suppression of the verify option could result in improved program performance.

CODING EXAMPLES FOR DIRECT ORGANIZATION FILES

The following examples illustrate how to create and retrieve, sequentially or randomly, a file with direct data organization.

The following job control cards can be used for the examples:

```
// DLBL   SYS004,'DIRECT ACCESS FILE',67/365,DA

// EXTENT SYS004,111111,1,1,00001,00030

// EXEC
```

Creating the File

This example illustrates how to create a direct organization file from cards. The DA-FILE is composed of unblocked 100 character records that are preceded by a 10-byte key. The key contains the customer identification, and the data portion contains customer name balance.

The file control section defines the DA-FILE. The SYMBOLIC KEY clause defines the data-name KEY-ID, which is a field in the CARD-FILE. This field will become the record key used by LIOCS to create the key portion of the disk record.

The ACTUAL KEY clause defines the data-name address that is in working storage. This field will contain the binary disk address used by LIOCS for its track reference field.

To properly align the binary CC and HH portions of this track reference field on a halfword boundary, the data-name address is preceded by a 01 FILLER. This forces FILLER to begin on a doubleword boundary. The M portion of the address is not aligned, but the BB, CC, and HH portions of the address are all on halfword or fullword boundaries.

The M, BB, and R portions of the address are assigned a picture of X with a value of LOW-VALUE to cause a binary zero to be inserted in these portions of the address. The BB and R portions should always be binary zeros in 2311 applications. The M portion is always zero in this example, since the data file is contained on one disk pack.

If the data file extends over several disk packs, the M portion of the address would have to be changed to access the correct disk pack. For example, if the file required 250 cylinders, it could be contained on two disk packs. The first 199 cylinders could be located on the first pack (assuming that cylinder zero contains the VTOC). A cylinder address in excess of 199 would indicate that the record is to be located on the second disk pack. To illustrate, a cylinder address of 229 should be located on cylinder 30 of pack 2. This can be accomplished by subtracting 199 from the cylinder address. If the results are positive, move a binary one to the M portion of the address, and the results of the subtraction to the CC portion of the address. This results in an address, as follows:

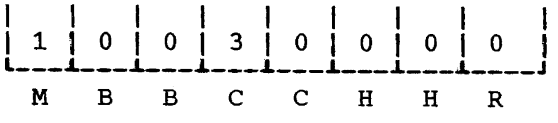


Table 6. Skeleton DTF Table for Direct Organization File

BYTE	0	-X'00'=RANDOM ACCESS X'F0'=SEQUENTIAL ACCESS
	1	-X'00'=2311 X'F0'=2321
	2	-X'00'=RESTRICTED SEARCH X'F0'=SEARCH MULTIPLE
	3	-X'00'=NO VERIFY X'F0'=VERIFY
	4-7	-I/O AREA ADDRESS
	8-11	-SYMBOLIC KEY ADDRESS
	12-15	-ACTUAL KEY ADDRESS
	16-19	-USER LABEL
	20-21	-LENGTH OF DATA FIELD
	22-29	-SYMBOLIC FILE-NAME
	30	-SYMBOLIC KEY LENGTH
	31	-X'00'=INPUT X'F0'=OUTPUT X'FF'=I/O
	32-35	-GLOBAL TABLE ADDRESS
	36	-X'00'=FIXED LENGTH RECORDS X'FF'=UNDEFINED LENGTH RECORDS
	37	-X'FF'=USER LABELS X'00'=NO USER LABELS

To assure that a binary one is moved to the M field, the following procedure may be used.

```
WORKING-STORAGE SECTION.
01 M-FLD PICTURE99USAGE COMPUTATIONAL.
01 M-FLD-2 REDEFINES M-FLD.
    02 FILLER PICTURE X.
    02 M-2 PICTURE.
```

M-FLD defines a halfword binary field. Move 1 to M-FLD. Then move M-2 to M. This will move the eight low-order bits of M-FLD to M.

If the literal 1 were moved directly to M, it would be stored there as a display item with a hexadecimal notation of 'F1'. This will produce an invalid address. The recommended procedure will cause a X'01' to be stored in M field, yielding the desired result.

The Procedure Division starts by opening the files. This will cause the transient open routine to construct the complete DTF table. In addition to the open functions of checking labels and creating VTOC entries, COBOL subroutine IHD03600 is entered at this time. The purpose of this subroutine is to issue the WRITE RECORD ZERO macro instruction to all the tracks specified by the EXTENT cards for the DA-FILE. This will assure that the track is cleared and that record zero is initialized with the correct information.

This subroutine relieves the user of the responsibility of running clear disk utilities or of rerunning the Initialize Disk program.

After the card is read, the randomizing routine is entered. This routine uses division by prime number. It is assumed that this small file fits on two cylinders, and a prime number of 19 is used as a divisor. The results of the routine (the remainder) are stored in TRACK, giving a decimal track address. Ten is added to the track address to avoid any references to cylinder zero.

The low-order byte must now be moved to the binary HH field of the ACTUAL KEY, and the three high-order bytes to the binary CC field. This is done by redefining the 4-digit track address into a 3-byte cylinder

number and a 1-byte head number. The move is then accomplished by accessing the appropriate data-names.

If there is room for the record on the accessed track, the record is written, an audit trail is printed, and a branch is made to get the next transaction.

If there is no room on the track, a branch to the synonym routine is made. This synonym routine uses the "spilling" technique. It checks the HH field for 9 to determine whether or not the end of cylinder has been reached. If it has not been reached, 1 is added to the head number and the write is repeated, this time attempting to write the synonym on the following track.

If the end of cylinder is reached without successfully writing the record, a branch is made to the end-of-cylinder routine. This routine will write synonyms on an overflow track located on cylinder 3, head 0. If the overflow track becomes full, the job is terminated. Abnormal termination, for this reason, would indicate the need for a better randomizing formula or more track reserved for overflow.

The END-JOB routine closes the file and terminates the run. It will also use information obtained by COBOL subroutine IHD03100 to write an end-of-file record. This subroutine has kept track of the last record location. It will write the EOF record on either the last track of the extent, or after the last record, whichever is greater.

```
01 001001 IDENTIFICATION DIVISION.
02        PROGRAM-ID. 'LOADDA'.
03        REMARKS.    ILLUSTRATE CREATION OF DIRECT ACCESS FILE.
04      3 AUTHOR.
05      4 INSTALLATION. 360 PROGRAMMING CENTER.
06        ENVIRONMENT DIVISION.
07        CONFIGURATION SECTION.
08        SOURCE-COMPUTER.  IBM-360.
09        OBJECT-COMPUTER.  IBM-360.
10 002001 INPUT-OUTPUT SECTION.
11        FILE-CONTROL.
12            SELECT  DA-FILE ASSIGN TO 'SYS004' DIRECT-ACCESS 2311
13              ACCESS IS SEQUENTIAL ORGANIZATION IS DIRECT
14              RESERVE NO ALTERNATE AREA
15              SYMBOLIC KEY IS KEY-ID
16              ACTUAL KEY IS ADDRESS.
17            SELECT CARD-FILE ASSIGN TO 'SYS005' UNIT-RECORD 2540R
18              RESERVE NO ALTERNATE AREA.
19            SELECT PRINT-FILE ASSIGN TO 'SYS006' UNIT-RECORD 1403
20              RESERVE NO ALTERNATE AREA.
21 003002 DATA DIVISION.
22        FILE SECTION.
23        FD  DA-FILE     DATA RECORD IS DISK
24                        RECORDING MODE IS F
25                        LABEL RECORDS ARE STANDARD.
26        01  DISK.
27            02  DISK-NAME   PICTURE X(20).
28            02  DISK-BAL    PICTURE  99999V99.
29            02  FILLER      PICTURE X(73).
30 004001 FD  CARD-FILE   DATA RECORD IS CARDS
31                        RECORDING MODE IS F
32                        LABEL RECORDS ARE OMITTED.
33        01  CARDS.
34            02  KEY-ID1 PICTURE  9(10).
35            02  CD-NAME PICTURE  X(20).
36            02  CD-BAL  PICTURE  99999V99.
37 005001 FD  PRINT-FILE  DATA RECORD IS PRINTER
38                        RECORDING MODE IS F
39                        LABEL RECORDS ARE OMITTED.
40        01  PRINTER.
```

```
41              02  PRINT-ID     PICTURE  X(10).
42              02  FILLER       PICTURE  X(10).
43              02  PRINT-NAME   PICTURE  X(20).
44              02  FILLER       PICTURE  X(10).
45              02  PRINT-BAL    PICTURE  $ZZ,ZZ9.99-.
46          WORKING-STORAGE SECTION.
47              77  KEY-ID PICTURE X(10).
48              77  NINE         PICTURE   99    USAGE COMPUTATIONAL VALUE 09.
49              77  SAVE         PICTURE S9(10)  USAGE COMPUTATIONAL-3.
50              77  QUOTIENT     PICTURE S9999   USAGE COMPUTATIONAL-3.
51              77  PRODUCT      PICTURE S9999   USAGE COMPUTATIONAL-3.
52          01  TRACK            PICTURE S9999.
53          01  TRACK2       REDEFINES TRACK.
54              02  CYL          PICTURE  999.
55              02  HEAD         PICTURE    9.
56          01  FILLER.
57              02  FILLER PICTURE X.
58              02  ADDRESS.
59                  03  M        PICTURE  X   VALUE LOW-VALUE.
60                  03  BB       PICTURE  XX   VALUE LOW-VALUE.
61                  03  CC       PICTURE  999    USAGE COMPUTATIONAL.
62                  03  HH       PICTURE  99     USAGE COMPUTATIONAL.
63                  03  R        PICTURE  X   VALUE LOW-VALUE.
64  006001 PROCEDURE DIVISION.
65          START.
66              OPEN INPUT  CARD-FILE
67                   OUTPUT PRINT-FILE  DA-FILE.
68          RD.
69              READ CARD-FILE AT END GO TO END-JOB.
70              MOVE KEY-ID1 TO KEY-ID.
71              MOVE KEY-ID TO SAVE.
72              DIVIDE 19 INTO SAVE   GIVING QUOTIENT.
73              MULTIPLY QUOTIENT BY 19 GIVING PRODUCT.
74              SUBTRACT PRODUCT FROM SAVE GIVING TRACK.
75              ADD 10 TO TRACK.
76              MOVE HEAD TO HH.
77              MOVE CYL TO CC.
78              MOVE CD-NAME TO DISK-NAME.
79              MOVE CD-BAL  TO DISK-BAL.
80          WR.
81              WRITE DISK INVALID KEY GO TO SYNONYMN-ROUTINE.
82          PRT.
83              MOVE CD-NAME TO PRINT-NAME.
84              MOVE CD-BAL  TO PRINT-BAL.
85              MOVE KEY-ID  TO PRINT-ID.
86              WRITE PRINTER.
87              GO TO RD.
88  007001 SYNONYMN-ROUTINE.
89              IF HH IS EQUAL TO NINE GO TO END-OF-CYLINDER.
90              ADD 1 TO HH.
91              GO TO WR.
92          END-OF-CYLINDER.
93              MOVE 3 TO CC.
94              MOVE ZERO TO HH.
95              WRITE DISK INVALID KEY GO TO NO-ROOM.
96              GO TO PRT.
97          NO-ROOM.
98              DISPLAY 'CYLINDER OVERFLOW FULL' UPON CONSOLE.
99          END-JOB.
00              CLOSE  CARD-FILE  PRINT-FILE  DA-FILE
01              DISPLAY 'END JOB' UPON CONSOLE.
02              STOP RUN.
```

Random Retrieval -- Direct Organization

This coding example illustrates random retrieval from the file created in the previous example.

The Data Division contains basically the same information as that in the previous example. The DA-FILE is opened as input, which permits updating. By opening the file as Input-Output, additions to the file could be made in the same run, or in a separate processing program.

The same randomizing formula is used as in loading the file. The SYMBOLIC KEY data-name (KEY-ID) specifies the key of the record to be found. The READ verb starts a search for an equal key on the track specified by the ACTUAL KEY address.

If the record is found, data is printed, the disk record is updated, and the next transaction is read.

Since the search was not restricted, the record will be found if it is either on the track specified or on any following tracks of the same cylinder. Only if the record is not located prior to reaching the end of the cylinder does a "no record found" condition occur. This will cause a branch to the END-OF-CYLINDER routine.

The END-OF-CYLINDER routine initiates a search for the record on the overflow cylinder. If the record is located, a branch is made to the processing routine. If another "no record found" condition occurs, the error and error record are identified, and processing continues with the next transaction.

The END-JOB routine terminates the run.

```
01 001001 IDENTIFICATION DIVISION.
02        PROGRAM-ID.   'RANDA'.
03        REMARKS.  ILLUSTRATE RANDOM RETRIEVAL FROM DA FILE.
04      3 AUTHOR.
05      4 INSTALLATION.  360 PROGRAMMING CENTER.
06        ENVIRONMENT DIVISION.
07        CONFIGURATION SECTION.
08        SOURCE-COMPUTER.  IBM-360.
09        OBJECT-COMPUTER.  IBM-360.
10 002001 INPUT-OUTPUT SECTION.
11        FILE-CONTROL.
12            SELECT  DA-FILE ASSIGN TO 'SYS004' DIRECT-ACCESS 2311
13              ACCESS IS RANDOM     ORGANIZATION IS DIRECT
14              RESERVE NO ALTERNATE AREA
15              SYMBOLIC KEY IS KEY-ID
16              ACTUAL KEY IS ADDRESS.
17            SELECT CARD-FILE ASSIGN TO 'SYS005' UNIT-RECORD 2540R
18              RESERVE NO ALTERNATE AREA.
19            SELECT  PRINT-FILE ASSIGN TO 'SYS006' UNIT-RECORD 1403
20              RESERVE NO ALTERNATE AREA.
21 003002 DATA DIVISION.
22            FILE SECTION.
23        FD  DA-FILE     DATA RECORD IS DISK
24                        RECORDING MODE IS F
25                        LABEL RECORDS ARE STANDARD.
26        01  DISK.
27            02  DISK-NAME    PICTURE  X(20).
28            02  DISK-BAL     PICTURE  99999V99.
29            02  FILLER       PICTURE  X(73).
30 004001 FD  CARD-FILE  DATA RECORD IS CARDS
31                        RECORDING MODE IS F
32                        LABEL RECORDS ARE OMITTED.
```

```
33          01  CARDS.
34              02  KEY-ID1  PICTURE  9(10).
35              02  CD-NAME PICTURE  X(20).
36              02  CD-AMT  PICTURE  S99999V99.
37 005001 FD  PRINT-FILE  DATA RECORD IS PRINTER
38                        RECORDING MODE IS F
39                        LABEL RECORDS ARE OMITTED.
40          01  PRINTER.
41              02  PRINT-ID     PICTURE  X(10).
42              02  FILLER       PICTURE  X(10).
43              02  PRINT-NAME   PICTURE  X(20).
44              02  FILLER       PICTURE  X(10).
45              02  PRINT-BAL    PICTURE  $ZZ,ZZ9.99-.
46              02  FILLER       PICTURE  X(10).
47              02  PRINT-AMT    PICTURE  ZZ,ZZ9.99-.
48              02  FILLER       PICTURE  X(10).
49              02  PRINT-NEW-BAL  PICTURE  ZZ,ZZ9.99-.
50          WORKING-STORAGE SECTION.
51              77  KEY-ID PICTURE X(10).
52              77  NINE         PICTURE   99    USAGE COMPUTATIONAL VALUE 09.
53              77  SAVE         PICTURE S9(10)  USAGE COMPUTATIONAL-3.
54              77  QUOTIENT     PICTURE S9999   USAGE COMPUTATIONAL-3.
55              77  PRODUCT      PICTURE S9999   USAGE COMPUTATIONAL-3.
56          01  TRACK            PICTURE S9999.
57          01  TRACK2       REDEFINES TRACK.
58              02  CYL          PICTURE  999.
59              02  HEAD         PICTURE    9.
60          01  FILLER.
61              02  FILLER PICTURE X.
62              02  ADDRESS.
63                  03  M        PICTURE  X      VALUE LOW-VALUE.
64                  03  BB       PICTURE  XX     VALUE LOW-VALUE.
65                  03  CC       PICTURE  999    USAGE COMPUTATIONAL.
66                  03  HH       PICTURE  99     USAGE COMPUTATIONAL.
67                  03  R        PICTURE  X      VALUE LOW-VALUE.
68 006001 PROCEDURE DIVISION.
69          START.
70              OPEN  INPUT   CARD-FILE
71                    OUTPUT  PRINT-FILE
72                    INPUT DA-FILE.
73          RD.
74              READ CARD-FILE AT END GO TO END-JOB.
75              MOVE KEY-ID1 TO KEY-ID
76              MOVE KEY-ID TO SAVE.
77              DIVIDE 19 INTO SAVE   GIVING QUOTIENT.
78              MULTIPLY QUOTIENT BY 19 GIVING PRODUCT.
79              SUBTRACT PRODUCT  FROM  SAVE  GIVING TRACK.
80              ADD 10 TO TRACK.
81              MOVE HEAD TO HH.
82              MOVE CYL  TO CC.
83              READ DA-FILE  INVALID KEY GO TO END-OF-CYLINDER.
84          ADD.
85              MOVE DISK-BAL   TO PRINT-BAL.
86              ADD  CD-AMT     TO DISK-BAL.
87              MOVE CD-AMT     TO PRINT-AMT.
88              MOVE DISK-NAME  TO PRINT-NAME.
89              MOVE DISK-BAL   TO PRINT-NEW-BAL.
90              MOVE KEY-ID     TO PRINT-ID.
91              WRITE PRINTER.
92              REWRITE DISK.
93              GO TO RD.
94          END-OF-CYLINDER.
95              MOVE 3 TO CC.
96              MOVE ZERO TO HH.
97              READ DA-FILE INVALID KEY GO TO NO-RECORD.
98              GO TO ADD.
99          NO-RECORD.
00              DISPLAY 'NO RECORD FOUND' UPON CONSOLE.
```

```
01              DISPLAY KEY-ID  UPON CONSOLE.
02              GO TO RD.
03          END-JOB.
04              CLOSE CARD-FILE  PRINT-FILE  DA-FILE
05              DISPLAY 'END JOB' UPON CONSOLE.
06              STOP RUN.
```

Sequential Retrieval -- Direct Organization

This program illustrates sequential retrieval of the direct-access records in their physical sequence.

