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IBM Systems Reference Library

IBM 1130 Subroutine Library

Ninth Edition (May 1974)

This is a reprint of GC26-5929-7 incorporating changes released in the following newsletter GN34-0182.

This edition applies to version 2, modification 12 of IBM 1130 Disk Monitor System and to all subsequent modifications until otherwise indicated in new editions or Technical Newsletters. Changes are continually made to the specifications herein; before using this publication in connection with the operation of IBM systems, consult the latest SRL Newsletter, Order No. GN20-1130, for the editions that are applicable and current.

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Preface

The publication describes how the programmer can use the IBM 1130 library subroutines to increase the efficiency of his programs and decrease his writing and testing time. The libraries include the following programs:

- Interrupt Level Subroutines.
- Interrupt Service Subroutines.
- RPG Subroutines.
- FORTRAN I/O Subroutines.
- Data Code Conversion Subroutines.
- Arithmetic and Functional Subroutines.
- Selective Dump Subroutines.
- Utility Programs.

The subroutines are available for use with the 1130 Assembler, the 1130 FORTRAN Compiler, and the 1130 RPG Compiler. The Utility Programs are executable under Monitor control.

In Assembler language, the user calls the subroutines via a calling sequence. The appropriate subroutine calls are generated by the FORTRAN Compiler whenever a read, write, arithmetic, or CALL statement is encountered. The RPG Compiler generates the appropriate subroutine linkages. This publication describes each subroutine and the required calling sequence. All subroutines in the 1130 libraries are included in the lists that appear in Appendix A.

It is assumed that the reader is familiar with the methods of data handling and the functions of instructions in the IBM 1130 Computing System. He must also be familiar with the Assembler or Compiler used in conjunction with the subroutines. The following IBM publications provide the prerequisite information:

<u>IBM 1130 Functional Characteristics</u>, Order No. GA26-5881.

<u>IBM 1130 Operating System</u>, Order No. GA26-5717.

<u>IBM 1130 Assembler Language</u>, Order No. GC26-5927.

<u>IBM 1130/1800 Assembler Language</u>, Order No. GC26-3778.

<u>IBM 1130/1800 Basic FORTRAN IV Language</u>, Order No. GC26-3715.

<u>IBM 1130 RPG Specifications</u>, Order No. GC21-5002.

The operating procedures manuals for the programming systems also provide information on subroutine usage. These manuals are:

<u>IBM 1130 Card/Paper Tape Programming System Operator's Guide</u>, Order No. GC26-3629.

<u>IBM 1130 Disk Monitor System, Version 2, Programmer's and Operator's Guide</u>, Order No. GC26-3717.

MACHINE CONFIGURATION

The use of the library subroutines requires the following minimum machine configuration:

IBM 1131 Central Processing Unit with 4096 words of core storage.

IBM 1442 Card Read Punch, or IBM 1134 Paper Tape Reader with IBM 1055 Paper Tape Punch.

Note: RPG, available only with the DM2 system, requires 8192 words of core storage.

In addition, the following input/output units and features can be controlled by the input/output subroutines.

Console Printer/Keyboard
Single Disk Storage
1132 Printer
1627 Plotter
1403 Printer (DM2 only)
2310 Disk Storage (DM2 only)
2311 Disk Storage (DM2 card system only)
2501 Card Reader (DM2 only)
1231 Optical Mark Page Reader (DM2 only)
Synchronous Communications Adapter (DM2 only)

Plotter subroutines are described in <u>IBM 1130/1800 Plotter Subroutines</u>, Order No. GC26-3755.

SCA subroutines are described in <u>IBM 1130 Synchronous Communications Adapter Subroutines</u>, Order No. GC26-3706.

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Introduction

It is often necessary to repeat a group, or block, of instructions many times during the execution of a program (examples include conversion of decimal values to equivalent binary values, computation of square roots, and the reading of data from a card reader). It is not necessary to write the instructions each time a function is required. Instead, the block of instructions is written once, and the main program transfers to that block each time it is required. Such a block of instructions is called a subroutine. Subroutines normally perform such basic functions that they can assist in the solution of many different kinds of problems.

When a main program uses a subroutine several times, which is the common situation, the block of instructions constituting the subroutine need appear only once. Control is transferred from a main program to the subroutine by a set of instructions known as a calling sequence, or basic linkage. A calling sequence transfers control to a subroutine and, through parameters, gives the subroutine any control information required.

The parameters of a calling sequence vary with the type of subroutine called. An input/output subroutine requires several parameters to identify an input/output device, storage area, amount of data to be transferred, etc., whereas an arithmetic/functional subroutine usually requires one parameter representing an argument. Each calling sequence used with subroutines in the 1130 system consists of a CALL or LIBF statement (whichever is required to call the specific subroutine), followed by the DC statements that make up the parameter list. The calling sequences for the various subroutines in the libraries are presented later in the manual. Each subroutine is self-contained, so that only those subroutines required by the current job are in core storage during execution.

In addition to the subroutines described in this publication, subroutines are available for use with the Disk Monitor System, Version 2 that are not provided in the system library for that version.

These subroutines are contained in the following separately available programs:

- Graphic Subroutine Package, which enables the FORTRAN IV or Assembler language programmer to display images in the form of lines, points, and characters on the screen of a 2250 Model 4 Display Unit attached to the 1130 system. The program also provides for communication between the 2250 operator and the user's program. It is described in the publication IBM 1130/2250 Graphic Subroutine Package for Basic FORTRAN IV, GC27-6934.

- Data Transmission Subroutines, which enable the FORTRAN IV or Assembler language programmer to transmit data between a program being processed by the Disk Monitor System Version 2 and a program being processed by a remote System/360 Operating System. These subroutines permit an 1130 program to use the high-speed computational capability and large storage capacity of the IBM System/360 Operating System. Communication between the two systems is accomplished in binary synchronous mode via telecommunication lines. The data transmission subroutines are described in the publication IBM System/360 Operating System and 1130 Disk Monitor System: System/360-1130 Data Transmission for FORTRAN, GC27-6937.