The starting disk address, Cylinder 1, Head 0, is moved to the ACTUAL KEY address.

The READ statement fetches the first record and locates the address of the next record. Both the key and data portion of the DASD record are read since the SYMBOLIC KEY clause is specified.

A listing is made of the DA-FILE. Each READ statement issued to the DA-FILE retrieves another record and locates the following record. This continues until the end-of-file record is reached, at which time the program branches to the END-JOB routine.

```
01 001001 IDENTIFICATION DIVISION.
02        PROGRAM-ID. 'SEQDA'.
03        REMARKS.      ILLUSTRATE SEQ. RETRIEVAL OF DIRECT ACCESS FILE.
04      3 AUTHOR.
05      4 INSTALLATION.    360 PROGRAMMING CENTER.
06        ENVIRONMENT DIVISION.
07        CONFIGURATION SECTION.
08        SOURCE-COMPUTER.  IBM-360.
09        OBJECT-COMPUTER.  IBM-360.
10 002001 INPUT-OUTPUT SECTION.
11        FILE-CONTROL.
12            SELECT  CA-FILE ASSIGN TO 'SYS004' DIRECT-ACCESS 2311
13              ACCESS IS SEQUENTIAL ORGANIZATION IS DIRECT
14              RESERVE NO ALTERNATE AREA
15              SYMBOLIC KEY IS KEY-ID
16              ACTUAL KEY IS ADDRESS.
17            SELECT  PRINT-FILE ASSIGN TO 'SYS006' UNIT-RECORD 1403
18              RESERVE NO ALTERNATE AREA.
19 003002 DATA DIVISION.
20        FILE SECTION.
21        FD  DA-FILE     DATA RECORD IS DISK
22                        RECORDING MODE IS F
23                        LABEL RECORDS ARE STANDARD.
24        01  DISK.
25            02  DISK-NAME    PICTURE  X(20).
26            02  DISK-BAL     PICTURE  99999V99.
27            02  FILLER       PICTURE  X(73).
28 005001 FD  PRINT-FILE  DATA RECORD IS PRINTER
29                        RECORDING MODE IS F
30                        LABEL RECORDS ARE OMITTED.
31        01  PRINTER.
32            02  PRINT-ID     PICTURE  X(10).
33        02  FILLER           PICTURE  X(10).
34            02  PRINT-NAME   PICTURE  X(20).
35            02  FILLER       PICTURE  X(10).
36            02  PRINT-BAL    PICTURE  $ZZ,ZZ9.99-.
37        WORKING-STORAGE SECTION.
38            77  KEY-ID       PICTURE  X(10).
39        01  FILLER.
40            02  FILLER  PICTURE X.
41            02  ADDRESS.
```

```
                03  M          PICTURE  X   VALUE LOW-VALUE.
                03  BB         PICTURE  XX   VALUE LOW-VALUE.
                03  CC         PICTURE  999    USAGE COMPUTATIONAL.
                03  HH         PICTURE  99     USAGE COMPUTATIONAL.
                03  R          PICTURE  X   VALUE LOW-VALUE.
006001 PROCEDURE DIVISION.
       START.
           MOVE  ZERO TO HH.
           MOVE  1    TO CC.
           OPEN  INPUT  DA-FILE
                 OUTPUT PRINT-FILE.
       RD.
           READ DA-FILE AT END GO TO END-JOB.
           MOVE DISK-NAME  TO PRINT-NAME.
           MOVE DISK-BAL   TO PRINT-BAL.
           MOVE KEY-ID     TO PRINT-ID.
       PRT.
           WRITE PRINTER.

           GO TO RD.
       END-JOB.
           DISPLAY 'END OF JOB' UPON CONSOLE.
           CLOSE  DA-FILE  PRINT-FILE.
           STOP RUN.
```

```
IDENTIFICATION DIVISION.
PROGRAM-ID.  'program-name'.
 [AUTHOR.  sentence...]
 [INSTALLATION.  sentence...]
 [DATE-WRITTEN.  sentence...]
 [DATE-COMPILED.  sentence...]
 [SECURITY.  sentence...]
 [REMARKS.  sentence...]

ENVIRONMENT DIVISION.
[CONFIGURATION SECTION.
  [SOURCE-COMPUTER.  IBM-360 [model-number].]
  [OBJECT-COMPUTER.  IBM-360 [model-number].]]

[INPUT-OUTPUT SECTION.
 FILE-CONTROL.  [COPY library-name.]
  SELECT file-name [COPY library-name.]

    ASSIGN TO external-name {DIRECT-ACCESS}
                            {UTILITY      } device-number UNIT [S]
                            {UNIT-RECORD  }
    [RESERVE {NO}
             {1 } ALTERNATE AREA[S]]

    [ACCESS IS {SEQUENTIAL}]
               {RANDOM    }
    [ORGANIZATION IS {INDEXED}]
                     {DIRECT }

    [SYMBOLIC KEY IS data-name]
    [ACTUAL KEY IS data-name]
    [RECORD KEY IS data-name].]

I-O-CONTROL.

 [SAME AREA FOR file-name-1 file-name-2 [file-name-3...].]

[RERUN ON 'external-name' {DIRECT-ACCESS} [device-number UNIT[S]]]
                          {UTILITY      }
    EVERY integer RECORDS OF file-name]

 [APPLY overflow-name TO FORM-OVERFLOW ON file-name.]

 [APPLY WRITE-ONLY ON file-name.....]

 [APPLY RESTRICTED SEARCH OF integer TRACKS ON file-name.....].

DATA DIVISION.

FILE SECTION.

FD file-name  [COPY library-name.]

   [BLOCK CONTAINS integer {CHARACTERS}]
                           {RECORDS   }

    [RECORDING MODE IS {U}
                       {F} ]
                       {V}
```

```
[RECORD CONTAINS [integer-1 TO] integer-2 CHARACTERS]

     {RECORD IS  }  {STANDARD  }
LABEL{RECORDS ARE}  {OMITTED   }
                    {data-name }

DATA {RECORDS ARE} record-name...
     {RECORD  IS }
```

Record Description Entry.

WORKING-STORAGE SECTION.

Record Description entries

LINKAGE SECTION.

Record Description entries

```
level-number  {data-name}[REDEFINES data-name-2] [COPY library-name.]
              {FILLER   }

[                 {alpha-form  }  ]
[PICTURE IS       {an-form     }  ]
[                 {numeric-form}  ]
[                 {report-form }  ]
[                 {fp-form     }  ]

   [OCCURS integer TIMES [DEPENDING ON data-name]]

   [JUSTIFIED RIGHT]

   [BLANK WHEN ZERO]

[VALUE IS literal]

[                 {DISPLAY           }  ]
[USAGE IS         {COMPUTATIONAL     }  ]
[                 {COMPUTATIONAL-1   }  ]
[                 {COMPUTATIONAL-2   }  ]
[                 {COMPUTATIONAL-3   }  ]
```

PROCEDURE DIVISION.

```
DECLARATIVES.
{section-name SECTION.  USE-SENTENCE.
{paragraph-name.    sentence...  .}   ...}   ...

END DECLARATIVES.

USE FOR CREATING [BEGINNING] LABELS ON OUTPUT file-name...
                 [ENDING   ]

USE FOR CHECKING [BEGINNING] LABELS ON INPUT file-name...
                 [ENDING   ]
```

USE AFTER STANDARD ERROR PROCEDURE ON file-name.

Conditionals.

IF Statement.

```
IF condition [THEN] {statement-1...  } [{ELSE     } {statement-2...  }]
                    {NEXT SENTENCE   } [{OTHERWISE} {NEXT SENTENCE   }]
```

Relation Test.

```
                                            { >            } { data-name-2    }
{data-name-1            }                   { <            } {                }
{arithmetic-expression-1}   IS [NOT]        { =            } { arithmetic     }
{figurative-constant-1  }                   { GREATER THAN } { expression-2   }
{literal-1              }                   { LESS THAN    } {                }
                                            { EQUAL TO     } { figurative     }
                                                             { constant-2     }
                                                             {                }
                                                             { literal-2      }
```

Sign Test.

```
{data-name            }  IS  [NOT]  {POSITIVE}
{arithmetic-expression}             {ZERO    }
                                    {NEGATIVE}
```

Class Test.

```
data-name IS  [NOT]   {NUMERIC   }
                      {ALPHABETIC}
```

Condition Name Test.

```
[NOT] condition-name
```

Overflow Test.

```
[NOT] overflow-name
```

Open and Close Statements.

```
      { INPUT  {file-name  [WITH NO REWIND   [REVERSED]]} ...          }
      {      [OUTPUT{file-name [WITH NO REWIND]}....]                  }
      {      [I-O {file-name} ...]                                     }
OPEN  {                                                                }
      { OUTPUT {file-name [WITH NO REWIND]}...                         }
      {        [INPUT {file-name [WITH NO REWIND [REVERSED]]}...]      }
      {        [I-O {file-name} ...]                                   }
      {                                                                }
      { I-O {file-name}...[OUTPUT{file-name [WITH NO REWIND]}...]      }
      {     [INPUT {file-name [WITH NO REWIND[REVERSED]]}...]          }

           {              [UNIT]  [      {NO REWIND}] }
CLOSE      {file-name     [REEL]  [WITH  {LOCK     }] } ...
```

Input/Output Verbs

```
READ file-name RECORD  [INTO data-name] AT END
     imperative statement...

READ file-name RECORD  [INTO data-name]

     {AT END     }   imperative statement...
     {INVALID KEY}

WRITE record-name  [FROM data-name-1]
      [INVALID KEY imperative statement...]
```

```
WRITE record-name[FROM data-name-1]

      [AFTER ADVANCING {data-name-2} LINES]
                       {integer    }
```

permissable values for data-name-2

Value	Interpretation
b (blank)	single spacing
0	double spacing
-	triple spacing
+	suppress spacing
1 through 9	skip to channels 1 through 9, respectively
A, B, C	skip to channels 10, 11, 12, respectively
V, W	pocket select 1 or 2, respectively on the IBM 1442, or 2540 and P1 or P2 on the IBM 2540

Permissible integer

0 - skip to next-page
1 - skip 1 line
2 - skip 2 lines
3 - skip 3 lines

```
REWRITE record-name  [FROM data-name]
       [INVALID KEY imperative-statement...]

DISPLAY  {data-name} ...  [UPON CONSOLE  ]
         {literal   }     [UPON SYSPUNCH]

ACCEPT data-name    [FROM CONSOLE]
```

Data Manipulation Verbs

```
MOVE {data-name-1} TO data-name-2 ...
     {literal    }
```

Option 1

```
EXAMINE data-name TALLYING {ALL       } 'character-1'
                           {LEADING   }
                           {UNTIL FIRST}

        [REPLACING BY 'character-2']
```

Option 2

```
EXAMINE data-name REPLACING {ALL       }
                            {LEADING   }
                            {UNTIL FIRST}'character-1'
                            {FIRST     }

       BY 'character-2'

TRANSFORM data-name-3 CHARACTERS

FROM  {figurative-constant-1}  TO  {figurative-constant-2}
      {non-numeric-literal-1}      {non-numeric literal-2}
      {data-name-1          }      {data-name-2          }
```

Arithmetic Verbs

```
ADD      {numeric-literal          }
         {floating point literal   } ...  {TO    }  data-name-n
         {data-name-1              }      {GIVING}

         [ROUNDED]    [ON SIZE ERROR imperative-statement...]


SUBTRACT{data-name-1              }
        {numeric-literal-1        }  ...
        {floating-point-literal-1 }

   FROM {data-name-m      [GIVING data-name-n]  }
        {numeric-literal-m  GIVING data-name-n   }
        {floating-point-literal-m  GIVING data-name-n}

        [ROUNDED]   [ON SIZE ERROR imperative statement...]

MULTIPLY{data-name-1              }
        {numeric-literal-1        }
        {floating-point-literal-1 }

     BY {data-name-2        [GIVING data-name-3]  }
        {numeric-literal-2   GIVING data-name-3   }
        {floating-point-literal-2 GIVING data-name-3}

        [ROUNDED]  [ON SIZE ERROR imperative statement...]


 DIVIDE {data-name-1              }
        {numeric-literal-1        }
        {floating-point-literal-1 }

   INTO {data-name-2    [GIVING data-name-3]  }
        {numeric-literal-2 GIVING data-name-3  }
        {floating-point-literal-2  GIVING data-name-3}

        [ROUNDED]  [ON SIZE ERROR imperative statement...]

COMPUTE data-name-1   [ROUNDED] ={data-name-2          }
                                 {numeric-literal      }
                                 {floating-point-literal}
                                 {arithmetic-expression}

     [ON SIZE ERROR imperative-statement...]
```

Procedure Branching Statements.

```
        STOP {RUN    }
             {literal}
```

Option_1

```
GO_TO   [procedure-name]
```

Option_2

```
GO_TO procedure-name-1 [procedure-name-2...] DEPENDING ON data-name

ALTER {procedure-name-1 TO PROCEED TO procedure-name-2}     ...
```

Option_1

```
PERFORM procedure-name-1  [THRU procedure-name-2]
```

Option 2

```
PERFORM procedure-name-1  [THRU procedure-name-2]  {integer   }  TIMES
                                                   {data-name}
```

Option 3

```
PERFORM procedure-name-1 [THRU procedure-name-2]
          UNTIL test-condition
```

Option 4

```
PERFORM procedure-name-1 [THRU procedure-name-2]
   VARYING data-name-1   FROM  {numeric-literal-2}
                               {  data-name-2    }

   BY  {numeric-literal-3}       UNTIL test-condition-1
       {  data-name-3    }

   [AFTER data-name-4    FROM  {numeric-literal-4}
                               {  data-name-5    }

   BY  {numeric-literal-6}       UNTIL test-condition-2]
       {  data-name-6    }

   [AFTER data-name-7    FROM  {numeric-literal-8}
                               {  data-name-8    }

   BY  {numeric-literal-9}       UNTIL test-condition-3]
       {  data-name-9    }
```

Compiler-Directing Statements.

```
ENTER LINKAGE.
CALL entry-name    [USING argument...]
ENTER COBOL.

ENTER LINKAGE.
ENTRY entry-name   [USING data-name...]
ENTER COBOL.

ENTER LINKAGE.
RETURN.
ENTER COBOL.
```

EXIT Statement.

```
paragraph-name.  EXIT.
```

NOTE Statement.

```
NOTE comment...
```

INCLUDE statement.

Option 1.

```
paragraph-name.  INCLUDE library-name.
```

Option 2.

```
section-name SECTION.  INCLUDE library-name.
```

COPY Statement.

(within the Input-Output Section):

```
{FILE-CONTROL.}  COPY library-name.
{I-O-CONTROL. }
```

(within the File-Control Paragraph):

```
SELECT file-name COPY library-name.
```

(within the File Section):

```
FD file-name COPY library-name.
```

(within a file, Working-Storage or Linkage Section):

```
01 data-name COPY library-name.
```

(within Working Storage or Linkage Section):

```
77 data-name COPY library-name.
```

COBOL Debugging Statements.

TRACE Statement.

```
{READY}
{RESET}   TRACE
```

EXHIBIT Statement.

```
                {NAMED        }                {data-name        }
EXHIBIT         {CHANGED NAMED}                {non-numeric-literal}   ...
                {CHANGED      }
```

ON (Count-Conditional) Statement

```
ON integer-1 [AND EVERY integer-2] [UNTIL Integer-3]

{imperative-statement}...  [{ELSE     }{statement ...}]
{NEXT SENTENCE       }     [{OTHERWISE}{NEXT SENTENCE}]
```

Debug Packet Statement

```
1       8
*DEBUG location
```

PERMISSIBLE COMPARISONS

		SECOND OPERAND									
		GR	AL	AN	ED	ID	BI	EF	IF	RP	FC
FIRST OPERAND	Group Item (GR)	NN	NN	NN	NN	NN	NN	NN	NN	NN	NN
	Alphabetic Item (AL).	NN	NN	NN							NN[1]
	Alphanumeric (non-report) Item (AN)	NN	NN	NN	NN[5]					NN	NN
	External Decimal Item (ED)	NN		NN[5]	NU	NU	NU	NU	NU		NU[3]
	Internal Decimal Item (ID)	NN			NU	NU	NU	NU	NU		NU[2]
	Binary Item (BI)	NN			NU	NU	NU	NU	NU		NU[2]
	External Floating-point Item (EF)	NN			NU	NU	NU	NU	NU		NU[2]
	Internal Floating-point Item (IF)	NN			NU	NU	NU	NU	NU		NU[2]
	Report Item (RP)	NN		NN						NN	NN[4]
	Figurative Constant (FC)	NN	NN[1]	NN	NU[3]	NU[2]	NU[2]	NU[2]	NU[2]	NN[4]	

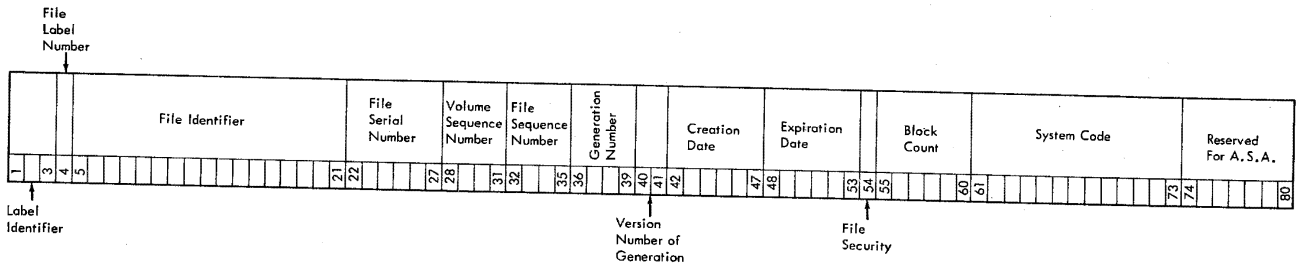
Abbreviations for Types of Comparison
NN - Comparison as described for non-numeric items
NU - Comparison as described for numeric items
[1]Permitted with the figurative constants SPACE and ALL 'character' where character must be alphabetic.
[2]Permitted only if figurative constant is ZERO.
[3]Permitted only if figurative constant is ZERO or ALL 'character' where character must be numeric.
[4]Not permitted with figurative constant QUOTE.
[5]External decimal field must consist of integers.