- Satellite Graphic Job Processor, which enables the user at a 2250 Model 4 Display Unit attached to the 1130 to easily start the processing of related programs in a remote System/360 Operating System. This allows the 2250 user to access the high-speed computational capability and large storage capacity of the IBM System/360 Operating System. Use of the Satellite Graphic Job Processor requires the data transmission subroutines discussed in the preceding paragraph. The Satellite Graphic Job Processor is described in the publication IBM System/360 Operating System and 1130 Disk Monitor System: User's Guide for Job Control from an IBM 2250 Display Unit Attached to an IBM 1130 System, GC27-6938.

Interrupt Service Subroutines

The interrupt service subroutines (ISSs) transfer data from and to the various input/output devices attached to the computer. These subroutines handle all the details peculiar to each device, including the usually complex interrupt functions, and can control many input/output devices at the same time by overlapping their operations.

ISS Characteristics

To fully understand subsequent descriptions of each ISS, the user should be familiar with the following characteristics, which are common to all ISSs:

- Methods of data transfer.
- Interrupt processing.
- ILS (interrupt level subroutine) operation.
- ISS (interrupt service subroutine) operation.
- General error-handling procedures.
- Basic calling sequence.

METHODS OF DATA TRANSFER

IBM 1130 I/O devices and their related subroutines can be differentiated according to their methods of transmitting and/or receiving data.

Direct Program Control

Serial I/O devices operate via direct program control, which requires a programmed I/O operation for each word or character transferred. A character interrupt occurs whenever a character I/O operation is completed. Direct program control of data transfer is used for the following system I/O devices: 1442 Card Read Punch, 1442 Card Punch, 1134 Paper Tape Reader and 1055 Paper Tape Punch, Console Printer, Keyboard, 1132 Printer, and 1627 Plotter.

Data Channel

Other system I/O devices operate via a data channel, which requires an I/O operation only to initiate data transfer. These devices are provided with control information, word counts, and data from the user's I/O area. Once initiated, data transfer proceeds concurrently with program execution. An operation-complete interrupt signals the end of an I/O operation when all data has been transferred. All disk drives, the 1403 Printer, and the 2501 Card Reader operate via a data channel.

INTERRUPT PROCESSING

Interrupt processing is divided into two parts, level processing and device processing. The flow of logic in response to an interrupt is: user program interrupted, level processing begun, device processing begun and completed, level processing completed, and user program continued.

Level Processing

Level processing consists of selecting the correct device processing subroutine, performing certain housekeeping functions, and clearing the level by a BOSC instruction when interrupt processing is complete.

Level processing is done by the ILSs (interrupt level subroutines). Entered by interrupts, ILSs give temporary control to device processing subroutines (ISSs) and eventually return control to the user program. The interrupt entrance address is stored during the loading of a core load or program, in the appropriate interrupt branch address; location 8 for interrupt level zero (ILS00), location 9 for interrupt level one (ILS01),..., location 12 (/000C) for interrupt level four (ILS04). The device processing entrance address is computed during the loading of a core load from identifying information that is a part of the ILS.

In the card/paper tape system, the device processing entrance address is stored during the loading of a program from identifying information stored in the ILS, in the compressed ISS header card, and in the loader interrupt Transfer Vector.

Device Processing

Device processing consists of operating an I/O device, processing the interrupts, and clearing the device by an XIO (sense DSW) instruction when interrupt processing is complete.

Device processing is done by the ISSs (interrupt service subroutines). The ISSs can be entered by a calling instruction (LIBF or CALL), which either requests certain initialization to be done or requests an I/O device operation. They can also be entered by an ILS as part of the interrupt processing. The calling entry point is specified in the ISS statement. The interrupt entry points are set up in the ISS and identified in the ILS. They are entered indirectly through a branch address table.

ILS OPERATION

The ISS/ILS package services all input/output interrupts.

Description

There is one ILS for each interrupt level used. Each subroutine determines which device on its level caused a particular interrupt; preserves the contents of the Accumulator, the Accumulator Extension, Index Register 1 (XR1), and the Carry and Overflow indicators; and transmits identifying information to the ISS. Disk Monitor ILSs also save Index Register 2 (XR2). The special ILSX subroutines in DM2 save and restore Index Register 3.

Interrupt service subroutines are loaded first so that the loader loads only the ILSs that are required. For example, if a main program does not call the 1132 Printer subroutine, the subroutine for interrupt level 1 (ILS01) need not be loaded because no interrupts will occur on that level. An ILS cannot be called; it is included in a core load or program only if requested by an ISS. If you use the 1130 Card/Paper Tape system, see "ISS-Define Interrupt Service Entry Point" in IBM 1130 Assembler Language. If you use the 1130 Disk Monitor, Version 2, system (DM2), see "Define Interrupt Service Subroutine Entry Point" in IBM 1130/1800 Assembler Language.

When the ILSs are loaded, the core addresses assigned to them are incorporated into the appropriate locations in the Interrupt Transfer Vector (decimal words 8-13). Interrupts occurring during execution of a user program cause a Branch Indirect, via the interrupt branch address, to the correct ILS.

Recurrent Subroutine Entries

Recurrent entries to a subroutine can result from interrupts. For example, during execution of the Console Printer subroutine, a disk interrupt can start execution of a subroutine to handle the condition that caused the disk interrupt. If this handling includes calling the Console Printer subroutine, certain information is destroyed, the most important of which is the return address of the program that originally called the Console Printer.

To prevent the loss of data resulting from such a recurrent entry, the <u>user</u> must provide the programming required to save the return address and any other data needed to continue an interrupted subroutine after an interrupt has been serviced.

<u>Note</u>: All ISSs were written with the assumption that all LIBFs to them would be executed on the mainline level (i.e., not while on the interrupt level). There are <u>no</u> provisions in any ISSs to handle recurrent entries. See Appendix G for information on user-written re-enterable code.

ISS OPERATION

This section briefly describes the operation of the ISSs. This description, along with some basic flowcharts, should make it easier for the reader to understand the descriptions of individual subroutines presented later.

The disk subroutines are included here as ISSs even though in the Disk Monitor System they are not truly ISSs. They do however, have most of the characteristics of an ISS.