PERMISSIBLE MOVES

	Receiving Field								
Source Field	GR	AL	AN	ED	ID	BI	EF	IF	RP
Group (GR)	Y	Y	Y	N	N	N	N	N	N
Alphabetic (AL)	Y	Y	Y	N	N	N	N	N	N
Alphanumeric (AN)	Y	Y	Y	N	N	N	N	N	N
External Decimal (ED)	Y	N	Y[1]	Y	Y	Y	Y	Y	Y
Internal Decimal (ID)	Y	N	Y[1]	Y	Y	Y	Y	Y	Y
Binary (BI)	Y	N	Y[1]	Y	Y	Y	Y	Y	Y
External Floating-Point (EF)	Y	N	N	Y	Y	Y	Y	Y	Y
Internal Floating-Point (IF)	Y	N	N	Y	Y	Y	Y	Y	Y
Report (RP)	Y	N	Y	N	N	N	N	N	N
Zeros	Y	N	Y	Y	Y	Y	Y	Y	Y
Spaces	Y	Y	Y	N	N	N	N	N	N
ALL 'character', HIGH-VALUES, LOW-VALUES, QUOTES	Y	N	Y	N	N	N	N	N	N

[1]For integers only.

APPENDIX B: STANDARD TAPE FILE LABELS

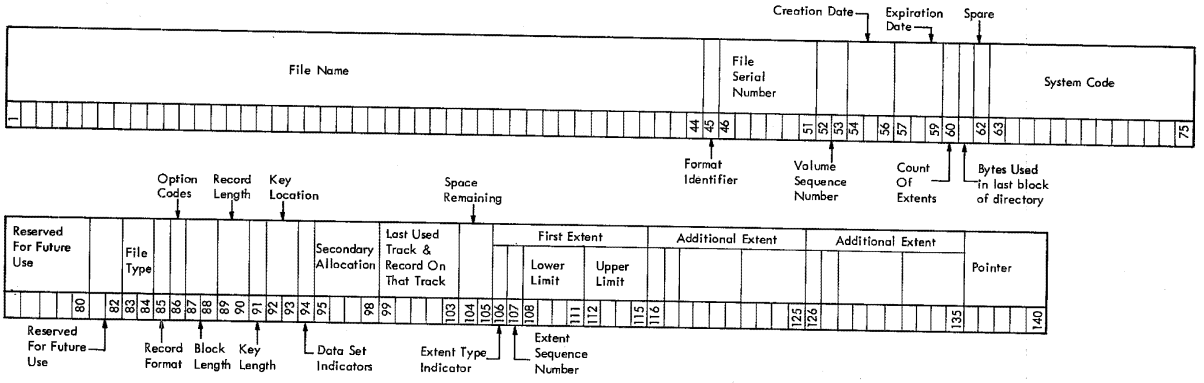


The standard tape file label format and contents are as follows:

FIELD	NAME AND LENGTH	DESCRIPTION
1.	LABEL IDENTIFIER 3 bytes, EBCDIC	identifies the type of label HDR = Header -- beginning of a data file EOF = End of File -- end of a set of data EOV = End of Volume -- end of the physical reel
2.	FILE LABEL NUMBER 1 byte, EBCDIC	Always a 1
3.	FILE IDENTIFIER 17 bytes, EBCDIC	uniquely identifies the entire file, may contain only printable characters.
4.	FILE SERIAL NUMBER 6 bytes, EBCDIC	uniquely identifies a file/volume relationship. This field is identical to the Volume Serial Number in the volume label of the first or only volume of a multi-volume file or a multi-file set. This field will normally be numeric (000001 to 999999) but may contain any six alphameric characters.
5.	VOLUME SEQUENCE NUMBER 4 bytes	indicates the order of a volume in a given file or multi-file set. The first must be numbered 0001 and subsequent numbers must be in proper numeric sequence.
6.	FILE SEQUENCE NUMBER 4 bytes	assigns numeric sequence to a file within a multi-file set. The first must be numbered 0001.
7.	GENERATION NUMBER 4 bytes	uniquely identifies the various editions of the file. May be from 0001 to 9999 in proper numeric sequence.
8.	VERSION NUMBER OF GENERATION 2 bytes	indicates the version of a generation of a file.

FIELD	NAME AND LENGTH	DESCRIPTION
9.	CREATION DATE 6 bytes	indicates the year and the day of the year that the file was created: Position / Code / Meaning 1 / blank / none 2-3 / 00-99 / Year 4-6 / 001-366 / Day of Year (e.g., January 31, 1965 would be entered as 65031)
10.	EXPIRATION DATE 6 bytes	indicates the year and the day of the year when the file may become a scratch tape. The format of this field is identical to Field 9. On a multifile reel, processed sequentially, all files are considered to expire on the same day.
11.	FILE SECURITY 1 byte	indicates security status of the file. 0 = no security protection 1 = security protection. Additional identification of the file is required before it can be processed.
12.	BLOCK COUNT 6 bytes	indicates the number of data blocks written on the file from the last header label to the first trailer label exclusive of tape marks. Count does not include checkpoint records. This field is used in Trailer Labels.
13.	SYSTEM CODE 13 bytes	uniquely identifies the programming system.
14.	RESERVED 7 bytes	Reserved for American Standards Association (A.S.A.). At present should be recorded as blanks.

APPENDIX C: STANDARD DASD FILE LABELS -- FORMAT 1



Format 1: This format is common to all data files on disk.

FIELD	NAME AND LENGTH	DESCRIPTION
1.	FILE NAME 44 bytes, alphameric EBCDIC	This field serves as the key portion of the file label. It can consist of three sections: 1. File ID is an alphameric assigned by the user and identifies the file. Can be 1 - 35 bytes if generation and version numbers are used, or 1 - 44 bytes if they are not used. 2. Generation Number. If used, this field is separated from File ID by a period. It has the format Gnnnn, where G identifies the field as the generation number and nnnn (in decimal) identifies the generation of the file. 3. Version Number of Generation. If used, this section immediately follows the generation number and has the format Vnn, where V identifies the field as the version of generation number and nn (in decimal) identifies the version of generation of the file. Note: IBM System/360 Disk and Tape Operating Systems compares the entire field against the file name given in the DLAB card. The generation and version numbers are treated differently by Operating System/360.

The remaining fields comprise the DATA portion of the file label:

FIELD	NAME AND LENGTH	DESCRIPTION
2.	FORMAT IDENTIFIER 1 byte, EBCDIC numeric	1 = Format 1
3.	FILE SERIAL NUMBER 6 bytes, alphameric EBCDIC	Uniquely identifies a file/volume relationship. It is identical to the Volume Serial Number of the first or only volume of a multi-volume file. It is the disk pack number identification.
4	VOLUME SEQUENCE NUMBER 2 bytes, binary	Identifies each volume in a multi-volume file. Each volume is relative to the first volume on which the data file resides.
5	CREATION DATE 3 bytes, discontinuous binary	Indicates the year and the day of the year the file was created. It is of the form YDD, where Y signifies the year (0- 99) and DD the day of the year (1 - 366).
6	EXPIRATION DATE 3 bytes, discontinuous binary	Indicates the year and the day of the year the file may be deleted. The form of this field is identical to that of Field 5.
7A	EXTENT COUNT 1 byte, binary	Contains a count of the number of extents for this file on this volume.
7B	BYTES USED IN LAST BLOCK OF DIRECTORY 1 byte, binary	Used by Operating System/360 only for partitioned (library structure) data sets. Not used by Disk and Tape Operating Systems.
7C	SPARE 1 byte	Reserved for future use.
8	SYSTEM CODE 13 bytes	Uniquely identifies the programming system.
9	RESERVED 7 bytes	This field is reserved for future use.
10	FILE TYPE 2 bytes	The contents of this field uniquely identify the type of data file: Hex 4000 = Consecutive organization Hex 2000 = Direct - access organization Hex 8000 = Indexed - sequential organization Hex 0200 = Library organization Hex 0000 = Organization not defined in the file label.
11	RECORD FORMAT 1 byte	The contents of this field indicate the type of records contained in the file:

Bit Position	Content	Meaning
0 and 1	01	Variable - length records
	10	Fixed - length records
	11	Undefined format
2	0	No track overflow
	1	File is organized using track overflow (Operating System/360 only)
3	0	Unblocked records
	1	Blocked records

FIELD	NAME	DESCRIPTION
12	OPTION CODES 1 byte	Bits within this field are used to indicate various options used in building the file. BIT 0 = If on, indicates data file was created using Write Validity Check. 1-7 = unused
13.	BLOCK LENGTH 2 bytes, binary	Indicates the block length for fixed length records or maximum block size for variable length blocks.
14.	RECORD LENGTH 2 bytes, binary	Indicates the record length for fixed length records or the maximum record length for variable length records.
15.	KEY LENGTH 1 byte, binary	Indicates the length of the key portion of the data records in the file.
16.	KEY LOCATION 2 bytes, binary	Indicates the high order position of the data record.
17.	DATA SET INDICATORS 1 byte	Bits within this field are used to indicate the following: BIT 0 If on, indicates that this is the last volume on which this file normally resides. This bit is used by the Disk and Tape Operating Systems DTFSR routine only. None of the other bits in this byte are used by Disk and Tape Operating Systems. 1 If on, indicates that the data set described by this file must remain in the same absolute location on the direct access device. 2 If on, indicates that Block Length must always be a multiple of 8 bytes. 3 If on, indicates that this data file is security protected; a password must be provided in order to access it. 4-7 Spare. Reserved for future use.

Bit Position	Content	Meaning
4	0	No truncated records
	1	Truncated records in file
5 and 6	01	Control character ASA code
	10	Control Character machine code
	00	Control Character not stated
7	0	Records have no keys
	1	Records are written with keys

FIELD	NAME	DESCRIPTION
18.	SECONDARY ALLOCATION 4 bytes, binary	Indicates the amount of storage to be requested for this data file at End of Extent. This field is used by Operating System/360 only. It is not used by Disk and Tape Operating Systems routines. The first byte of this field is an indication of the type of allocation request. Hex code "C2" (EBCDIC "B") indicates bytes, hex code "E3" (EBCDIC "T") indicates tracks, and hex code "C3" (EBCDIC "C") indicates cylinders. The next three bytes of this field is a binary number indicating how many bytes, tracks or cylinders are requested.
19.	LAST USED TRACK AND RECORD ON THAT TRACK 5 bytes discontinuous binary	Indicates the last occupied track in a consecutive file organization data file. This field has the format CCHHR. It is all binary zeros if the last track in a consecutive data file is not on this volume or if it is not consecutive organization.
20.	AMOUNT OF SPACE REMAINING ON LAST TRACK USED 2 bytes, binary	A count of the number of bytes of available space remaining on the last track used by this data file on this volume.
21.	EXTENT TYPE INDICATOR 1 byte	Indicates the type of extent with which the following fields are associated: HEX CODE 00 Next three fields do not indicate any extent. 01 Prime area (indexed Sequential); or Consecutive area, etc., (i.e., the extent containing the user's data records.) 02 Overflow area of an indexed Sequential file. 04 Cylinder index or master index area of an Indexed Sequential file. 40 User label track area 80 Shared cylinder indicator.
22.	EXTENT SEQUENCE NUMBER 1 byte, binary	Indicates the extent sequence in a multi-extent file.
23.	LOWER LIMIT 4 bytes, discontinuous binary	The cylinder and the track address specifying the starting point (lower limit) of this extent component. This field has the format CCHH.
24.	UPPER LIMIT 4 bytes	The cylinder and the track address specifying the ending point (upper limit) of this extent component. This field has the format CCHH.
25-28	ADDITIONAL EXTENT 10 bytes	These fields have the same format as the fields 21-24 above.
29-32	ADDITIONAL EXTENT 10 bytes	These fields have the same format as fields 21-24 above.
33	POINTER TO NEXT FILE LABEL WITHIN THIS LABEL SET 5 bytes, discontinuous binary	The disk address (format CCHHR) of a continuation label if needed to further describe the file. If field 9 indicates Indexed Sequential organization, this field will point to a Format 2 file label within this label set. Otherwise, it points to a Format 3 file label, and then only if the file contains more than three extent segments. This field contains all binary zeros if no additional file label is pointed to.

The track format for the 2311, 2314, and 2321 is illustrated in Figure 25. The names of the fields are described in the following discussion.

Index Marker: All tracks start with an index marker. It is a signal to the hardware indicating the beginning of the track.

Home Address: The home address, preceded by a gap, follows the index marker. The home address uniquely identifies each track by specifying the cylinder and head number.

Track Descriptor Record (Record Zero): Record zero consists of two parts: a count portion and a data portion. The count portion is the same as it is for any other record (see the following description of count for record one). The 8-byte data portion is used to record information used by LIOCS. The information in the data portion depends on the data organization (direct or indexed sequential) that is being used.

For direct organization, this portion in the form of CCHHR contains the address of the last record on the track and the number of bytes remaining on the track. This information is used to determine if there is room for another record on the track. For indexed sequential, the data portion contains the address of the last record in the cylinder overflow area and the number of tracks remaining in the cylinder overflow area. Record zero is then used as the cylinder overflow control record.

Address Marker: All records after record zero will be preceded by a 2-byte address marker. The address marker is a signal to the hardware that a record is starting.

Data Records: Data records (see R1 in Figure 25) can consist of a count and data portion for sequential organization, or a count, key, and data portion for direct and indexed sequential organizations.

1. Count Portion. The count portion contains the identification of each record, the key length, and the data length.

   Identification. Each record is identified with its cylinder number, head number, or record number. The cylinder and head numbers will be the same as those of the home address. The record number will indicate which record this is on the track. That is, the first record after record zero will be record 1, followed by record 2, etc. This 5-byte binary field in the form of CCHHR is often referred to as the record ID.

   Key Length. The key length is specified in an 8-bit byte; its length can range from zero to 255. This field will contain a zero if there is no key.

   Data Length. The data length is specified in the 16 bits of the next two bytes.

   Note: It is the count portion that identifies the presence or absence of a key, as well as indicating the data length. In this way, each record is unique and self-formatting.

2. Key Portion. The key portion of the record is normally used to store the control field of the data record, such as a man number. Direct and indexed sequential files must have a key portion.

3. Data Portion. The data portion of the record contains the data record.

Note that all records, including the data record, end with a 2-byte cyclic check. The hardware uses this cyclic check to assure that it correctly reread what it had written. The cyclic check is cumulative and is appended to each record when it is written. Upon reading the record, the cyclic check is again accumulated and then compared with the appended cyclic check. If they do not agree, a data check is initiated.

The first byte of the count portion of each record and the home address is reserved for a flag byte. If a track becomes defective, a utility may be used to transfer the data to an alternate track. (Cylinders 200 through 202 are reserved for alternate tracks on the 2321. Strips 6 through 9 of subcell 19 of each cell are reserved for alternate tracks on the 2321.) In this case, a flag bit within the byte is set on to indicate that this is a defective track and the address of an alternate track will be placed in the record ID of record zero. Subsequent references to this defective track will result in the supervisor accessing record zero for the address of the alternate track.

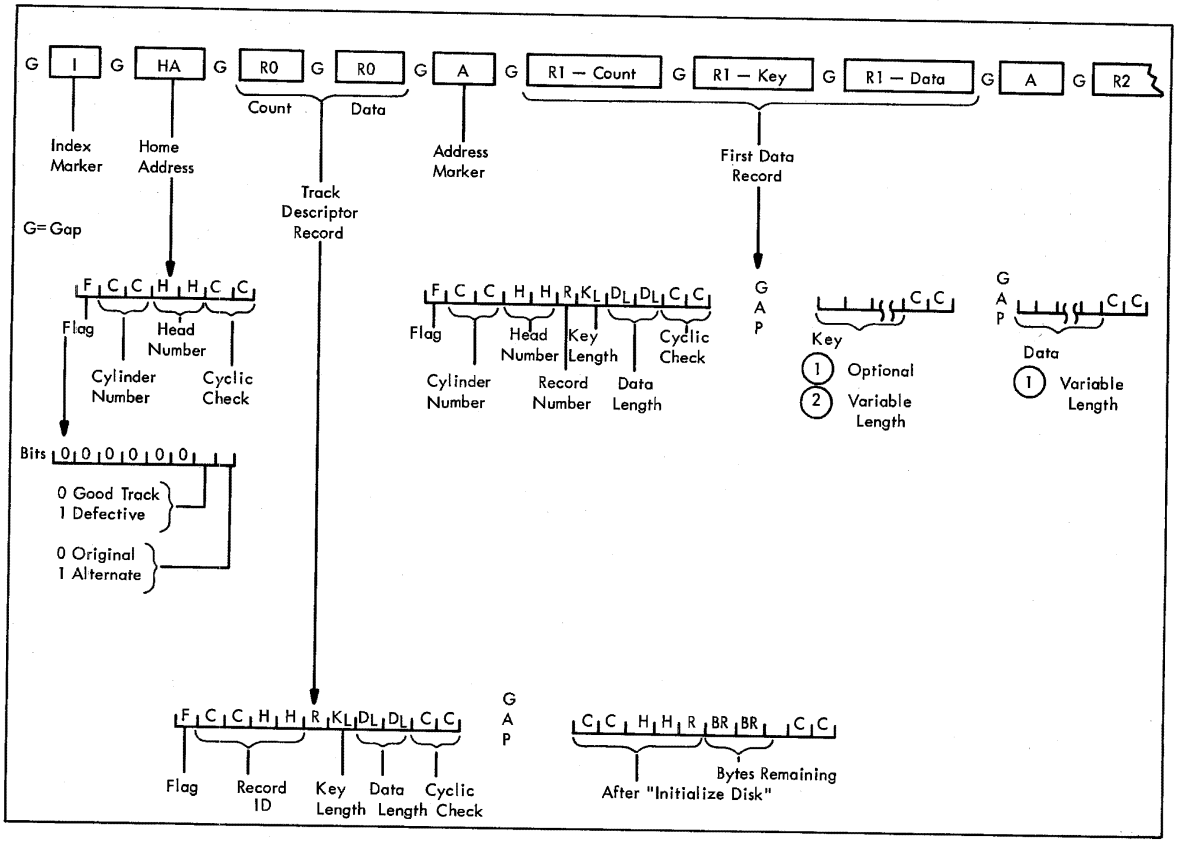
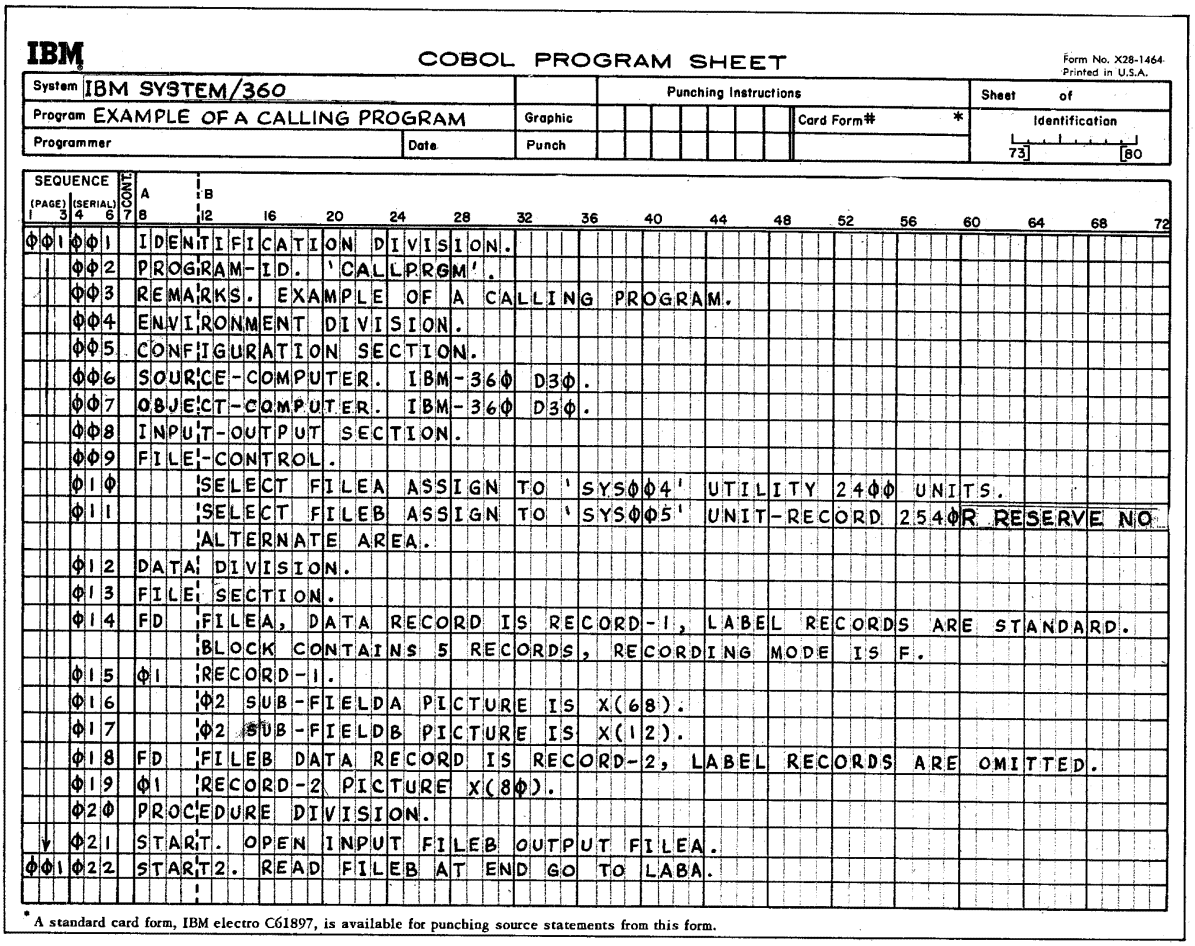


Figure 24. Track Format

This appendix contains two sample COBOL programs. Figure 25 is a calling program, the other, Figure 26, is a subprogram which is linked by the calling program. The linkage subprogram illustrated need not be a COBOL program. However, COBOL assumes option 2 of the standard CALL, SAVE, and RETURN macros.



IBM COBOL PROGRAM SHEET

Form No. X28-1464 Printed in U.S.A.

System: IBM SYSTEM/360 | Punching Instructions | Sheet of

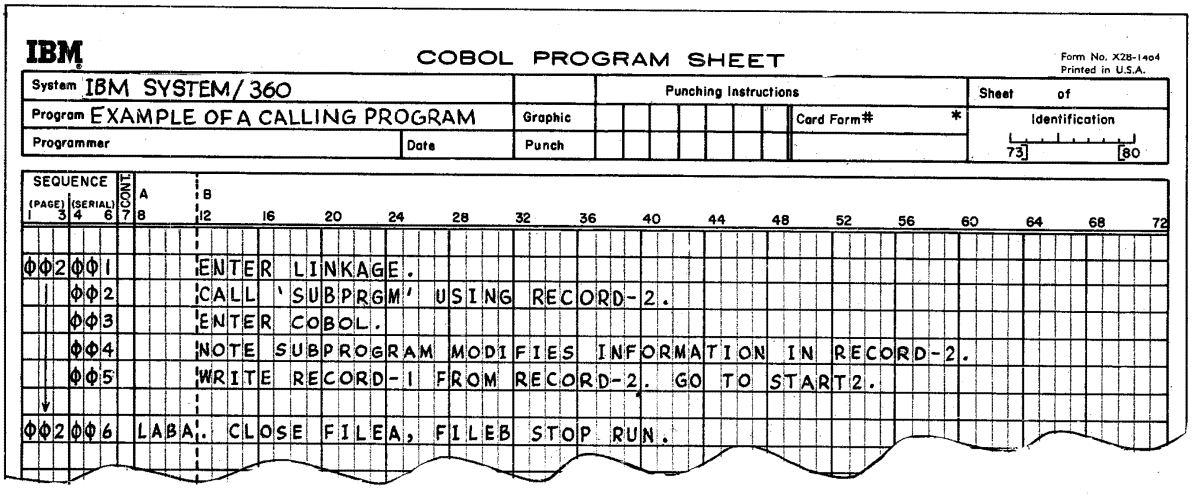
Program: EXAMPLE OF A CALLING PROGRAM | Graphic | Card Form# * | Identification (73–80)

Programmer | Date | Punch

```
SEQUENCE (PAGE) (SERIAL) CONT  A  B
                          7    8  12  16  20  24  28  32  36  40  44  48  52  56  60  64  68  72
ØØ1 ØØ1        IDENTIFICATION DIVISION.
    ØØ2        PROGRAM-ID. 'CALLPRGM'.
    ØØ3        REMARKS. EXAMPLE OF A CALLING PROGRAM.
    ØØ4        ENVIRONMENT DIVISION.
    ØØ5        CONFIGURATION SECTION.
    ØØ6        SOURCE-COMPUTER. IBM-36Ø D3Ø.
    ØØ7        OBJECT-COMPUTER. IBM-36Ø D3Ø.
    ØØ8        INPUT-OUTPUT SECTION.
    ØØ9        FILE-CONTROL.
    Ø1Ø            SELECT FILEA ASSIGN TO 'SYSØØ4' UTILITY 24ØØ UNITS.
    Ø11            SELECT FILEB ASSIGN TO 'SYSØØ5' UNIT-RECORD 2540R RESERVE NO
                   ALTERNATE AREA.
    Ø12        DATA DIVISION.
    Ø13        FILE SECTION.
    Ø14        FD  FILEA, DATA RECORD IS RECORD-1, LABEL RECORDS ARE STANDARD.
                   BLOCK CONTAINS 5 RECORDS, RECORDING MODE IS F.
    Ø15        Ø1  RECORD-1.
    Ø16            Ø2 SUB-FIELDA PICTURE IS X(68).
    Ø17            Ø2 SUB-FIELDB PICTURE IS X(12).
    Ø18        FD  FILEB DATA RECORD IS RECORD-2, LABEL RECORDS ARE OMITTED.
    Ø19        Ø1  RECORD-2 PICTURE X(8Ø).
    Ø2Ø        PROCEDURE DIVISION.
    Ø21        START. OPEN INPUT FILEB OUTPUT FILEA.
ØØ1 Ø22        START2. READ FILEB AT END GO TO LABA.
```

A standard card form, IBM electro C61897, is available for punching source statements from this form.

Figure 25. Example of a Calling Program (Part 1 of 2)



IBM COBOL PROGRAM SHEET

Form No. X28-1464 Printed in U.S.A.

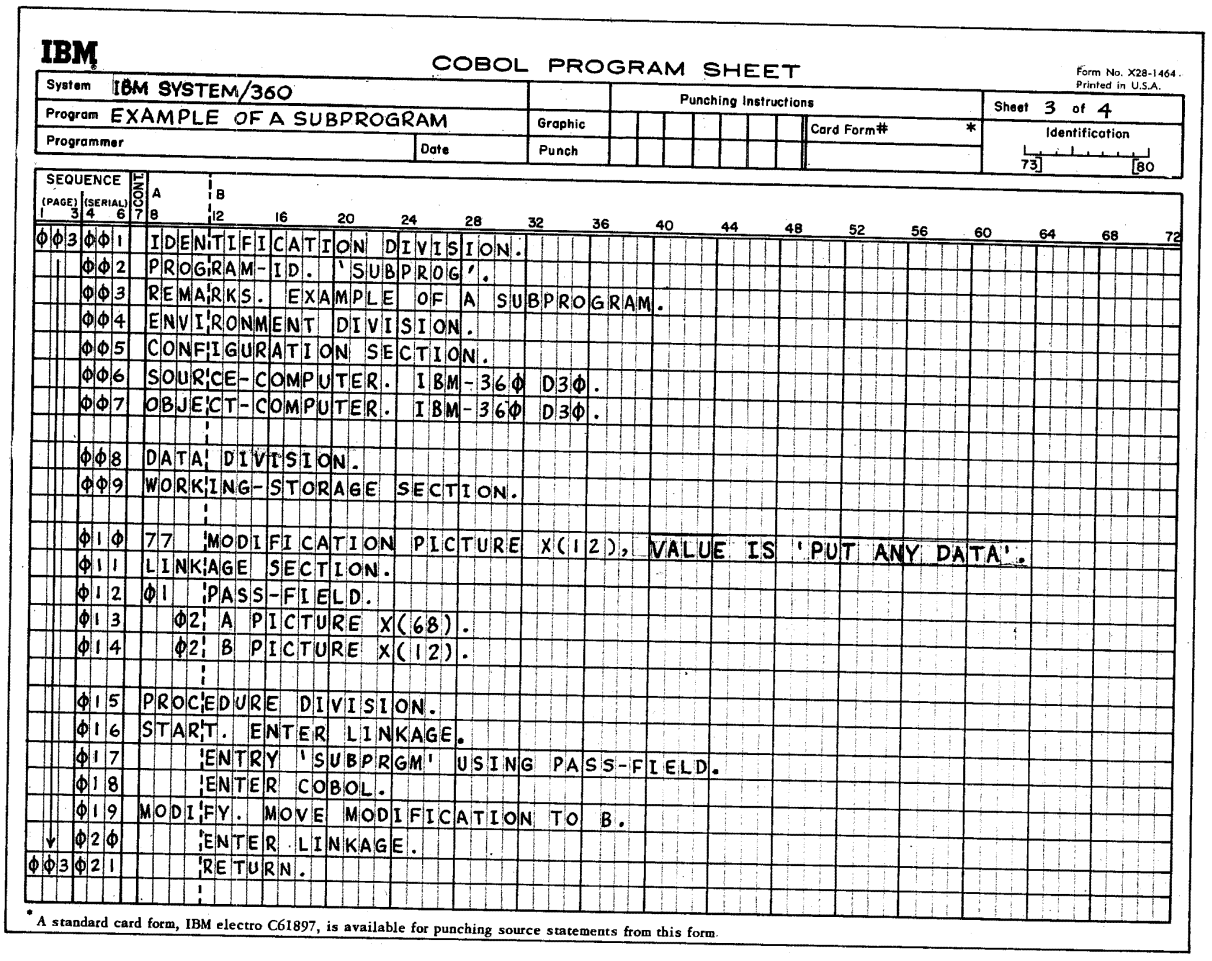
System: IBM SYSTEM/360 | Punching Instructions | Sheet of

Program: EXAMPLE OF A CALLING PROGRAM | Graphic | Card Form# * | Identification (73–80)

Programmer | Date | Punch

```
SEQUENCE (PAGE) (SERIAL) CONT  A  B
                          7    8  12  16  20  24  28  32  36  40  44  48  52  56  60  64  68  72
ØØ2 ØØ1            ENTER LINKAGE.
    ØØ2            CALL 'SUBPRGM' USING RECORD-2.
    ØØ3            ENTER COBOL.
    ØØ4            NOTE SUBPROGRAM MODIFIES INFORMATION IN RECORD-2.
    ØØ5            WRITE RECORD-1 FROM RECORD-2. GO TO START2.
ØØ2 ØØ6        LABA. CLOSE FILEA, FILEB STOP RUN.
```

Figure 25. Example of a Calling Program (Part 2 of 2)



IBM

COBOL PROGRAM SHEET

Form No. X28-1464. Printed in U.S.A.

System: IBM SYSTEM/360 | Punching Instructions | Sheet 3 of 4

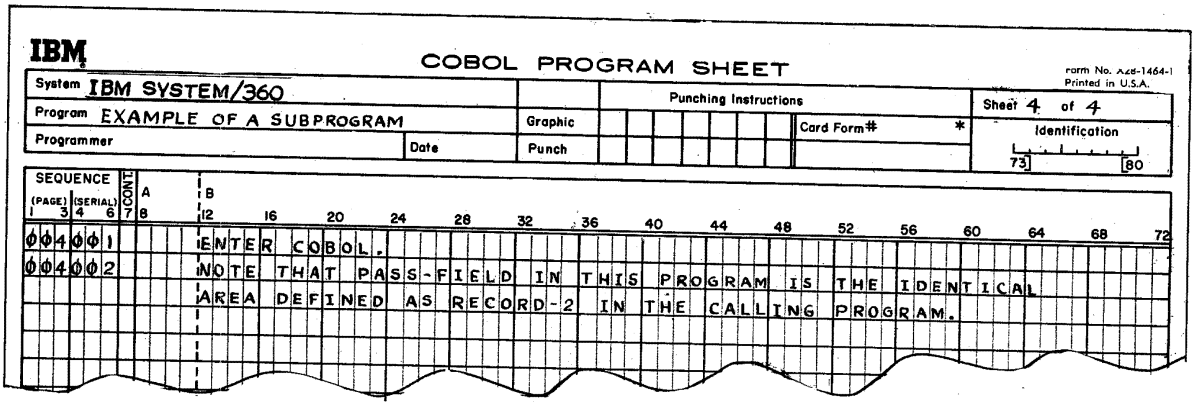
Program: EXAMPLE OF A SUBPROGRAM | Graphic | Card Form# * | Identification 73 80

Programmer | Date | Punch

SEQUENCE (PAGE)	SEQUENCE (SERIAL)	CONT	A / B
00	001		IDENTIFICATION DIVISION.
	002		PROGRAM-ID. 'SUBPROG'.
	003		REMARKS. EXAMPLE OF A SUBPROGRAM.
	004		ENVIRONMENT DIVISION.
	005		CONFIGURATION SECTION.
	006		SOURCE-COMPUTER. IBM-360 D30.
	007		OBJECT-COMPUTER. IBM-360 D30.
	008		DATA DIVISION.
	009		WORKING-STORAGE SECTION.
	010		77 MODIFICATION PICTURE X(12), VALUE IS 'PUT ANY DATA'.
	011		LINKAGE SECTION.
	012		01 PASS-FIELD.
	013		02 A PICTURE X(68).
	014		02 B PICTURE X(12).
	015		PROCEDURE DIVISION.
	016		START. ENTER LINKAGE.
	017		ENTRY 'SUBPRGM' USING PASS-FIELD.
	018		ENTER COBOL.
	019		MODIFY. MOVE MODIFICATION TO B.
	020		ENTER LINKAGE.
00	021		RETURN.

A standard card form, IBM electro C61897, is available for punching source statements from this form.

Figure 26. Example of a Subprogram (Part 1 of 2)



IBM

COBOL PROGRAM SHEET

Form No. A26-1464-1 Printed in U.S.A.

System: IBM SYSTEM/360 | Punching Instructions | Sheet 4 of 4

Program: EXAMPLE OF A SUBPROGRAM | Graphic | Card Form# * | Identification 73 80

Programmer | Date | Punch

SEQUENCE (PAGE)	SEQUENCE (SERIAL)	CONT	A / B
00	001		ENTER COBOL.
00	002		NOTE THAT PASS-FIELD IN THIS PROGRAM IS THE IDENTICAL AREA DEFINED AS RECORD-2 IN THE CALLING PROGRAM.

Figure 26. Example of a Subprogram (Part 2 of 2)

A table of subroutines used by COBOL to accomplish the statements or actions specified follows. The table should guide the programmer in his efforts to conserve storage and to isolate a troublespot (debugging).

SUBROUTINE NAME	ACTION
IHD00000 Converts an external floating-point number to an internal floating-point number	Required for manipulation of external floating-point data in: MOVE - When send field is external floating point in MOVE statement. COMPUTATIONAL - When one field is external, and one field is internal floating point in computational statement.
IHD00100 Floating-point exponential subroutine.	Required for exponentiation to non-integer power.
IHD00200 Packed divides subroutine. It divides a 16-byte 30-character dividend by a 16-byte 30-character divisor, producing a 16-byte 30-character quotient. No registers are used.	Required for complex computations, COMPUTATIONAL fields of over 9 digits, and COMPUTATIONAL-3 fields of over 16 digits.
IHD00300 Packed multiply subroutine. It multiplies two 30-character packed fields and produces a 60-character packed product.	Required for complex computations, COMPUTATIONAL fields of over 9, or COMPUTATIONAL-3 fields of over 16 digits.
IHD00400 Error message subroutine. It generates execution time messages.	Required with floating-point and non-integer exponentiation.
IHD00500 Packed exponentiation subroutine.	Required for exponentiation to an integer power. [Used with IEP00700 (floating-point exponentiation) subroutine.]
IHD00600 Floating-point logarithm subroutine.	Required whenever floating-point conversion is needed. Used with IEP00700 (floating-point exponentiation) subroutine.
IHD00700 Floating-point exponentiation subroutine.	Required to set up floating-point conversion routines for nonfloating point exponentiation.