ISS Subdivision

Each ISS is divided into a call portion and an interrupt response portion. The call portion is entered when a user's calling sequence is executed; the interrupt response portion is entered as a result of an I/O interrupt.

Call Processing

The Interrupt Service Subroutines -- with the exception of those used by FORTRAN -- save and restore the contents of the Accumulator, Index Registers 1 and 2, and the Carry and Overflow Indicators. However, the contents of the Accumulator will be destroyed if a preoperative error is detected. The call portion, illustrated in Figure 1, has four basic functions:

1. Determines if any previous operations on the specified device are still in progress.

2. Checks the calling sequence for legality.

3. Saves the calling sequence.

4. Initiates the requested I/O operation.

The flow diagram (Figure 1) is not exact for any one ISS. It is only a general picture of the internal operation of the call portion of an ISS.

Determine Status of Previous Operation. This function can be performed by using a programmed subroutine-busy indicator to determine if a previous operation is complete. The CARD1 subroutine is a good example. When an operation is started on the 1442, a subsequent LIBF CARD1 for the 1442 is not honored until the subroutine-busy indicator is turned off. A call to any other ISS subroutine, such as TYPE0, is not affected by the fact that the CARD1 subroutine is busy.

Each ISS, except PAPTN and DISKN, can use one programmed subroutine-busy indicator to determine if a previous operation is complete. The PAPTN subroutine uses two busy indicators, one for the paper tape reader and one for the punch. If an operation is started on the reader, a subsequent LIBF PAPTN for the reader is not honored until the Reader Busy indicator is turned off. However, a LIBF PAPTN for the paper tape punch is treated in the same manner as a call to any other ISS and is not affected by the fact that the paper tape reader is busy. The subroutine DISKN uses five busy indicators, one for each disk drive. (Each disk drive corresponds to a certain bit in $DBSY.) This provides the possibility to operate all of the disk drives simultaneously.

Check Legality of Calling Sequence. Calling sequences are checked for such items as illegal function character, illegal device identification code, zero or negative word count, etc.

Save Calling Sequence. The call portion saves, within itself, all of the calling sequence information needed to perform an I/O operation. The user can modify a calling sequence, even though an I/O operation is not yet complete.

Note: The I/O data area should be left intact during an operation because the ISS is continually accessing and modifying that area.

Initiate I/O Operation. The call portion only initiates an I/O operation. Subsequent character interrupts or operation complete interrupts are handled by the interrupt response routine.

Interrupt Response Processing

The I/O interrupt response portion of an ISS is illustrated in Figure 2.

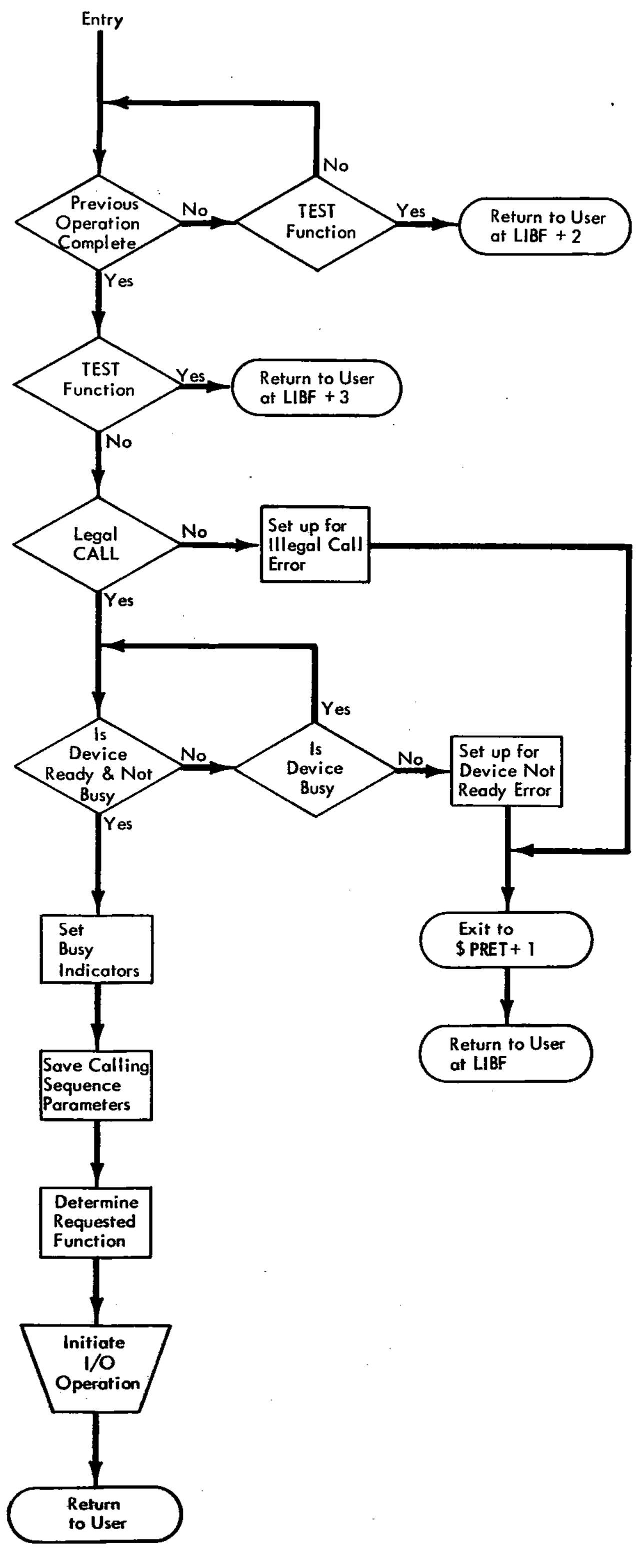
Operation. An I/O interrupt causes a user program to exit to an interrupt level subroutine, which in turn exits to the I/O interrupt response portion of an ISS. The interrupt response portion checks for errors, does any necessary data manipulation, initiates character operations, and initiates retry operations in case of errors. It then returns control to the interrupt level subroutine, which returns control to the user.

Character Interrupts. These interrupts occur for devices under direct program control whenever data can be read or written, e.g., a card column punched or a paper tape character read.