SUBROUTINE NAME	ACTION
IHD00800 Converts packed decimal to floating point. Conversion is accomplished by calling two other subroutines IHD01600 (TOBIN), which converts the number from packed decimal to binary, and IHD01500 (BINFL), which converts the binary number to floating point and then returns.	May be required when floating-point and/or non-integer exponentiation is used. ARITHMETIC - Required when packed and floating-point operation are in the same statement. MOVE - Required if the sending field is packed and the receiving field is floating point in a move statement. COMPUTATIONAL - Required if one field is packed, and one field is floating point in a computational statement.
IHD00900 Converts floating-point numbers to zoned decimal numbers. Conversion is accomplished by calling two other subroutines; IHD01100 (FRFLPT), which converts the number from floating point to binary, and IHD01800 (BINZN), which converts the binary number to zoned decimal and returns.	ARITHMETIC - Required when there is a floating-point operand, and the receiving field is zoned in an arithmetic statement. MOVE - Required if the sending field is floating point, and the receiving field is zoned in a move statement.
IHD01000 Converts a binary number to a packed decimal number. Used with IHD01300 (floating point to packed decimal) subroutine.	Required for: ARITHMETIC - Required when multiplying a binary field by a packed field or visa versa. - Required if multiplication is done in binary. MOVE - (Special Class) - If sending field is internal floating point, and receiving field is binary. The binary number must fall within the limits specified. (9 decimal digits <binary number <18 decimal digits.) - If sending field is binary and receiving field is binary. - If sending field is less than 9 and Receiving field is less than or equal to 9, or both are greater than 9 decimal digits. - If sending field is binary and receiving field is packed, and sending field is greater than 9 decimal digits. COMPUTATIONAL - If one field is binary and the other is zoned. - If one field is binary and the other is packed. - If both fields are binary and A is less than 10, and B is less than 10 and the scales of both fields are equal.

SUBROUTINE NAME	ACTION
	- If the scale of the sending field is greater than the scale of the receiving field, and the real or implied integer positions of the receiving field plus the scale of the sending field is less than 10. - If the scale of the sending field is less than the scale of the receiving field, and the real or implied decimal positions plus the scale of the receiving field is less than 10.
IHD01100 Converts an external floating-point number to a binary number. Used with IHD00900 (floating-point to zoned decimal) subroutine, IEP01300 (floating-point to packed decimal) subroutine, IHD01400 (floating-point to binary) subroutine and IHD01900 (miscellaneous fields to external floating-point) subroutine.	MOVE - Required when sending field is external or internal floating point, and receiving field is external floating point.
IHD01200 Converts a zoned decimal number to a floating-point number. Conversion is accomplished by calling the same subroutine used by FLPZND (IHD00900).	MOVE - Required when sending field is zoned and receiving field is floating point. COMPUTATIONAL - Required when one field is zoned and the other field internal floating point.
IHD01300 Converts a floating-point number to packed decimal format. Conversion is accomplished by calling IHD01100 (FRFLPT), which converts a floating-point number to binary, and IHD0100 (BINPK), which converts the binary number to packed decimal and then returns.	MOVE - Required when sending field is external or internal floating point and receiving field is packed.
IHD01400 Converts an internal floating-point number to a binary format. Conversion is accomplished by calling subroutine IHD01100 (FRFLPT), which does the actual converting of the floating-point number to a binary number format.	MOVE - Required when sending field is external or internal floating point and receiving field is binary.

SUBROUTINE NAME	ACTION
IHD01500 Converts a binary number into double precision floating point. May be required when floating-point and/or non-integer exponentiation are used. Used with IHD00800 (packed to floating-point) subroutine, IHD00000 (external floating-point) subroutine, IHD01200 (zoned decimal to floating-point) subroutine, IHD01900 (miscellaneous field type to external floating-point) subroutine.	MOVE - Required when sending field is binary and receiving field is floating point. ARITHMETIC - Required when one operand is binary and one operand is floating point. COMPUTATIONAL - Required when one field is binary and one is internal floating point.
IHD01600 Converts either a packed decimal or a zoned decimal number to a binary number when receiving field is greater than 9 digits.	Required for: MOVE - Required if the sending field is external decimal, and receiving field is packed; receiving field must be 9 decimal digits. COMPUTATIONAL - If one field is binary or zoned and one field is packed. - If both fields are binary and the following conditions are not met: • the length of the fields are unequal • A and B are both less than 10 and the scales of the fields are equal - If the scale of the sending field is greater than the scale of the receiving field and the real or implied integer positions of the receiving field plus the scale of the sending field is less than 10. - If the scale of the sending field is less than the scale of the receiving field and the real or implied decimal positions plus the scale of the receiving field is less than 10.

SUBROUTINE NAME	ACTION
IHD01700 Compares two alphabetic fields of different lengths, no restriction on maximum length, when either or both fields are greater than 255 bytes.	COMPUTATIONAL - Required when either or both fields are 255 bytes.
IHD01800 Converts a binary number to a zoned decimal number. Used with IHD00900 (floating-point zoned decimal) subroutine.	ARITHMETICS - Required when operations are performed in binary and the receiving field is zoned. MOVE - Required when sending field is binary and receiving field is zoned; zoned field is 9. MISCELLANY - Required if user displays binary item.
IHD01900 Converts a field of any of the following formats to external floating point: external decimal, internal decimal, binary, internal floating point, figurative constant of zero. Conversion is accomplished in same cases by calling IHD01100 FRFLPT) which converts internal floating point to binary, and IHD01500 (BINFL) which converts binary to external floating point.	MOVE - Required when receiving field is external floating point. MISCELLANY - Required if user displays internal floating point.
IHD02000	Used to move group items longer than 256 bytes.
IHD02100	Performs the class test on alphameric fields, as specified in the IBM publication IBM System/360 Disk and Tape Operating Systems: COBOL Language Specifications, Form C24-3433.

SUBROUTINE NAME	ACTION
IHD02200 Converts a packed decimal number to a zoned decimal number.	ARITHMETIC - Required when the operations are performed in packed decimal and the receiving field is zoned. MISCELLANY - Required if user displays packed decimal format.
IHD02300	This subroutine consists of three parts: 1. The first part builds a table of the beginning and end addresses of the PERFORM or nested PERFORM statements and the return address. It checks the validity of addresses. 2. The second part checks to see if the PERFORM is complete by comparing return addresses. 3. The third part deletes or eliminates the table entries by resetting pointers and counters. Required when linkage editing a version I object deck with a version II system.
IHD02400	Used to move fields when either or both fields are variable groups. Requirements: R1 points to 'sending' field R2 points to 'receiving' field WORKA is length of 'sending' field WORKA+2 is length of 'receiving' field WORKA+4 is '01' if 'receiving' field is right justified.
IHD02500	Used to compare two fields either or both of which are group variable. Used with fields defined with OCCURS...DEPENDING ON clauses. Requirements: R1 points to FIELD1. R2 points to FIELD2. WORKA is the same length as FIELD1. WORKA+2 is the same length as FIELD2.

SUBROUTINE NAME	ACTION
IHD02600	Checks length of field to be displayed to be sure it fits into defined field, and moves DISPLAY data to an output buffer. Used if a display data fit check is specified at execution time. Requirements: WORKW - must be address of byte after buffer. WORKA+4 - must be number of bytes to move minus 1. R1 - points to next available buffer byte. R2 - points to data to be moved.
IHD02700	Writes out display data on SYSPCH. Used when display on SYSPCH is specified.
IHD02800	Writes out display data on SYSLST. Required when EXHIBIT, TRACE, or standard DISPLAY statements are used (i.e., not UPON CONSOLE or UPON SYSPCH).
IHD02900	Reads a record from SYSIPT and moves data to the field specified by data-name. Required when ACCEPT is specified (not ACCEPT FROM CONSOLE).
IHD03000	Used for display on console.
IHD03100	Used for execution of direct-access statements. Required when any direct-access statement is used.
IHD03200	If problem program has user labels, this subroutine is the linkage with the declaratives section.

SUBROUTINE NAME	ACTION
IHD03300	If one field is divided by another and the divisor is zero, this subroutine links to the ON SIZE error routine.
IHD03400	Prints out object time diagnostic messages when errors are encountered in direct-access processing. Required when IHD03100 is used.
IHD03500	Produces object time diagnostic messages for indexed sequential organization of files. Required when indexed sequential data organization is indicated.
IHD03600	Required to write record number zero on all tracks for an output operation when using direct-access method.
IHD03700	Used for initializing tape or disk when using read and write operations.
IHD03800	Used for maintaining a list of tapes to be repositioned, linking to the system's checkpoint routine, and providing a restart entry point.
IHD03900	Converts internal decimal to sterling non-report.
IHD04000	Converts sterling non-report to internal decimal.
IHD04100	Edits internal decimal into sterling report.

This appendix contains a detailed description of the diagnostic messages that are generated during processing. They consist of:

- Compiler diagnostic messages
- Execution time messages
- Debug packet error messages

Certain conditions that may occur when a module is being processed will generate linkage editor diagnostic messages. For a complete description of these messages, see the publications IBM System/360 Disk Operating System, System Control and System Service Programs, Form C24-5036, and IBM System/360 Tape Operating System, System Control and System Service Programs, Form C24-5034.

COMPILER DIAGNOSTIC MESSAGES

IJS001I C LITERAL EXCEEDS 120 CHARACTERS.

System Action: The element count begins following the next quote on the line if there is one, or following the element beginning after the 120th character.

User Response: Change the length of the literal so it does not exceed the allowed maximum, or insert the missing quote, or define the literal with two statements; execute the compilation again.

IJS002I W LITERAL CONTINUATION QUOTE INVALID IN MARGIN A.

Explanation: The literal continuation quote should appear in margin B.

System Action: The continuation is allowed.

IJS003I C LITERAL IMPLY CONTINUED OR CONTINUATION QUOTE IS MISSING.

Explanation: This may be the result of a missing quote sign on the preceding line.

System Action: The non-numeric literal is truncated at the end of the preceding line. The syntax scan resumes with the first element of the next line.

User Response: Check for missing quote, column 7 continuation hyphen, or improper formation of the non-numeric literal.

IJS004I SYNTAX REQUIRES A BLANK AFTER A PERIOD OR THIS PERIOD IS INVALID DECIMAL POINT.

System Action: The inverted print/edit word with the invalid decimal point is dropped, and processing continues with the next word.

User Response: Check syntax of statement in error, and try again.

IJS005I C XXX EXCEEDS 30 CHARACTERS.

Explanation: Any element that is not a non-numeric literal is truncated after 30 characters.

System Action: Normal processing continues with a literal made up of the first 30 characters.

User Response: Alter the length of the literal to conform with the specifications for this class of literal.

IJS006I C XXX REQUIRES QUALIFICATION.

Explanation: This indicates that the name is defined in more than one location, and requires qualification in order to be unique.

System Action: The first name defined is used and the compilation continues. If it is the name desired, the run compiles as desired. For further system action, see message IJS013I. It explains the handling for the Procedure Division statement.

User Response: Correct the procedural statements in error, or change the duplicate data-names so they are unique. Execute the job again.

IJS007I C XXX HAS UNDEFINED QUALIFICATION.

Explanation: One or more of the names in the qualification hierarchy are not defined as a group containing the data-name. This may have resulted from the dropping of a data-name because of an error at its point of declaration, or because of a misspelling.

System Action: The first name defined is used. If it is the name desired, the run compiles as desired.

User Response: Check for misspelling of the data-name, or the data-name's qualifier in the hierarchy order.

IJS008I C XXX REQUIRES MORE QUALIFICATION.

Explanation: The number of qualifiers or the names are not sufficient to make the subject name unique. Another name could have the same qualification.

System Action: The first name defined is used and the compilation continues. If it is the name desired, the run compiles as desired. For further system action, see message IJS013I. It explains the handling for the procedure division statement.

IJS009I E SUBSCRIPTED 88 MUST HAVE A RIGHT PARENTHESIS. WILL BE TREATED AS A DATA NAME.

IJS010I W SYNTAX REQUIRES A BLANK AFTER A RIGHT PAREN, SEMICOLON AND OR COMMA.

System Action: Normal processing continues.

IJS011I B XXX IS UNDEFINED.

IJS012I C XXX HAS MORE SUBSCRIPTS THAN DECLARED IN THE DATA DIVISION.

Explanation: The Procedure Division reference to the data-name has too many subscripts. The number of subscripts

must match the number of OCCURS...DEPENDING ON clauses in the definition hierarchy in the Data Division.

System Action: Normal processing continues with the next word.

IJS013I C RECORD NAME 'XXX' IS ASSOCIATED WITH INVALID FD ENTRY.

Explanation: The FD associated with the SELECT clause is invalid.

System Action: The error attribute for the record is generated, and normal processing continues with the next word.

User Response: Check FD entries for proper device labels, required clauses, missing period terminator, etc.

IJS023I C COPY AND INCLUDE MUST NOT BE USED WITHIN LIBRARY ENTRIES.

System Action: Words following the library name are diagnosed according to the clause being processed, up to the next required clause.

IJS024I C PERIOD MISSING FOLLOWING XXX. THE NEXT CARD MAY BE SKIPPED.

System Action: For the Data Division COPY statement -- Any other entry following the name is diagnosed as the missing period and the return is made to the phase. The phase diagnoses all entries up to the next period according to the current clause string. Normal processing continues.

For the Procedure Division INCLUDE statement -- Interrogation of the library name continues to determine its validity and whether or not it is in the library. If the library name is valid and it is found, normal processing continues.

User Response: A period should be inserted following library book name.

IJS025I C XXX IS AN INVALID LIBRARY NAME OR NOT FOUND ON LIBRARY.

Explanation: The library name may have been misspelled, not previously cataloged, or not properly terminated with a quote.

System Action: Any word other than period immediately following the library name is diagnosed according to the current clause string up to the next period. This includes the current card and the next card if read.

User Response: Check for the possible causes given in the explanation.

IJS026I C FLOATING-POINTING NUMBER XXX IS BELOW OR ABOVE VALID RANGE.

System Action: The value zero is assumed.

IJS027I W NUMBER OF DECIMALS IN LITERAL XXX AND DATA ENTRY DISAGREE.

System Action: Truncation or padding is performed according to the rules governing the MOVE verb.

IJS028I C LITERAL XXX IS INVALID AND IS DROPPED.

Explanation: The value clause conflicts with the description of the entry.

System Action: The value clause is dropped.

IJS029I W LITERAL XXX AND PICTURE SIZE DISAGREE.

Explanation: This message indicates a literal that is larger than its picture.

System Action: The literal is truncated to picture size from left to right, unless right justification is specified. The scan is continued as though no error occurred.

IJS030I W LITERAL XXX WAS SIGNED, ENTRIES PICTURE WAS UNSIGNED.

Explanation: The literal encountered in this entry contains a sign; it does not appear as part of the entry because the picture is unsigned.

IJS031I W NUMBER OF INTEGERS IN LITERAL XXX AND DATA ENTRY DISAGREE.

System Action: Same as for message IJS027I.

IJS032I C LIBRARY NAME IS AN INVALID EXTERNAL NAME OR NOT IN THE LIBRARY.

Explanation: The library name may have been misspelled, not cataloged, or not properly terminated with a quote.

System Action: The invalid or not found library name is dropped and the next card is read.

IJS041I C THIS CLAUSE IGNORED AT THE 01 LEVEL IN XXX ENTRY.

Explanation: The OCCURS...DEPENDING ON clause not valid as a level 01 or level 88 entry.

System Action: The clause is dropped.

User Response: Alter the clause level number to one that is valid or remove the OCCURS...DEPENDING ON clause from the statement in error.

IJS042I C THIS CLAUSE IGNORED IN XXX ENTRY AS IT PROVIDES MORE THAN 3 LEVELS OF SUBSCRIPTING.

IJS043I C DEPENDING ON OPTION IN XXX ENTRY IS IGNORED DUE TO PRIOR USE.

IJS044I C DEPENDING ON OPTION IN XXX ENTRY IS IGNORED BECAUSE IT IS SUBORDINATE TO A PREVIOUS CLAUSE.

IJS045I C THE LEVEL OF XXX ENTRY INVALIDATES THE DEPENDING OPTION AT THE PRECEDING XXX ENTRY. THE DEPENDING OPTION IS DROPPED.

Explanation: The level number just encountered indicates that there was an OCCURS...DEPENDING ON clause that did not include the last entry within the level 01.

System Action: The OCCURS...DEPENDING ON option is dropped.

IJS046I C XXX ENTRY CONTAINS AN ILLEGAL LEVEL NUMBER OR REDEFINES CLAUSE WHICH IS IGNORED.

Explanation: A redefines clause must redefine an entry at the same level number.

System Action: The level number or the redefines clause is ignored.

User Response: Alter the level number or relocate the redefines clause to conform with the specification.

IJS047I E INTERNAL QUALIFIER TABLE OVERFLOWED WHEN HANDLING XXX. RESTARTED QUALIFIERS WITH XXX.

Explanation: The sum of all the characters in the data-name and all its qualifiers + 4 times (the number of qualifiers + 1) must not exceed 300.

IJS048I W ENTRY PRECEDING XXX IS OF VARIABLE LENGTH.

IJS049I W XXX IS LARGER THAN ENTRY REDEFINED.

Explanation: The current entry is larger than the area redefined.

System Action: The area is assumed to be expanded.

User Response: The redefined area may be expanded.

IJS050I W XXX ENTRY PRECEDING XXX IS LARGER THAN ENTRY REDEFINED.

Explanation: Same as for message IJS049I, only for a group entry.

System Action: Same as for message IJS049I.

IJS051I E THIS CLAUSE INVALID IN XXX ENTRY AS REDEFINED AREA IS SUBSCRIPTED.

Explanation: It is invalid to redefine an item containing an OCCURS clause, or to redefine an item subordinate to an item containing an OCCURS clause.

System Action: The redefinition clause is dropped.

IJS052I C THIS CLAUSE IGNORED IN XXX ENTRY DUE TO REDEFINES OR OCCURS CLAUSE IN PRECEDING XXX LEVEL.

Explanation: A value clause cannot appear in an entry subordinate to a redefines clause.

System Action: The value clause is dropped.

IJS053I W FOR PROPER ALIGNMENT, A XXX BYTE LONG FILLER ENTRY IS INSERTED PRECEDING XXX.

Explanation: Binary or floating-point data improperly aligned for computations.

System Action: Binary and floating-point data are aligned on an appropriate boundary by the compiler. The alignment is performed by inserting an assumed filler entry preceding the item requiring alignment.

User Response: The number of slack bytes required can be reduced by the use of a different data format such as: internal decimal, grouping aligned items to the beginning of a record, or otherwise positioning them so that they will have the proper alignment within the record. A discussion of slack bytes can be found in the publication IBM System/360 Disk and Tape Operating System: COBOL Language Specifications, Form C24-3433.

IJS054I W FOR PROPER ALIGNMENT, A XXX BYTE LONG XXX FILLER ENTRY IS INSERTED PRECEDING XXX.

Explanation: Binary or floating-point data is improperly aligned for computations.

System Action: Groups are aligned according to the alignment requirements of the first elementary entry within that group. The level number indicated in the diagnostic message reflects the group in which the filler was added. The filler will occur the number indicated by the OCCURS clause on the group level. For further explanation, see message IJS053I.

IJS055I E XXX ENTRY PRECEDING XXX EXCEEDS MAXIMUM SIZE OF 4092 BYTES.

Explanation: The group defined at the indicated level preceding the point where this message was generated exceeded the maximum size permitted in the file or linkage section.

System Action: The compilation is continued, but execution is not attempted.

User Response: Reduce the record size to the allowable maximum size.

IJS056I W XXX ENTRY PRECEDING XXX EXCEEDS MAXIMUM LENGTH OF 32,768 BYTES.

Explanation: See message IJS055I. It applies to Working-Storage Section.

System Action: See message IJS055I. It applies to Working-Storage Section.

IJS057I E PROGRAM EXCEEDS 240 BASE LOCATORS MAXIMUM AT XXX.

Explanation: A base locator is assigned for each file for each level 01 or level 77 in the linkage section, and for every 4,096 bytes in the Working-Storage Section.

System Action: The base locator counter wraps around and the results are unpredictable.

User Response: Reduce the number of base locators.

IJS058I E ERRONEOUS OR MISSING DATA DIVISION.

Explanation: No data division entries were present.

System Action: All data division entries were dropped because of errors.

IJS060I W XXX LEVEL PRECEDING XXX IS OF VARIABLE LENGTH.

Explanation: The entry, defined at the level indicated, that preceded this clause contained an OCCURS...DEPENDING ON clause.

System Action: The redefined clause is dropped because it is invalid to redefine a variable-length entry.

IJS061I C XXX ENTRY EXCEEDS MAXIMUM LENGTH FOR ITS DATA TYPE.

Explanation: The maximum permitted length of an entry depends on the type of data defined for that entry. Numeric data cannot exceed 18 digit positions, report entries cannot exceed 127 character positions.

System Action: The maximum size is used.

IJS062I W XXX REQUIRED ALIGNMENT AND STARTS XXX BYTES PAST THE START OF THE ENTRY IT REDEFINED.

Explanation: The entry containing the REDEFINES clause requires alignment that differs from the alignment of the clause redefined. If alignment is required, insert a filler the size of the number of bytes indicated in the message before the item being redefined.

IJS063I W TO ALIGN BLOCKED RECORDS ADD XXX BYTES TO THE 01 CONTAINING DATANAME XXX.

Explanation: The first record in a buffer is aligned on a doubleword boundary. All level 01 records are assumed to start on a doubleword boundary. If binary or floating-point numbers are used in the record and if the records are blocked in a buffer, the succeeding records may not be properly aligned. Alignment can be obtained by padding each record by the indicated number of bytes and processing in the buffer, or by moving each record, as a group, to a level 01 record in the Working-Storage Section before processing the COMPUTATIONAL field. The pointer to this diagnostic message indicates the last element within a record. The padding must go into the preceding level 01 record, not the level 01 record that may immediately follow the indicated data-name.

IJS064I W IF THE PRECEDING RECORD IS BLOCKED, IT MAY BE ALIGNED BY MOVING TO AN 01 IN THE WORKING-STORAGE SECTION.

Explanation: When records are variable and blocked, only the first record can be aligned.

IJS076I W INTEGER OPTION IS NOT PERMITTED.

System Action: The clause is dropped.

IJS078I C INTERNAL FILE-NAME AND DESCRIPTION TABLE OVERFLOWED. XXX NOT PROCESSED.

Explanation: There is a fixed number of files that can be handled by a given COBOL compilation (25). If additional files must be handled, they can be processed in a subprogram and accessed via the linkage facility.

System Action: Any files encountered after the maximum permitted are dropped. The maximum permitted is 25.

IJS079I C RESTRICTED SEARCH INTEGER TOO LARGE ON XXX. CLAUSE DROPPED.

IJS080I C MORE THAN THREE FORMS OVERFLOW CLAUSES. OVERLOW-NAME XXX ENTRY IS DROPPED.

IJS081I W XXX APPEARED PREVIOUSLY IN A 'SAME' CLAUSE. REMAINDER OF 'SAME' CLAUSE DROPPED.

Explanation: A given file-name can appear in only one SAME-AREA clause. Any duplication encountered is dropped.

System Action: The entire SAME-AREA clause is dropped.

User Response: Eliminate the duplicate statement.

IJS082I W INTERNAL 'SAME' TABLE OVERFLOW. ENTRIES AFTER XXX DROPPED.

Explanation: A fixed number of file-names and combinations of filenames are allowed in an internal same-area table. If reducing the number of file-names or the number of SAME-AREA clauses does not relieve the situation, it may require an entry to a subprogram to permit a large number of files to be referenced in this manner.

IJS083I W RECORD LENGTH SPECIFIED DISAGREES WITH CALCULATED MAX. RECORD LENGTH OF XXX ON XXX. CALCULATED RECORD LENGTH ASSUMED.

Explanation: The actual length of each record is calculated during compilation time by totaling all its components. If the length disagrees with the specified maximum, this warning message is given to indicate that the specified record size is ignored.

IJS084I W BLOCK SIZE FOR XXX TOO BIG. 32K ASSUMED.

Explanation: The integer specifying block size of the referenced files is too large.

System Action: The maximum size allowed is used.

IJS085I W SYMBOLIC KEY MUST BE SPECIFIED FOR XXX IF INPUT.

Note: This message is used only for a direct-access storage device.

IJS086I E ACTUAL KEY MUST BE SPECIFIED FOR XXX.

Note: This message is used only for a direct-access storage device.

IJS087I C THE XXX FILE MUST BE DESCRIBED IN A SELECT CLAUSE. CURRENT ENTRY IGNORED.

Explanation: The subject file was referenced in the Environment Division or in an FD clause. There is no select clause to define this file. The file-name referenced may be an invalid entry encountered at the point that a file-name was expected.

IJS088I C LABEL RECORD DATA-NAME MUST BE DEFINED IN LINKAGE SECTION.

System Action: Label records are assumed standard.

IJS089I C UNIT IS MISSING FOR XXX FILE. 2400 IS ASSUMED.

IJS090I C THE DESCRIPTION OF XXX FILE CONFLICTS ON THE FOLLOWING POINTS -- XXX.

Explanation: The description of the file referenced contains factors that conflict with each other. The factors can be in the description of the file in the Environment Division, in the FD of the file section, or in other areas such as the record description for that file.

System Action: The points in conflict are defined by the trailing clauses of the diagnostic message.

IJS091I E INDEXED ORGANIZATION ON XXX NOT VALID FOR THIS LEVEL COMPILER.

IJS092I E DIRECT ORGANIZATION ON XXX NOT VALID FOR THIS LEVEL COMPILER.

IJS093I E XXX NOT HANDLED WITH PRESENT RELEASE.

IJS094I E XXX FILE WAS NOT DEFINED BY AN FD ENTRY.

Explanation: No DTF table is built for this file, therefore, it cannot be used.

IJS096I W ONLY ONE CHECKPOINT FILE MAY BE SPECIFIED.

IJS097I E STANDARD LABELS ARE REQUIRED ON XXX FILE.

IJS098I C XXX FILE ASSUMED TO BE UTILITY.

IJS099I C XXX FILE UNIT MISSING AND ASSUMED TO BE 1403 PRINTER.

IJS100I E DIRECT-ACCESS ASSIGNED TO XXX NOT SUPPORTED IN THIS VERSION.

IJS101I C XXX FILE IS ASSIGNED TO UNIT RECORD AND MUST BE RECORDING MODE IS F.

Explanation: Unit record must be fixed length.

System Action: The largest described length is assumed.

IJS102I C A MAXIMUM OF 1 ALTERNATE AREA IS ALLOWED FOR XXX FILE.

System Action: One alternate area is reserved.

IJS103I E XXX IS NOT A VALID SYSTEM ASSIGNMENT.

Explanation: Must be SYS000 to SYS244.

System Action: SYS000 is assumed.

IJS104I E RECORD/BLOCK SIZE ON XXX GREATER THAN 3625.

IJS105I C INVALID DEVICE NUMBER SPECIFIED. DISK 2311 ASSUMED.

IJS106I W ONLY ONE AREA SUPPORTED FOR INDEXED OR DIRECT ORGANIZATION. ONE AREA ASSIGNED FOR XXX.

IJS107I C RECORD KEY REQUIRED FOR INDEX ORGANIZATION FILE XXX.

IJS108I E LENGTH OF SYMBOLIC/RECORD KEY GREATER THAN 255.

IJS109I E LENGTH OF ACTUAL KEY IS GREATER/LESS THAN 8.

IJS110I E INCORRECT DATA ITEM TYPE SPECIFIED FOR KEY.

IJS111I W TRACK AREA INTEGER EXCEEDS MAXIMUM. 32,767 IS ASSUMED.

IJS112I C SYMBOLIC AND RECORD KEY LENGTH FOR XXX DISAGREE.

IJS113I E RELATIVE ORGANIZATION ASSIGNED TO XXX NOT SUPPORTED IN THIS VERSION. COMPLETE SELECT STATEMENT DROPPED.

IJS114I E RECORD/BLOCK ON XXX IS GREATER THAN 2000.

IJS117I E SYMBOLIC KEY MUST BE SPECIFIED FOR XXX.

IJS118I W DIRECT ACTUAL KEY MUST BE SPECIFIED FOR OUTPUT FILES.

IJS120I E BLOCK SIZE IS NOT A MULTIPLE OF RECORD SIZE.

IJS121I E MULTIPLE CORE-INDEX AREAS ARE REFERENCED BY 'XXX'. ONLY ONE DATA-NAME PER FILE-NAME IS ALLOWED.

IJS176I C WORD RECORD OR RECORDS IS REQUIRED. FOUND 'XXX'.

Explanation: Syntax skips until the next clause, level number, or period at the end of the file description is encountered.

IJS177I W PERIOD REQUIRED AFTER WORD 'SECTION'.

IJS179I W 'XXX' IS AN INVALID FILE-NAME FORMAT.

Explanation: A file-name must follow the format rules for data-names.

System Action: Invalid names are truncated to 30 characters and treated as valid names.

IJS180I E XXX EXCEEDS 30 CHARACTERS AND IS DROPPED.

System Action: The picture is too long and is dropped.

IJS181I W THE OPTION WORD IS MISSPELLED OR OMITTED. FOUND XXX.

System Action: The usage assumed is DISPLAY.

IJS183I C 'XXX' IS AN INVALID OR EXCESSIVE INTEGER.

Explanation: The integer indicated in this clause is determined to be invalid.

System Action: The integer is not used.

IJS184I W XXX IS AN INVALID LEVEL NUMBER.

IJS185I W LABEL RECORDS IS OMITTED. LABELS ASSUMED STANDARD.

IJS186I W SYNTAX REQUIRES DATA RECORD CLAUSE.

System Action: Syntax scanning proceeds.

IJS187I C MODE MUST BE 'V', 'F', OR 'U'. FOUND XXX.

User Response: If V, F, or U was specified, check the element number on this line for a misspelled optional word.

IJS190I W 'XXX' IS AN INVALID DATA-NAME FORMAT.

System Action: The invalid data-name(s) are truncated to 30 characters and used.

IJS191I W SD OR SA ENTRY REQUIRES F LEVEL COMPILER.

System Action: Syntax skips to next margin A entry.

IJS192I W 'XXX' IS AN INVALID RECORD-NAME FORMAT.

System Action: Invalid record names are truncated to 30 characters and treated as valid names.

IJS194I C 'XXX' IS INVALID AT THIS POINT. CHECK FOR SYNTAX ERROR ON CURRENT/PREVIOUS STATEMENT.

Explanation: While processing a given clause or sentence, an unexpected element was encountered. The clause may be valid but misplaced. This message is also given for

clauses that are not valid source input to this level compiler.

User Response: Check for prior diagnostic messages, an extra or missing period, invalid continuation of non-numeric literals, or a misspelled word.

IJS196I W SYNTAX REQUIRES AN 01 LEVEL ENTRY. FOUND XXX.

IJS197I W NOT VALID FOR THIS LEVEL COMPILER.

IJS201I C XXX IS AN INVALID DATA-NAME FORMAT BUT ASSUMED VALID.

System Action: Invalid data-names are truncated to 30 characters and treated as valid names.

IJS202I C Same as diagnostic message IJS194I.

IJS203I C THIS USAGE XXX CONFLICTS WITH THE GROUP USAGE AND IS IGNORED.

IJS204I C XXX IS AN INVALID OR EXCESSIVE INTEGER.

System Action: The invalid integer is dropped.

IJS205I W XXX IS AN INVALID DATA-NAME FORMAT, BUT ASSUMED VALID.

IJS206I W WORD ZERO IS REQUIRED. FOUND XXX.

System Action: The clause is ignored.

IJS207I W WORD RIGHT IS REQUIRED. FOUND XXX.

System Action: The clause is ignored.

IJS210I C THIS ENTRY CONFLICTS WITH THE FOLLOWING DESCRIPTIONS --- XXX.

Explanation: Various clauses specified for a data entry are compared with previous specifications for the entry. If there is any factor that conflicts with the subject clause, it is listed as a trailer to this entry. Factors included that are not themselves clauses would be elementary or group item usage, specified at a group level in previous clauses. This message can appear if a period is missing at the end of a data entry, or (for example) when the PICTURE clause for the second entry is encountered and automatically conflicts with the PICTURE clause for the previous entry.

IJS211I C XXX EXCEEDS 30 CHARACTERS AND IS TRUNCATED.

IJS212I C ONLY LEVELS 77 OR 01 ARE PERMITTED AT THIS POINT. FOUND XXX.

System Action: Syntax skips until a section name or level number is found.

IJS213I C THE FOLLOWING DESCRIPTIONS INVALID AT GROUP LEVEL --- XXX.

Explanation: The data entry described is determined to be a group, although the entries specified as trailers to this message are invalid at the group level. This diagnostic message can be produced by an invalid level number that was changed to a level 01, or because of a misunderstanding as to how a group is defined and what clauses are valid at the group level. A missing period can also produce this diagnostic message.

IJS214I C XXX DATA ENTRY REQUIRES A PICTURE, COMPUTATIONAL-1 OR COMPUTATIONAL-2.

Explanation: This diagnostic message can be produced by an error in the following level number that caused its level to be changed to a level 01, thereby making this an elementary entry.

System Action: Any statement in the Procedure Division containing a reference to this entry is diagnosed and dropped.

User Response: Check for missing periods or other diagnostic messages.

IJS215I W SYNTAX REQUIRES AN ENTRY IN MARGIN A. FOUND XXX IN MARGIN B.

System Action: Following certain entries in a source program, a specific clause must be encountered in margin A. If it is found in margin B, it is diagnosed but handled by the compiler.

IJS216I W SYNTAX REQUIRES AN ENTRY IN MARGIN B. FOUND XXX IN MARGIN A CHECK FOR MISSING PERIOD.

Explanation: All entries in margin A must be preceded by a period.

System Action: The compiler was in the middle of processing a clause or sentence and encountered the indicated word in margin A. Thus, a diagnostic message is issued and the word is processed as though it were valid.

IJS217I W LEVEL 77 ENTRIES MUST PRECEDE OTHER LEVELS AND ARE ASSUMED TO BE 01 LEVEL.

IJS218I W SYNTAX PERMITS ONLY LEVELS 77, 88, OR 01 AFTER A 77 LEVEL. CHANGED XXX TO 01.

IJS221I C SYNTAX FOR 'ALL' REQUIRES 'XXX' BE A SINGLE CHARACTER IN QUOTES.

System Action: The value clause is dropped.

IJS222I C PICTURE XXX WAS FOUND INVALID WHILE PROCESSING XXX. THE PICTURE IS DROPPED.

Explanation: Any element that follows the word PICTURE in a data description, other than the word that is dropped, is assumed to be a PICTURE and is passed to a later phase for analysis. The analysis proceeds from left to right on a character-by-character basis. The character identified in the message is the one processed at the time the PICTURE is determined to be invalid. The specific character itself may be invalid or may have indicated that a previous character or condition is invalid. For example, an E encountered in an external floating-point PICTURE may indicate that a preceding decimal was omitted in the mantissa.

System Action: The PICTURE is dropped and the entry identified as an error.

IJS277I W FILE SECTION OUT OF SEQUENCE.

IJS228I E SYNTAX PERMITS ONLY ONE XXX IN SOURCE PROGRAM.

System Action: Syntax proceeds.

IJS229I E WORKING STORAGE SECTION OUT OF SEQUENCE.

IJS231I E ENVIRONMENT DIVISION MISSING.

IJS233I C REPORT SECTION REQUIRES F LEVEL COMPILER.

IJS234I W WORD 'SECTION' MISSING.

IJS235I W 'PERIOD' MUST FOLLOW WORD SECTION.

IJS237I E 'XXX' IS MISPLACED.

Explanation: The statement is probably out of place in the source deck; that is, FD is working-storage.

System Action: The statement is processed as it is; however, execution may not be as desired.

User Response: Properly locate the misplaced statement.

IJS238I W 'XXX' IS AN INVALID SECTION NAME, A MISSING FD OR AN INVALID/MISPLACED LEVEL INDICATOR.

System Action: Syntax skips until a valid section-name or level number is found.