Operation Complete Interrupts. These interrupts occur in disk and card operations when a specified block of data has been read or written, e.g., a disk record read.

Error Detection and Recovery Procedures. These procedures are an important part of an ISS. However, little can be done about reinitiating an operation until a character interrupt or operation complete interrupt occurs. Therefore, error indicators are not examined until one of these interrupts occurs.

Recoverable Device. This is an I/O device that can be easily repositioned by a subroutine or by an operator and an I/O operation reinitiated. If a device is not recoverable, or if an error cannot be corrected after a specified number of retries, the user is informed of the error condition. If a device is recoverable, the user may request, via his error subroutine, that the operation be reinitiated.



• **Figure 1. Call Portion of an ISS**

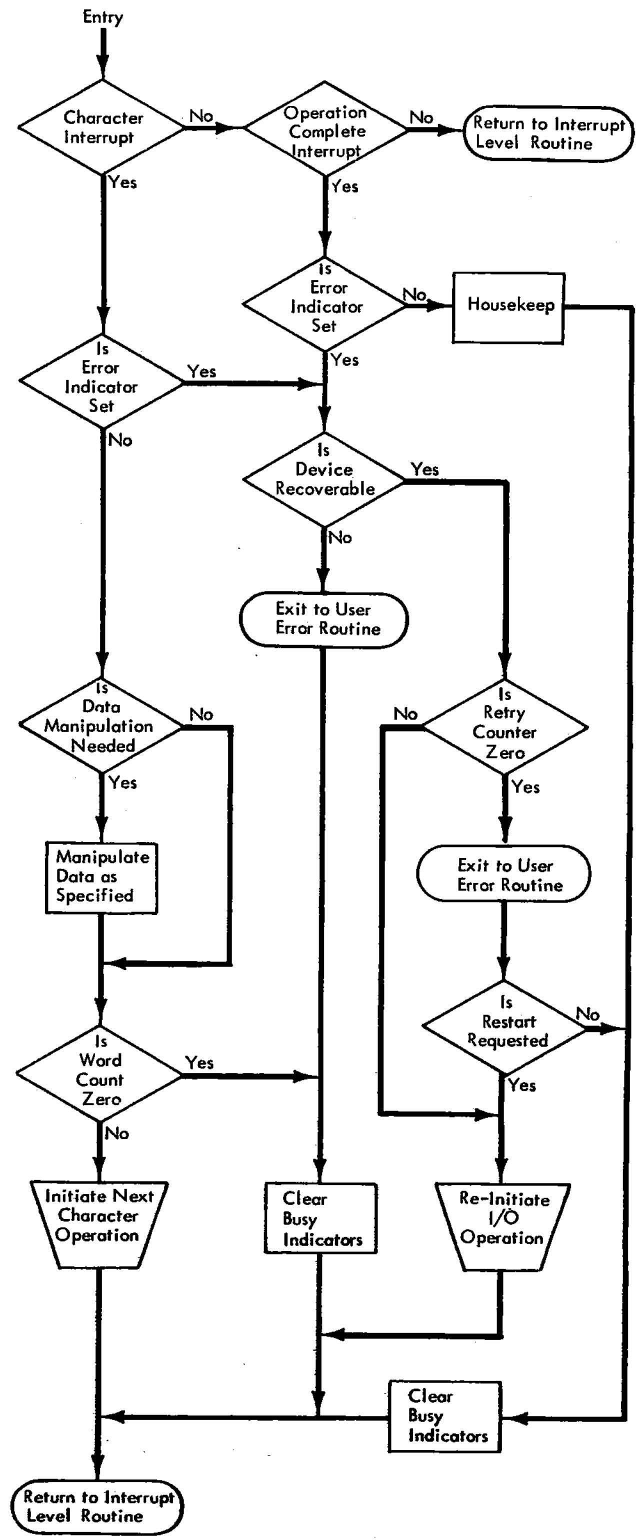


Figure 2. Interrupt Response Portion of an ISS

GENERAL ERROR-HANDLING PROCEDURES

Each ISS has its own error detecting portion, which determines the type of error and chooses an error procedure. (In this context, the term error includes such conditions as last card, channel 9, channel 12, etc.) Errors fall into one of two categories: those that are detected before an I/O operation is initiated, and those that are detected after an I/O operation has been initiated. Appendix B contains a list of the errors detected by the ISSs; Appendix C contains descriptions of the actions taken by each ISS after the return from user-written error subroutines.

Preoperative Error Detection

Before an ISS initiates an I/O operation, it checks the device status and the legality of calling parameters. If a device is not ready or a parameter is in error, the Interrupt Service Subroutine will wait at $PRET+1 displaying an error indicator that defines the error (see Appendix E). This error indicator consists of four hexadecimal digits that are defined below.

$PRET is entered via a Branch and Store Instruction Counter (BSI) instruction in the following subroutines: DISKZ, DISK1, DISKN, OMPR1, PLOTX, and the ISSs used by FORTRAN. All other ISSs store the address of the LIBF statement in $PRET and then branch to $PRET+1 to wait and display the error; i.e., when PROGRAM START is pressed, the call to the subroutine is retried.

Digit 1 identifies the ISS subroutine called:

C/PT System	DM2 System
1-CARD0 or CARD1	1- CARD0, CARD1, or CARDZ; PNCH0, PNCH1, or PNCHZ
2-TYPE0 or WRTY0	2- TYPE0 or TYPEZ, WRTY0, or WRTYZ
3-PAPT1 or PAPTN	3- PAPT1, PAPTN, PAPTX, or PAPTZ
	4- READ0, READ1, or READZ
5-DISK0, DISK1, or DISKN	5- DISKZ, DISK1, or DISKN
6-PRNT1	6- PRNT1 or PRNTZ
7-PLOT1	7- PLOT1 or PLOTX
8-SCAT1, SCAT2 or SCAT3	8- SCAT1, SCAT2, or SCAT3
	9- PRNT3 or PRNZ
	A- OMPR1

Digits 2 and 3 are reserved.

Digit 4 identifies the error:

0- device not ready.