IJS239I W SYNTAX REQUIRES WORD 'DIVISION'.

IJS240I C 'UNIT' OR 'REEL' CANNOT BE SPECIFIED FOR UNIT-RECORD FILE.

IJS241I C LEVEL PRECEDING 88 MUST BE AN ELEMENTARY.

Explanation: Any level number preceding a level 88 entry must be an elementary level number.

System Action: If the level number preceding the level 88 entry is not an elementary level number, it is assumed to be one and is processed as such.

IJS242I W THE 88 ENTRY DOES NOT HAVE A VALUE, THEREFORE, IT IS DROPPED.

IJS301I W SYNTAX REQUIRES 'XXX' IN MARGIN A. FOUND 'XXX'. RESTART WITH 'XXX'.

Explanation: Syntax requires the specific entry indicated to be in margin A. If the entry is found in margin B, compilation resumes.

IJS302I C SYNTAX REQUIRES 'XXX'. FOUND 'XXX'. RESTART WITH 'XXX'. IF WORDS REQUIRED AND FOUND ARE THE SAME, THE ENTRY IS IN THE WRONG MARGIN.

System Action: Syntax scan skips to the RESTART clause.

IJS303I W 'XXX' IS AN INVALID CONDITION-NAME FORMAT.

Explanation: The name shown is an invalid condition-name.

System Action: The name is truncated to 30 characters and processed as though it were valid.

IJS304I E 'XXX' IS AN INVALID EXTERNAL-NAME FORMAT. RESTART WITH 'XXX'.

Explanation: An external-name was expected at this point in the scan of the subject clause. An external-name must be enclosed in quotes. It must start with an alphabetic character, cannot contain more than eight characters, and letters and numerals are the only valid characters. A dash is not permitted.

IJS305I C SYNTAX REQUIRES SAME, RERUN, APPLY, OR 'XXX' DIVISION. FOUND 'XXX'. RESTART WITH 'XXX'.

User Response: Check for invalid sequence of source program cards or extra periods.

IJS306I W SYNTAX REQUIRES ENVIRONMENT OR 'XXX' DIVISION IN MARGIN A. FOUND 'XXX'. RESTART WITH 'XXX'.

User Response: Same as for message IJS305I.

IJS307I E SYNTAX REQUIRES I-O-CONTROL, INPUT-OUTPUT, OR 'XXX' DIVISION IN MARGIN A. FOUND 'XXX'. RESTART WITH 'XXX'.

User Response: Same as for message IJS305I.

IJS308I W 'XXX' IS AN INVALID DATA-NAME FORMAT. RESTART WITH 'XXX'.

Explanation: A data-name was expected at this point in the scan of the subject clause.

System Action: Invalid format is truncated to 30 characters and processed as though it were valid.

IJS309I C ENVIRONMENT PARAGRAPHS OUT OF ORDER.

System Action: Statements are handled anyway.

IJS310I W 'XXX' IS AN INVALID 360 MODEL-NUMBER. RESTART WITH 'XXX'.

System Action: Syntax scan skips to the restart clause.

IJS311I E SYNTAX REQUIRES 'FILE-CONTROL', 'XXX' OR 'DATA DIVISION' IN MARGIN A. FOUND 'XXX'. RESTART WITH 'XXX'.

User Response: Same as for message IJS305I.

IJS312I C 'XXX' IS AN INVALID OR EXCESSIVE INTEGER. RESTART WITH 'XXX'.

Explanation: The syntax at this point of scan of the specified clause requires an integer.

System Action: The element found was invalid and is dropped.

IJS313I W 'XXX' IS AN INVALID FILE-NAME FORMAT. RESTART WITH 'XXX'.

Explanation: The syntax scan of the subject clause requires a file name at this point.

System Action: The element found was invalid. It was truncated to 30 characters and processed as though it were valid.

IJS314I E 'XXX' IS AN INVALID LIBRARY-NAME FORMAT. RESTART WITH 'XXX'.

Explanation: A library name is required at this point.

System Action: The format is invalid. It is dropped.

IJS315I W MORE THAN THREE OVERFLOW OPTION CLAUSES ARE USED.

Explanation: An internal table permits a maximum of three form overflow names to be assigned in any compilation.

System Action: All form overflow names in excess of the maximum allowed (three) are dropped.

IJS316I C SYNTAX REQUIRES 'INDEXED' OR 'XXX'. FOUND 'XXX'. RESTART WITH 'XXX'.

Explanation: This message applies to a direct-access storage device only.

IJS317I C SYNTAX REQUIRES 'SEQUENTIAL' OR 'XXX'. FOUND 'XXX'. RESTART WITH 'XXX'.

Explanation: This message applies to a direct-access storage device only.

IJS318I W SYNTAX REQUIRES 'XXX' OR DATA DIVISION IN MARGIN A, OR SELECT IN MARGIN B. FOUND 'XXX'. RESTART WITH 'XXX'.

Explanation: The syntax for the specific clause requires specific entries at this point.

User Response: Check for misspelled words, or excessive periods.

IJS319I C SYNTAX REQUIRES 'UTILITY', 'DIRECT-ACCESS' OR 'XXX'. FOUND 'XXX'. RESTART WITH 'XXX'.

Explanation: Same as for message IJS316I.

IJS320I W 'XXX' IS AN INVALID I-O-DEVICE-NUMBER. RESTART WITH 'XXX'.

Explanation: Same as for message IJS316I.

IJS321I E NO PROCESSING OF THIS MULTIPLE SPECIFIED DIVISION OR SECTION. RESTART WITH 'XXX'.

Explanation: A section or division was encountered more than once.

System Action: The additional section or division is dropped, rather than disturb the internal sequence of the compilation.

IJS322I W FILE-NAME OR DATA-NAME EXCEEDS 30 CHARACTERS. TREATED AS 30-CHARACTER NAME.

IJS323I W SYNTAX REQUIRES 'XXX' OR CLAUSE-NAME. FOUND 'XXX'. RESTART WITH 'XXX'.

System Action: Syntax scan skips to the restart clause.

IJS324I E SYNTAX REQUIRES 'REEL' OR 'XXX'. FOUND 'XXX'. RESTART WITH 'XXX'.

System Action: Syntax scan skips to restart clause.

IJS401I C SYNTAX REQUIRES A DATA-NAME. FOUND 'XXX'.

Explanation: The syntax of the indicated clause requires a data-name. The element found was not defined as a valid data-name. The element may be indicated here, or an indi-

cation given that it was an invalid name such as, file name, condition-name, figure configuration, or overflow name.

System Action: The compilation continues at the next verb or paragraph label.

User Response: Check for misspelled data-name in diagnostic messages, which would nullify the definition of a valid data-name, or the use of a COBOL word as a data-name.

IJS402I C SYNTAX REQUIRES NEXT ITEM BE 'XXX'.

Explanation: The syntax for this clause requires a specific word that was not found. The item encountered was probably a data-name. The next item indicates that the syntax requires a specific word or words. None were found.

System Action: The element found is displayed unless it was a name, in which case the word invalid name or data name is indicated. Compilation continues at the next verb or paragraph label.

User Response: The reference format for the clause specified should be consulted if the meaning of the message is not immediately clear. Also check for: missing periods, preceding diagnostic messages, invalid non-numeric literals, COBOL words used as data-names, or a section name beginning in an incorrect margin.

IJS403I C SYNTAX REQUIRES A DATA-NAME OR NUMERIC-LITERAL. FOUND 'XXX'.

Explanation: See message IJS402I.

IJS404I C SYNTAX REQUIRES EITHER WORD 'TO', OR 'GIVING'. FOUND 'XXX'.

Explanation: See message IJS402I.

IJS405I C SYNTAX REQUIRES A SINGLE CHARACTER IN QUOTES OR A FIGCON. FOUND 'XXX'.

Explanation: See message IJS402I.

IJS406I C SYNTAX REQUIRES A FILE-NAME. FOUND 'XXX'.

Explanation: See message IJS402I.

IJS407I C SYNTAX REQUIRES DATA-NAME OR INTEGER. FOUND 'XXX'.

Explanation: See message IJS402I.

IJS408I C SYNTAX REQUIRES WORD 'INPUT', 'OUTPUT', OR 'I-3'. FOUND 'XXX'.

Explanation: See message IJS402I.

IJS409I C SYNTAX REQUIRES A PROCEDURE-NAME. FOUND 'XXX'.

Explanation: See message IJS402I.

IJS410I C SYNTAX REQUIRES A DATA-NAME OR LITERAL. FOUND 'XXX'.

Explanation: See message IJS402I.

IJS411I C SYNTAX REQUIRES WORD 'CALL', 'ENTRY', OR 'RETURN'. FOUND 'XXX'.

Explanation: See message IJS402I.

IJS412I E SYNTAX REQUIRES AN EXTERNAL-NAME. FOUND 'XXX'.

Explanation: See message IJS402I.

IJS413I C SYNTAX REQUIRES '='. FOUND 'XXX'.

Explanation: See message IJS402I.

IJS414I C SYNTAX REQUIRES EXPRESSION TO BEGIN WITH EITHER A DATA-NAME, NUMERIC-LITERAL, '+', '-', OR '('. FOUND 'XXX'. TWO OPERATORS MAY NOT APPEAR ADJACENT TO ONE ANOTHER.

Explanation: See message IJS402I.

IJS415I C SYNTAX REQUIRES CALL PARAMETERS TO BE EITHER DATA-NAME, PROCEDURE-NAME OR FILE-NAME. FOUND 'XXX'.

Explanation: See message IJS402I.

IJS416I C SYNTAX REQUIRES DATA-NAME, LITERAL, FIGCON, '+', '-', '(' OR 'NOT'. FOUND 'XXX'.

Explanation: See message IJS402I.

IJS417I C SYNTAX REQUIRES ARITHMETIC OPERATOR OR RELATIONAL. FOUND 'XXX'.

Explanation: See message IJS402I.

IJS418I C SYNTAX REQUIRES A DATA-NAME, NUMERIC-LITERAL, OR '(' AFTER AN OPERATOR. FOUND 'XXX'.

Explanation: See message IJS402I.

IJS419I C SYNTAX REQUIRES A DATA-NAME, LITERAL, FIGCON, '(', '+' OR '-' AFTER A RELATIONAL. FOUND 'XXX'.

Explanation: See message IJS402I.

IJS420I C SYNTAX REQUIRES A VERB, PERIOD, 'ELSE' OR 'OTHERWISE'. FOUND 'XXX'.

Explanation: The end of a valid clause was encountered. The element that followed the valid termination of this clause is not valid.

System Action: Compilation continues at the next verb or paragraph label.

User Response: If the preceding clause had some options, check the reference format to determine whether or not the options were specified correctly. A COBOL word used as a data-name or an extra period can also produce this diagnostic message.

IJS421I C ENTRY PARAMETER MUST BE A DATA-NAME. FOUND 'XXX'.

Explanation: The only parameters that can be passed to a COBOL subprogram are data-names. The data-names must be defined in the linkage section of the subprogram.

System Action: Compilation continues at the next verb or paragraph label.

IJS422I C SYNTAX REQUIRES A RELATIONAL. FOUND XXX.

Explanation: Syntax requires that the next element be a relational.

System Action: Compilation continues at the next verb or paragraph label.

User Response: Check for invalid punching or a preceding error.

IJS423I C SYNTAX REQUIRES WORD 'INPUT' OR 'OUTPUT'. FOUND XXX.

Explanation: See message IJS402I.

IJS424I C SYNTAX REQUIRES WORDS 'TO PROCEED TO'. FOUND XXX.

Explanation: See message IJS402I.

IJS425I C SYNTAX REQUIRES WORD 'CONSOLE' OR 'SYSPCH'. FOUND XXX.

Explanation: See message IJS402I.

IJS426I E SYNTAX REQUIRES 'AT END' OR 'INVALID KEY', FOUND 'XXX'.

IJS427I C SYNTAX REQUIRES A DATA-NAME, FIGCON OR NON-NUMERIC LITERAL. FOUND XXX.

Explanation: See message IJS402I.

IJS428I C SYNTAX REQUIRES A PROCEDURE-NAME AFTER 'GO TO' NOT PRECEDED BY A PARAGRAPH-NAME. FOUND XXX.

Explanation: See message IJS402I.

IJS429I C SYNTAX REQUIRES 'ALL', 'LEADING', 'UNTIL', OR 'FIRST'. FOUND XXX.

Explanation: See message IJS402I.

IJS430I C SYNTAX REQUIRES WORD 'TALLYING' OR 'REPLACING'. FOUND XXX.

Explanation: See message IJS402I.

IJS431I C SYNTAX REQUIRES WORD 'DEPENDING ON'. FOUND XXX.

Explanation: See message IJS402I.

IJS432I C DATA TYPE MUST BE ED, ID OR BI.

Explanation: Valid syntax for the subject verb permits only specific data types. The data type as determined by the definition in the Data Division is invalid for its use here.

System Action: The statement is dropped from the point of error.

IJS433I C SYNTAX REQUIRES WORD 'TRACE'. FOUND XXX.

Explanation: See message IJS402I.*

IJS434I C SYNTAX REQUIRES THAT A PERIOD OR SECTION FOLLOWS PARAGRAPH-NAME. FOUND XXX.

---

*Also, the entire statement from the point of error is dropped and is not compiled.

Explanation: See message IJS402I.*

IJS435I E DATA NAME AND ANY QUALIFIER MUST APPEAR WITHIN THE FIRST SEVEN OPERANDS OF STATEMENT FOR CHANGED OPTION.

Explanation: See message IJS402I.

IJS436I C SYNTAX REQUIRES A DATA-NAME, FIGCON OR LITERAL. FOUND XXX.

Explanation: See message IJS402I.*

IJS437I C SYNTAX REQUIRES A FIGCON. FOUND XXX.

Explanation: See message IJS402I.*

IJS438I C SYNTAX REQUIRES DATA-ITEM TO BE NO LONGER THAN FOUR.

Explanation: See message IJS402I.*

IJS439I C WRONG SUBSCRIPT SPECIFICATION.

Explanation: Data-names and condition-names can be subscripted to a depth of three. A subscript is required for each OCCURS...DEPENDING ON clause specified at the specified data-name or in groups containing that data-name.

System Action: The compilation continues at the next verb or paragraph label.

User Response: Check for fewer or more subscripts than OCCURS...DEPENDING ON clauses in the hierarchy. Subscripts must be enclosed in parentheses and separated from each other by a comma or a blank.

IJS440I C INCORRECT SPECIFICATION IN DECLARATIVE-SECTION. FOUND XXX.

Explanation: See message IJS402I.

IJS441I C SYNTAX REQUIRES AN INTEGER NOT LONGER THAN 5. FOUND XXX.

Explanation: The integer exceeds the size permitted by language specifications.

System Action: The compilation continues at the next verb or paragraph label.

IJS442I C THE DECLARATION OF THIS DATA-NAME CAUSED IT TO BE FLAGGED AS AN ERROR.

Explanation: The data-name encountered was flagged by the Data Division as containing an error in its declaration.

System Action: Compilation continues at the next verb or paragraph label.

User Response: Correct the declaration as indicated by the Data Division diagnostics and recompile.

IJS443I E SYNTAX REQUIRES A VERB. FOUND XXX.

Explanation: A point was reached where a verb was required and was missing. For example, 'IF = B.' requires a verb between the B and the period.

---

*Also, the entire statement from the point of error is dropped and is not compiled.

System Action: The statement is skipped from the point of the error.

IJS444I E SYNTAX REQUIRES A RECORD NAME. FOUND XXX.

Explanation: See message IJS402I.

IJS500I W AN OPERAND'S LENGTH EXCEEDS AND IS TRUNCATED TO 256 BYTES.

Explanation: The maximum number of bytes that can be displayed is 256.

System Action: The operand is truncated to 256 bytes and displayed.

IJS501I W IF THIS VARIABLE-LENGTH ENTRY EXCEEDS 256, RESULTS WILL BE UNPREDICTABLE.

Explanation: A maximum of 256 bytes can be displayed.

System Action: The entry is truncated to 256 bytes and displayed.

IJS502I W LITERAL EXCEEDS AND IS TRUNCATED TO 72 BYTES.

System Action: In a stop-literal statement only the first 72 bytes of a longer field are typed on the console.

IJS503I W DATA EXCEEDS AND IS TRUNCATED TO 72 BYTES.

Explanation: A maximum of one line (72 bytes) can be retrieved using the ACCEPT FROM CONSOLE statement.

IJS504I W DATA EXCEEDS AND IS TRUNCATED TO 256 BYTES.

Explanation: A maximum of 256 bytes can be accepted from SYSIPT.

IJS505I C FILENAMES OR STERLING-DATA TYPE NOT ALLOWED IN COMPARE.

Explanation: See message IJS506I.

IJS506I C USAGE OF DATA-TYPES CONFLICT. THE TEST DROPPED.

Explanation: Only certain data types can be compared to each other. The types specified are invalid. Reference can be made to the compared table to determine the valid combinations. Logical comparisons of fields that are classified as invalid comparisons can often be made through a redefinition and a description of one or both of the fields as alphameric.

IJS507I W EXIT MUST BE ONLY STATEMENT IN PARAGRAPH.

System Action: Compilation continues normally.

IJS508I E THE STATEMENT CONTAINS AN UNDEFINED DATA NAME.

Explanation: See message IJS402I.

IJS509I C AN ALPHABETIC DATA-NAME CAN BE TESTED ONLY FOR ALPHABETIC OR NOT ALPHABETIC, AND NUMERIC DATA-NAME ONLY FOR NUMERIC OR NOT NUMERIC. THE TEST IS DROPPED.

IJS510I C COMPARISON OF TWO LITERALS OR FIGCONS IS INVALID.

Explanation: See message IJS506I.

IJS511I C DATA-TYPE IN ARITHMETIC STATEMENT IS NOT NUMERIC OR RECEIVING FIELD IS NOT NUMERIC OR REPORT.

Explanation: See message IJS506I.

IJS512I C DATA-NAME IN CLASS-TEST MUST BE AN, ED, OR ID.

Explanation: See message IJS506I.

IJS513I C DATA-NAME IN SIGN-TEST MUST BE NUMERIC.

Explanation: See message IJS506I.

IJS514I W DATA EXCEEDS AND IS TRUNCATED TO 72 BYTES.