1- illegal LIBF parameter or illegal specification in the I/O area.

There is a WAIT instruction in core location $PRET+1 and a branch instruction (BSC I $PRET) in the next location. Therefore, the LIBF may be executed again (after the error condition has been corrected) by pressing PROGRAM START on the console. The user can, if he chooses, replace these two instructions with an exit to his own error subroutine.

Postoperative Error Detection

After an I/O operation has been started, certain conditions may be detected about which the user should be informed. The conditions might be card jams for which manual intervention is needed before the operation can continue; read checks that have not been corrected after a specified number of retries; or indications of equipment readiness, such as last card or channel 12 indicators. All these conditions are detected by the interrupt response portion (see "ISS Operation").

No Error Parameter. If no error parameter is included in the calling sequence that initiated the I/O operation and a postoperative error condition is detected, the card/paper tape system subroutine initiates a Wait procedure (programmed loop), which continues until the operator corrects the detected condition.

The DM2 system does not use a programmed loop, but rather branches to a postoperative error trap that is similar to the preoperative error trap. Each interrupt level (1-4) has its own postoperative error trap with accompanying WAIT address.

Level 1 - $PST1 (0081)
Level 2 - $PST2 (0085)
Level 3 - $PST3 (0089)
Level 4 - $PST4 (008D)

Processing resumes -- at the address immediately following -- after the operator corrects the detected condition and presses PROGRAM START.

<u>Error Parameter Included</u>. If an error parameter is included in the calling sequence, a Branch and Store Instruction Counter (BSI) instruction to the user's error subroutine specified in the calling sequence is executed. Identifying information is placed in the Accumulator and Extension (see Appendix B). When the user's error subroutine returns control to the ISS using the return link (see "Basic ISS Calling Sequence"), the subroutine examines the Accumulator. If the user has cleared the Accumulator before returning to the subroutine, he is requesting that the error condition be ignored and the operation terminated. If the user has not cleared the Accumulator, he is requesting that the operation be restarted, in which case the subroutine reinitiates the operation before returning to the user's main program.

<u>Implications of the User's Error Subroutine</u>. It is important to note that a user's error subroutine (entered via the LIBF error parameter address) is executed as part of the interrupt processing. The interrupt level is still on, preventing recognition of other interrupts of the same or lower priority. This has the following implications:

1. Return must be made to the ISS subroutine via the return link (set up by the BSI instruction executed by the ISS subroutine). Otherwise, normal processing cannot be continued because the ISS must return to the ILS to restore the contents of the Accumulator and Extension, Status Indicators, and Index Registers.

2. Return must be made with a BSC instruction, not a BOSC instruction. Otherwise, the interrupt level is turned off, setting up the possibility that another interrupt could occur on the same level, thus destroying the return address to the user from the ILS.

3. A LIBF or CALL to another subroutine from the user's error subroutine can cause a recurrent-entry problem. If that subroutine is already in use when the interrupt occurs, the user's new LIBF or CALL destroys the original return address and disrupts operation of the called subroutine.

4. A LIBF or CALL to another ISS can cause an endless loop if the new I/O device operates on the same or lower priority interrupt level than the device that caused the error.

<u>Note</u>: A call to WRTY0 to type an error message can be made only if the user does not wait for the completion of typing or for operator intervention before returning to the ISS. A test loop on level 4 (typewriter) or a WAIT loop will both block the clearing of the level that caused the interrupt to the user's error subroutine.

5. The user should have a separate error subroutine for each device to prevent errors on several devices (on different levels) from causing recurrent-entry problems in the user's error subroutine.

<u>Note</u>: The error codes in the Accumulator may not distinguish between ISSs, as the preoperative error codes do.

Since the ILS saves Index Register 1 as part of its interrupt processing, the user's error subroutine can also use this index register without saving and restoring it. However, the user cannot depend on the contents of Index Register 1 unless he initializes it as part of his error subroutine. The DM2 ILSs also save Index Register 2. The special ILSX subroutines in the DM2 save and restore Index Register 3.

<u>Programming Techniques - User's Error Subroutine Exits</u>. Some programming techniques that can be used in conjunction with the ISS error exit are as follows:

1. To try the operation again:

Label	Operation	F	T	Operands & Remarks
USER	DC			Ø
	BSC		I	USER

2. To terminate the operation:

Label	Operation	F	T	Operands & Remarks
USER	DC			Ø
	SRA			16 TO CLEAR THE ACCUMULATOR
	BSC	I		USER

3. To indicate that a condition ("last card" or "channel 9") was detected and that the normal program flow should be altered:

Label	Operation	F	T	Operands & Remarks
	LD			INDIC
	BSC	L		NEW,Z ALTER PROGRAM FLOW
	LIBF			CARD1
	DC			/1ØØØ
	DC			INPUT READ ONE CARD
	DC			USER
	•			•
	•			•
	•			•
USER	DC			Ø
	BSC	I		USER,Z
	LD			DØØØ1
	STO			INDIC
EXIT	BSC	I		USER
	•			•
INDIC	DC			*-*
	•			•
NEW	SRA			16
	STO			INDIC
	•			•
	•			•
	•			•

BASIC ISS CALLING SEQUENCE

Each ISS described in this manual is entered via a calling sequence. These calling sequences follow a basic pattern. In order not to burden the reader with redundant descriptions, this section presents the basic calling sequences and describes those parameters that are common to most of the subroutines.

Basic Calling Sequence

```
LIBF    Name
DC      Control parameter
DC      I/O area
DC      Error subroutine
```

The above calling sequence, with the parameters shown, is basic to most of the ISSs. Detailed descriptions of the above four parameters are omitted when the subroutines are described later in the manual. Unless otherwise specified, the subroutine returns control to the instruction immediately following the last parameter.

Name Parameter

Each subroutine has a symbolic name that must be written in the LIBF statement exactly as listed in Figures 3 and 4.

Device	Subroutine
1442 Card Read Punch	CARD0, CARD1, or CARDZ
Disk	DISK0, DISK1 DISKN
1132 Printer	PRNT1 or PRNTZ
Keyboard/Console Printer	TYPE0 or TYPEZ
Console Printer	WRTY0 or WRTYZ
1134/1055 Paper Tape	PAPT1, PAPTN or PAPTZ
1627 Plotter	PLOT1 or PLOTX
Synchr. Comm. Adapter	SCAT1, SCAT2, or SCAT3

Figure 3. C/PT System ISS Names

For some devices more than one subroutine is available, although only one can be selected for use in any one program (including called subroutines).

NAME0. The NAME0 subroutine is the shortest and least complicated. The NAME0 version is the standard subroutine for the 1442, 2501, and Console Printer/Keyboard. The NAME0 version of the Disk routine (DISK0) can be used if transfer of data is 320 words or less (C/PT system only).

Device	Subroutine
1442 Card Read Punch	CARDZ, CARD0, or CARD1
2501 Card Reader	READZ, READ0, or READ1
1442 Card Punch	PNCHZ, PNCH0 or PNCH1
Disk	DISKZ, DISK1, or DISKN
1132 Printer	PRNTZ, PRNT1, or PRNT2
1403 Printer	PRNZ, or PRNT3
Keyboard/Console Printer	TYPEZ, or TYPE0
Console Printer	WRTYZ, or WRTY0
1134/1055 Paper Tape Reader Punch	PAPTZ, PAPT1, PAPTN, or PAPTX
1627 Plotter	PLOT1, or PLOTX
1231 Optical Mark Page Reader	OMPR1
Synchr. Comm. Adapter	SCAT1, SCAT2, or SCAT3
2250 Display Unit, Model 4	DSPYN

Figure 4. DM2 System ISS Names

NAME1. The NAME1 version is the standard subroutine for the disk, 1132, 1403, 2501, 1134/1055, 1231, and 1627. It may be used if a user error exit is needed rather than the internal looping and retries by the NAME0 subroutine.

NAMEN. The NAMEN version is available to operate the 1134/1055 Paper Tape Reader and Punch simultaneously and to minimize extra disk revolutions when transferring more than 320 words to or from the disk. The NAMEN subroutine offers more options than the NAME1 subroutine. In DM2, it also operates as many as 5 disks simultaneously.

NAMEZ. The NAMEZ version is designed for use in an error-free environment. It provides no preoperative parameter checking. The FORTRAN formatting subroutines use these ISSs but they do not use the calling sequence listed below (see "Subroutines Used by FORTRAN").

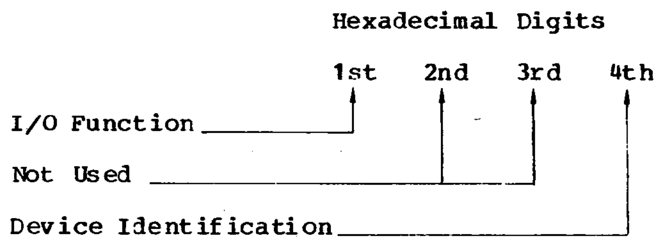
PRNT2. The PRNT2 version is used when the 1132 is used with the SCA.

PRNT3. The PRNT3 version is used with the 1403.

Control Parameter

The control parameter, in the form of four hexadecimal digits, conveys necessary control data to the ISSs by specifying the desired function (read, write, etc.), the device identification, and similar control information. Most subroutines do not use all four digits.

A typical control parameter is illustrated below.



Since the I/O function and device identification digits are used in most subroutines, a description of the purpose of each is given here.

I/O Function

The function digit in the calling sequence specifies which I/O operation the user is requesting. Three of these functions--read, write, and test-- are used in most subroutines.

Read. The read function causes a specified amount of data to be read from an input device and placed in a specified input area. Depending upon the device, an interrupt signals the subroutine either when the next character is ready or when all requested data has been read. When the specified number of characters has been read, the subroutine becomes available for another call to that device.

Write. The write function causes a specified amount of data from the user's output area to be written, i.e., printed or punched, by an output device. As with the read function, an interrupt signals the subroutine when the device can accept another character, or when all characters have been written. When the specified number of characters has been written, the subroutine becomes available for another call to that device.

Test. The test function causes a check to be made as to the status of a previous operation initiated on an I/O device. If the previous operation has been completed, the subroutine branches to the LIBF+3 core location; if the previous operation has not been completed, the subroutine branches to the LIBF+2 core location. The test function is illustrated below:

```
         LIBF     Name

LIBF+1   DC       Control Parameter
                  (specifying Test function)

LIBF+2   OP Code  xxxx....

LIBF+3   OP Code  xxxx....
```

Note: Specifying the test function requires two statements (one LIBF and one DC), except in disk subroutines, where three statements are required.

The test function is useful in situations in which input data has béen requested, but no processing can be done until the data is available.

Device Identification

This digit should be zero except for the Test function with the PAPTN (paper tape) subroutine.

Note: For all disk subroutines, this digit appears in the I/O area rather than in the control parameter.

I/O Area Parameter

The I/O area for a particular operation consists of one table of control information and data. This table is composed of a data area preceded by a control word (two control words for disk operations) that specifies how much data is to be transferred. The area parameter in the calling sequence is the address (symbolic or actual) of the first control word that precedes the data area.

The control word contains a word count referring to the number of data words in the table. It is important to remember that the number of words in the table is not always the number of characters to be read or written, because some codes pack two characters per word. The disk subroutines require a second control word, which is described along with those subroutines.

Error Parameter

The error parameter is the means by which an ISS can give temporary control to the user in the event of conditions such as error, last card, etc. This parameter is not required for the NAME0 subroutines for the 2501, 1442, Console Printer, or Keyboard. The instruction sequence for setting up the error subroutine is shown below.

```
         LIBF   NAME
         .      .
         DC     ERROR (error parameter)
         .      .
ERROR    DC     0 (return link)
         .      .
         .      . (error routine)
         BSC I  ERROR (branch to return link)
```

The return link is the address in the related ISS to which control must be returned upon completion of the error subroutine. The link is inserted in location ERROR by a BSI from the ISS when the subroutine branches to the error subroutine.

The types of errors that cause a branch to the error address are listed in Appendix B.

Note: The user's error subroutine is executed as part of the interrupt response handling. The interrupt level is still on and remains on until control is returned to the ISS (see "General Error-Handling Procedures").