System Action: If the data is longer than 72 bytes, only the first 72 bytes are printed for a DISPLAY ON CONSOLE statement.

IJS515I W DATA EXCEEDS AND IS TRUNCATED TO 120 BYTES.

System Action: If the data is longer than 120 bytes, only the first 120 bytes are printed for a DISPLAY statement.

IJS516I C OPEN 'NO REWIND' OR 'REVERSED' CANNOT BE SPECIFIED FOR A UNIT RECORD, DIRECT-ACCESS OR DISK/DATA CELL UTILITY FILE.

System Action: The options are ignored.

IJS517I C 'NO REWIND' OR 'LOCK' CANNOT BE SPECIFIED FOR A UNIT RECORD, DIRECT-ACCESS OR DISK/DATA CELL UTILITY FILE.

System Action: The options are ignored.

IJS518I E MORE THAN FORTY PARAMETERS ARE NOT ALLOWED WITH THE STATEMENT.

IJS519I C SYNTAX ALLOWS ZERO AS ONLY VALID FIGCON IN A COMPARISON WITH BI, ID, EF, AND IF.

Explanation: See message IJS506I.

IJS520I C SYNTAX ALLOWS SPACE OR ALL AS ONLY VALID FIGCONS IN COMPARISON WITH AN ALPHABETIC FIELD.

Explanation: See message IJS506I.

IJS521I C DATATYPE MUST BE ED, EF, AL, AN OR GF. FOUND XXX.

Explanation: The data types indicated are the only valid ones that can be used in the clause indicated.

System Action: Compilation continues at the next verb or paragraph label.

IJS522I C SYNTAX REQUIRES WORD RUN OR LITERAL. FOUND XXX.

System Action: The syntax scan skips the rest of the statement.

IJS523I C RECEIVING FIELDS IN PRECEDING STATEMENT IS A LITERAL.

Explanation: A Procedure Division literal cannot be changed as the result of arithmetic or a move. The statement, SUBTRACT data-name FROM literal, would specify invalid action of this type.

System Action: Compilation continues at the next verb or paragraph label.

IJS524I C SYNTAX REQUIRES AT LEAST TWO OPERANDS BEFORE GIVING OPTION.

Explanation: For example, ADD A GIVING B.

System Action: The statement is skipped.

IJS525I C THE EXPRESSION HAS MORE RIGHT PARENS THAN LEFT PARENS TO THIS POINT. FOUND XXX.

Explanation: The number of right parentheses and left parentheses in a statement must agree. At no point in time can there be more right parentheses than left parentheses.

System Action: The statement is skipped from the point of the error.

User Response: Check for extra periods or missing periods, an error in a non-numeric literal, mispunched operators, or subscripted fields that are invalidly packed together without an intervening blank.

IJS526I C THE EXPRESSION HAS UNEQUAL NUMBER OF RIGHT AND LEFT PARENS.

Explanation: See message IJS525I.

IJS527I C DATA-TYPE MUST BE ED, ID, OR BI. FOUND XXX.

System Action: The statement is skipped from the point of error.

IJS528I C VARYING OPTION EXCEEDS THREE LEVELS.

Explanation: A maximum of three levels is permitted with the varying option of the PERFORM verb.

System Action: The statement is dropped from the point of error.

IJS529I C DATA-TYPE MUST BE ED, ID, BI, EE, OR IF.

Explanation: The data types shown are the only valid ones. The data-name found is not one of these types.

System Action: The statement is skipped from the point of error.

IJS530I C NUMBER OF ELSES EXCEEDS NUMBER OF IFS.

Explanation: Number of ELSE clauses must balance out with the appropriate number of ELSE or OTHERWISE clauses.

System Action: Statement is skipped from the point of error.

User Response: Recount and make corrections.

IJS531I E INTERNAL OCCURS-DEPENDING-ON TABLE OVERFLOWED AVAILABLE CORE.

IJS532I E STATEMENT HAS TOO MANY OPERANDS.

Explanation: The statement referenced is too large or complex for the internal tables needed for compilation.

System Action: The statement is skipped from the occurrence of this condition.

User Response: The statement should be divided into more than one statement.

IJS533I E PARENTHESIZING REQUIRES SAVING TOO MANY OPERANDS.

Explanation: See message IJS532I.

IJS534I E PARENTHESIZING REQUIRES SAVING TOO MANY INTERNALLY GENERATED LABELS.

Explanation: See message IJS532I.

IJS535I E PARENTHESIZING REQUIRES SAVING TOO MUCH OF STATEMENT.

Explanation: See message IJS532I.

IJS536I E ARITHMETIC EXPRESSION REQUIRES MORE THAN 9 INTERMEDIATE RESULT FIELDS.

Explanation: See message IJS532I.

IJS538I W 'OUTPUT' CANNOT BE SPECIFIED FOR INDEX/DIRECT ORGANIZATION WITH RANDOM ACCESS. 'I-O' IS ASSUMED.

IJS539I C 'I-O' IS AN INVALID SPECIFICATION FOR DIRECT ORGANIZATION WITH SEQUENTIAL ACCESS.

IJS540I W 'NO REWIND' CANNOT BE SPECIFIED WITH 'REVERSED' OPTION. 'REVERSED' IS ASSUMED.

IJS549I E WORD XXX WAS EITHER INVALID OR SKIPPED DUE TO ANOTHER DIAGNOSTIC.

Explanation: The majority of these messages will probably be caused by words skipped because of another diagnostic message that occurred earlier in the statement. This diagnostic message also occurs because of misspelled words.

User Response: In the case of words skipped, correct the previous error, or correct the current misspellings.

IJS550I C A FIGURATIVE CONSTANT IS NOT ALLOWED AS A CALL OR ENTRY PARAMETER.

System Action: The statement is skipped from the point of error.

IJS551I C SYNTAX REQUIRES WORD 'TO'. FOUND XXX.

System Action: Syntax scan skips the rest of the statement.

IJS552I C RECEIVING FIELD MUST BE A DATA-NAME. FOUND XXX.

System Action: The statement is skipped from the point of error.

IJS553I E FIGURATIVE CONSTANT IS NOT ALLOWED AS A RECEIVING FIELD.

System Action: The statement is skipped from the point of the error.

IJS554I C THE 'XXX' DATA-TYPE IS NOT LEGAL RECEIVING FIELD.

System Action: The statement is skipped from the point of the error.

User Response: Check the table of permissible moves in the COBOL specification.

IJS555I C OVERFLOW NAME IS NOT A VALID SENDING FIELD.

System Action: The statement is skipped from the point of the error.

IJS556I E END DECLARATIVES IS MISSING FROM PROGRAM.

Explanation: The entire Procedure Division is treated as a declarative section.

IJS557I W FLOATING-POINT CONVERSION MAY RESULT IN TRUNCATION.

Explanation: Conversion of floating-point numbers can result in truncation of low-order digits.

IJS558I E I-O OPTION FOR FILE CONFLICTS WITH NO REWIND.

System Action: The statement is skipped from the point of the error.

IJS559I E OUTPUT OPTION FOR FILE CONFLICTS WITH REVERSED.

Explanation: The OUTPUT option conflicts with an opening of a file that has a reversed option specified.

System Action: The statement is skipped from the point of the error.

IJS560I C SYNTAX REQUIRES WORD 'NAMED', 'CHANGED', OR 'CHANGED NAMED'. FOUND XXX.

System Action: The statement is skipped from the point of error.

IJS561I C DATA TYPE MUST BE ED, ID, BI, EF, IF, RP, AL, AN, OR GF. FOUND XXX.

Explanation: A file-name, condition name, figure configuration, or variable-length group is not valid at this point.

System Action: The statement is skipped from the point of the error.

IJS562I C DATA ENTRY MUST NOT EXCEED 120 CHARACTERS.

Explanation: The data entry specified exceeds the maximum permitted for this type of output.

System Action: The statement is skipped from the point of the error.

IJS563I C DATA ENTRY MUST BE DISPLAY.

System Action: The statement is skipped from the point of the error.

IJS564I C SYNTAX REQUIRES ONE OF THE ALLOWABLE CHARACTERS. FOUND XXX.

System Action: The statement is skipped from the point of the error.

IJS565I C IF STATEMENT MUST BE TERMINATED BY A PERIOD.

Explanation: This message is obtained when the IF statement is the last statement of a paragraph and a label is detected instead of a period.

System Action: The statement is skipped from the point of error.

IJS566I C DATA TYPE MUST BE AL, AN, RP, OR GROUP.

System Action: The statement is skipped from the point of error.

IJS567I C DATA TYPE MUST BE AL, AN, FIGCON OR FIXED-LENGTH GROUP.

System Action: The statement is skipped from the point of the error.

IJS568I C DATA ITEM MUST NOT EXCEED 256 CHARACTERS.

System Action: The statement is skipped from the point of the error.

IJS569I C DATA ENTRIES MUST BE OF EQUAL LENGTH.

System Action: The statement is skipped from the point of the error.

IJS570I C THE LENGTH OF THE SECOND OPERAND MUST BE EQUAL TO THE FIRST OR A SINGLE CHARACTER.

System Action: The statement is skipped from the point of the error.

IJS571I E A RECORD NAME MUST BE ASSOCIATED WITH THIS FILE. FOUND XXX.

System Action: The statement is skipped from the point of the error.

IJS572I C ONLY ONE DATA-NAME MAY BE ASSOCIATED WITH THE CHANGED OPTION.

System Action: The statement is skipped from the point of the error.

IJS573I C DATA TYPE MUST BE ED, ID, BI, EF, IF, SN, SR, RP, AL, AN, FC, OR GROUP.

System Action: The statement is skipped from the point of error.

IJS601I W NO SIGNIFICANT POSITION MATCHES BETWEEN SENDING AND RECEIVING FIELDS IN MOVE. RECEIVING FIELD IS SET TO ZERO.

Explanation: There are no digit positions in common between the sending and receiving fields. This can be illustrated by moving a field with PICTURE 99 to a receiving field with PICTURE V99.

System Action: The receiving field is set to zero.

IJS602I W DESTINATION FIELD DOES NOT ACCEPT THE WHOLE SENDING FIELD IN MOVE.

Explanation: The sending field is larger than the receiving field in either its integer or decimal positions, or both.

System Action: The sending field is truncated.

IJS603I C AFTER ADVANCING OPTION NOT ALLOWED WITH REWRITE.

System Action: The statement is skipped from the point of the error.

IJS604I E SOURCE PROGRAM EXCEEDS INTERNAL LIMITS.

Explanation: The program is too large.

User Response: The user should do one of the following, then retry:

- Divide the program into two or more parts
- Simplify compound conditional statements.

IJS605I E PROCEDURE NAME MULTIPLY DEFINED.

Explanation: Procedure-name indicated was multiply defined and was not qualified properly by the appropriate section-name when used.

IJS606I E PROCEDURE-NAME XXX NOT DEFINED.

Explanation: The name indicated was incorporated into a GO TO or a PERFORM statement, and was never defined. Procedure names must begin in columns 8 through 11 at the point where they are defined.

IJS607I E INVALID LITERAL XXX.

User Response: Check for multiple decimal points, non-numeric characters that have not been enclosed in quotes.

IJS608I E XXX IS NOT ALLOWED TO HANDLE MORE THAN 25 FILES IN ONE STATEMENT.

System Action: The rest of the statement is skipped. Only 25 files are handled.

IJS609I E PROCEDURE-NAME XXX HAS ILLEGAL CONTENT AND IS DROPPED.

IJS610I E 'CONDITION NAME' WAS EITHER NOT ALLOWED IN THIS STATEMENT OR SKIPPED DUE TO ANOTHER DIAGNOSTIC.

IJS611I E TOO MANY PARAGRAPH NAMES HAVE BEEN USED IN CALL STATEMENTS.

IJS612I W OPEN STATEMENT CONTAINS MORE THAN 9 FILENAMES. OPEN WILL SPLIT.

System Action: Handles multiple OPEN statements each containing nine file-names.

IJS613I W USING STATEMENT HAS BEEN INCORRECTLY SPECIFIED.

IJS614I E THIS CONDITIONAL HAS A MISSING RELATIONAL OPERATOR.

System Action: The statement is skipped from the point of the error.

IJS615I E READ 'AT END' REQUIRED FOR FILES WITH ACCESS SEQUENTIAL.

IJS617I E WRITE 'FROM' REQUIRED WITH APPLY WRITE ONLY.

IJS618I E REWRITE INVALID ON DIRECT OR RELATIVE SEQUENTIAL FILES.

IJS621I E OPEN 'I-O' INVALID FOR DIRECT OR RELATIVE SEQUENTIAL FILES.

IJS622I E OPEN 'OUTPUT' INVALID FOR FILES WITH ACCESS RANDOM, I-O ASSUMED.

IJS623I E OPEN 'REVERSED' VALID ONLY ON STANDARD SEQUENTIAL FILES.

IJS625I E OPEN 'REVERSED' INVALID FOR FILES WITH FORMAT V RECORDS.

IJS626I E CLOSE 'UNIT' OR 'REEL' VALID ONLY FOR STANDARD SEQUENTIAL FILES.

IJS627I E 'INVALID KEY' INVALID FOR STANDARD, DIRECT, OR RELATIVE SEQUENTIAL FILES, OR FOR REWRITE ON INDEXED SEQUENTIAL FILES.

IJS628I E OPEN 'ACTUAL KEY' REQUIRED FOR DIRECT SEQUENTIAL OUTPUT FILES.

IJS629I E 'APPLY WRITE-ONLY' OPTION MUST BE SPECIFIED FOR OUTPUT FILES ONLY.

IJS700I E SOURCE PROGRAM NOT FOUND. COMPILATION CANCELED.

IJS701I E DATA DIVISION NOT FOUND. COMPILATION CANCELED.

IJS702I E PROCEDURE DIVISION NOT FOUND. COMPILATION CANCELED.

IJS703I E SOURCE PROGRAM EXCEEDS INTERNAL LIMITS. COMPILATION CANCELED.

Explanation: The size of the assembler phase tables exceeds the core storage available for these tables.

User Response: Modify the source program to allow compilation on the source computer. There are essentially three variables that can be modified:

- The length and number of source labels could be reduced as the table for source labels must reserve 3 + L bytes per source label.
- The number of literals could be reduced as 3 bytes are reserved for each literal.
- The size of the buffer can be reduced in machines above 16K storage size.

IJS704I E DATA-NAME TABLE OVERFLOW. COMPILATION CANCELED.

IJS705I NO DIAGNOSTICS IN THIS COMPILATION.

IJS706I E EXECUTION CANCELED DUE TO E LEVEL DIAGNOSTIC.

IJS707I E CONFLICTING I/O ASSIGNMENTS.

Explanation: SYS001, SYS002, and SYS003 are not assigned to the same type of device.

System Action: Compilation is canceled.

IJS708I E STORAGE ALLOCATED TO THE COMPILER IS LESS THAN 10K. compilation canceled.

IJS708I E STORAGE ALLOCATED TO THE COMPILER IS LESS THAN 14K. COMPILATION CANCELED.

IJS709I W INCORRECT COBOL OPTION 'XXX'.

IJS710I W BUFFSIZ CANNOT BE LESS THAN 170. ASSUMED 170.

IJS711I W BUFFSIZ CANNOT BE GREATER THAN 32000. ASSUMED 32000.

IJS712I W BUFFSIZ CANNOT BE GREATER THAN 3625 (7294) FOR WORK FILES ON DISK. ASSUMED 3625 (7294).

Explanation: 3625 for 2311
7294 for 2314

IJS713I W BUFFSIZ IS TOO LARGE FOR SIZE OF STORAGE ALLOCATED TO THE COMPILER. ASSUMED XXX.

EXECUTION TIME MESSAGES

A list of execution time messages follows. Most of them are self-explanatory. Where deemed necessary, examples are included to explain the message.

#IHD901I* AN UNCORRECTABLE DASD ERROR HAS OCCURRED.

#IHD902I* WRONG LENGTH RECORD.

#IHD903I* NO RECORD FOUND.

#IHD904I* ILLEGAL ID SPECIFIED.

#IHD905I* DUPLICATE RECORD.

#IHD906I* CYLINDER OVERFLOW AREA FULL.

#IHD907I* PRIME DATA AREA FULL.

#IHD908I* CYLINDER INDEX AREA FULL.

#IHD909I* MASTER INDEX AREA FULL.

#IHD910I* RECORD OUT OF SEQUENCE.

#IHD911I WRONG LENGTH RECORD.

#IHD912I NO MORE ROOM FOUND ON TRACK.

#IHD913I DATA CHECK IN COUNT AREA.

#IHD914I DATA CHECK WHEN READING KEY OR DATA.

#IHD915I NO RECORD FOUND.

#IHD993I ZERO BASE-MINUS EXPONENT-PACKED RESULT MADE ALL NINES.

#IHD996I RESULT TOO BIG-FLOATING POINT RESULT MADE MAX FP NUMBER.

#IHD997I ZERO BASE-MINUS EXPONENT-FLOATING POINT RESULT IS MAX FP NUMBER.

---

*These messages pertain to indexed sequential data organization only.

#IHD998I ZERO BASE-PLUS EXPONENT-FLOATING POINT RESULT MADE ZERO.

#IHD999I MINUS BASE MADE PLUS AND FLOATING POINT EXPONENTIATION CONTINUED.

------- AWAITING REPLY.

DEBUG PACKET ERROR MESSAGES

The following is a complete list of precompile error messages. They apply to errors in the debugging packet only.

IJS850I TABLE OF DEBUG REQUESTS OVERFLOWED. RUN TERMINATED.

IJS851I THE FOLLOWING CARD DUPLICATES A PREVIOUS *DEBUG CARD. THIS PACKET WILL BE IGNORED.

IJS852I THE FOLLOWING PROCEDURE DIVISION NAMES WERE NOT FOUND. INCOMPLETE DEBUG EDIT IS NOT TERMINATED.

IJS853I THE FOLLOWING *DEBUG CARD DOES NOT CONTAIN A VALID LOCATION FIELD. THIS PACKET WILL BE IGNORED.

IJS854I IDENTIFICATION DIVISION NOT FOUND. RUN TERMINATED.

IJS855I DEBUG EDIT RUN COMPLETE. INPUT OR COBOL COMPILATION ON SYS004.

360 COBOL Programmer's Guide Printed in U.S.A. GC24-5025-5

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]