Assignment of Core Storage Locations (C/PT System)

The portion of core storage used by the ISS and ILS subroutines is defined below. Care should be used in altering any of these locations (see Figure 5).

The areas illustrated in Figure 5 are described below.

Interrupt Branch Addresses

ILS Subroutines. When required, the address of ILS00 is always stored in location 8, ILS01 in location 9,..., ILS05 in location 13 (/000D).

Interrupt Trap. The address of the interrupt trap is stored in any location for which no ILS is loaded.

1132 Printer

This area is used by 1132 Printer.

Preoperative Error Trap

This exit is used whenever a preoperative error (illegal LIBF or device not ready) is detected by an ISS. To retry the call, press START.

ISS Exit

The ISS exit results from pressing the Keyboard Interrupt Request key. The TYPE0, and WRTY0 subroutines execute a BSI I /002C whenever a keyboard operator request is detected. Note that interrupt level 4 is still on.

The user-written subroutine must return to the TYPE0 or WRTY0 subroutine in order to allow interrupts of equal or lower priority to occur. Also a call executed to any subroutine might cause a recurrent-entry problem unless the user can guarantee that the subroutine was not in use when the keyboard interrupt occurred.

Location /002C is initialized with the address of the interrupt trap in case the user fails to store an address in the interrupt trap to process Keyboard operator requests.

Interrupt Trap

This trap is entered when an interrupt occurs for which there is no ILS and/or no ISS assigned to the pertinent bit in the Interrupt Level Status Word (ILSW).

Interrupts of higher priority will be processed before the system finally halts with the IAR displaying /002F.

ISS Counter

The ISS counter is incremented by +1 every time an ISS initiates an interrupt-causing I/O operation and is decremented by +1 when the operation is complete. A positive value in this location indicates the number of interrupt(s) pending. This counter should never be negative.

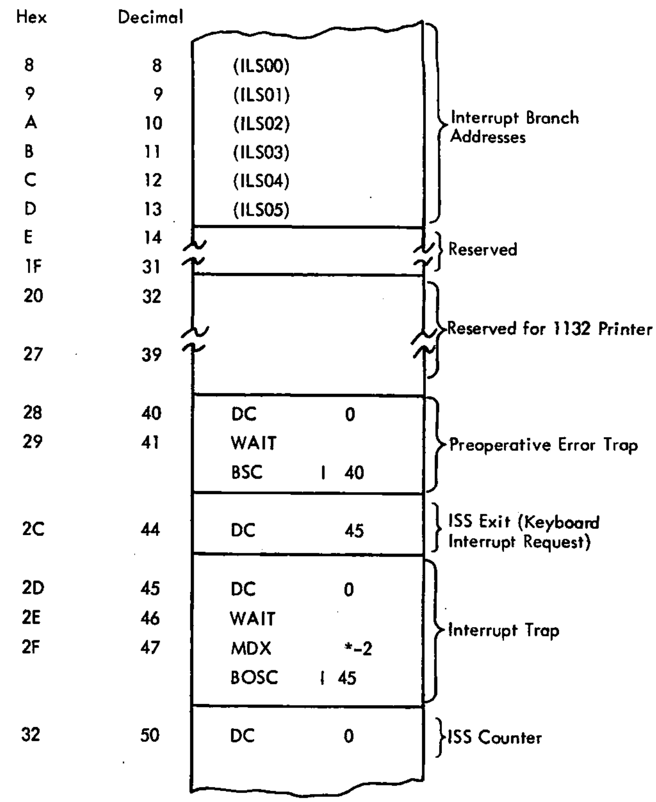


Figure 5. ISS and ILS Core Locations for the C/PT System

Assignment of Core Storage Locations (DM2 System)

The portion of core storage used by the ISS and ILS subroutines is defined below. Care should be used in altering any of these locations (see Figure 6) .

The areas illustrated in Figure 6 are described below.

Interrupt Branch Addresses

ILS Subroutines. The address of ILS00 is always stored in location 8, ILS01 in location 9,..., ILS05 in location decimal 13.

Interrupt Trap. The address of the Program Stop Key trap ($STOP-location /0091) is stored in any location for which no ILS is loaded.

Reserved Areas

These locations are reserved for the DM2 system.

1132 Printer

This area is used by 1132 Printer.

Preoperative Error Trap

This exit is used whenever a preoperative error (illegal LIBF or device not ready) is detected by an ISS. To retry the call, press START.

ISS Counter

The ISS counter is incremented by +1 every time an ISS initiates an interrupt-causing I/O operation and is decremented by +1 when the operation is complete.

A positive value in this location indicates the number of interrupts (s) pending. This counter should never be negative.

Interrupt Request Branch Address

The subroutine ILS04 or ILSX4 executes a BSI I $IREQ whenever a Keyboard operator request is detected.

$IREQ (location /002C) is initialized with the address $I420 in Resident Monitor. This allows the user to terminate the job by pressing the Interrupt Request key (INT REQ).

Note the following when writing an interrupt request subroutine:

- Interrupt level 4 is still on.
- An XIO instruction sensing Keyboard with reset must be performed.
- Return to ILS04 or ILSX4 to exit address +6.
- ILS04 or ILSX4 will turn off the interrupt.
- Subroutines that are in use when the interrupt occurs may not be called.

For examples of INT REQ see IBM 1130 Disk Monitor System, Version 2, Programmer's and Operator's Guide.

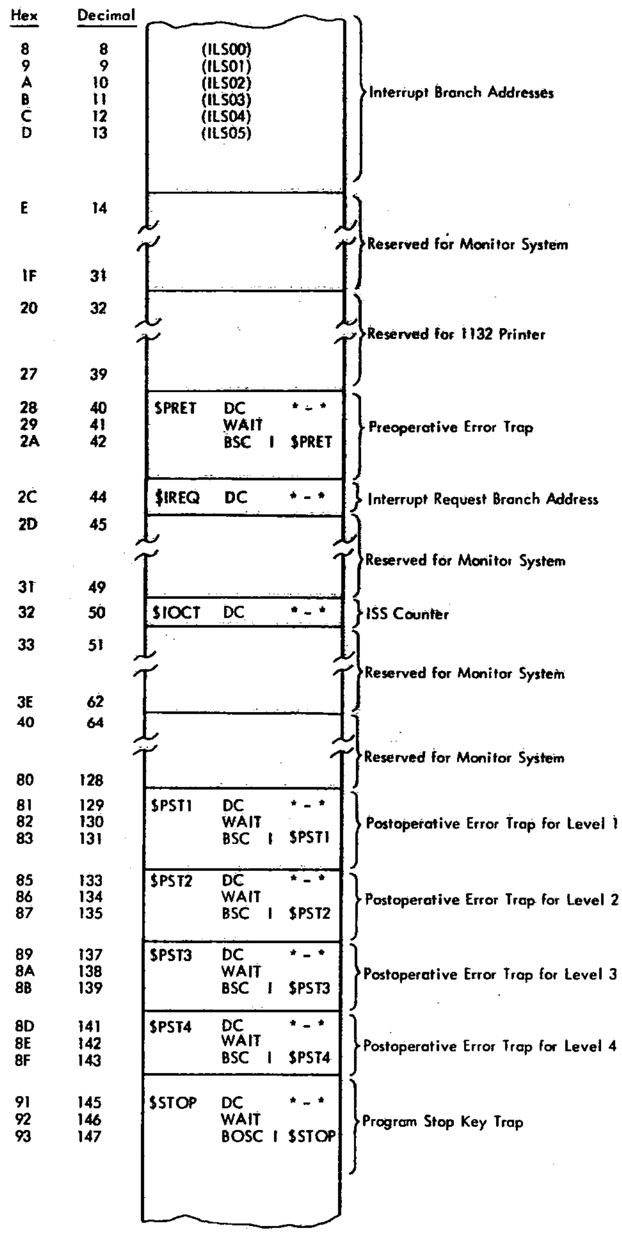


Figure 6. ISS and ILS Core Locations for the DM2 System

Postoperative Error Traps

These traps are entered when a device-not-ready condition is detected prior to the initiation of an I/O operation in the interrupt response portion of an ISS subroutine. Each interrupt level (1-4) has its own postoperative error trap. The system will WAIT with the IAR displaying the address of $PST1+2, $PST2+2, $PST3+2, or $PST4+2, depending on the interrupt level of the device.

Description of Interrupt Service Subroutines

Note that the subroutine READ0, READ1, PNCH0, PNCH1, PRNT3, and OMPR1 are available only with the DM2 system.

1442 CARD READ PUNCH SUBROUTINES (CARD0 AND CARD1)

The card subroutines perform all I/O functions relative to the IBM 1442 Card Read Punch: read, punch, feed, and stacker select.

CARD0 Subroutine. The CARD0 subroutine is shorter and less complicated than CARD1 and is the standard subroutine for the 1442.

CARD0 can be used if the error parameter is not needed. When an error occurs, the subroutine loops (DM1 and C/PT system) or will WAIT at $PST4+1 (DM2 system) until the operator takes corrective action. Last card conditions cause preoperative not-ready exits.

CARD1 Subroutine. The CARD1 subroutine can be used for the Card Read Punch if a user error exit is needed, rather than the error procedures of the CARD0 subroutine.

Calling Sequence

```
Label  Operation  F T  Operands & Remarks
       LIBF            CARDa        CALL CARD I/O
       DC              /b000        CONTROL PARAMETER
       DC              IOAR         I/O AREA PARAMETER
       DC              ERROR        ERROR PARAMETER
       .
       .
       .
ERROR  DC              *-*          RETURN ADDRESS
       .
       .
       .
       BSC        I    ERROR        RETURN TO CALLER
       .
       .
       .
IOAR   DC              f            WORD COUNT
       BSS             h            I/O AREA
```

where

a is 0 or 1,

b is the I/O function digit,

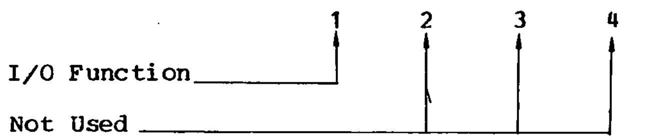
f is the number of columns to be read from or punched into the card,

h is the length of the I/O area. h must be equal to or greater than f.

The calling sequence parameters are described in the following paragraphs.

Control Parameter

This parameter consists of four hexadecimal digits as shown below:



I/O Function

The I/O function digit specifies the particular operation to be performed on the 1442 Card Read Punch. The functions, associated digital values, and required parameters are listed and described below.

Function	Digital Value	Required Parameters[1]
Test	0	Control
Read	1	Control, I/O Area, Error[2]
Punch	2	Control, I/O Area, Error[2]
Feed	3	Control, Error[2]
Stacker Select	4	Control

[1]Any parameter not required for a particular function must be omitted.
[2]Error parameter not required for CARD0.

Test. Branches to LIBF+2 if the previous operation has not been completed, to LIBF+3 if the previous operation has been completed.

Read. Reads one card and transfers a specified number of columns of data to the user's input area. The number of columns read (1-80) is specified by the user in the first location of the I/O area. The subroutine clears the remainder of the I/O area and stores a 1 in bit position 15 of each word, initiates the card operation, and returns control to the user's program. When each column is ready to be read, a column interrupt occurs. This permits the card subroutine to read the data from that column into the user's input area (clearing bit 15), after which the user's program is again resumed. This sequence of events is repeated until the requested number of columns has been read, after which the remaining column interrupts are cleared (no data read).

When an operation complete interrupt occurs, the card subroutine checks for errors, informs the user if an error occurred (CARD1 only), and sets up to terminate (CARD1 only) or retry the operation.

The data in the user's input area is in a code identical to IBM Card Code format; that is, each 12-bit column image is left-justified in one 16-bit word.

Punch. Punches into card the number of columns of data specified by the word count found at the beginning of the user's output area. The punch operation is similar to the read operation. As each column comes under the punch dies, a column interrupt occurs; the card subroutine transfers a word from the user's output area to the punch and then returns control to the user's program.

This sequence is repeated until the requested number of columns has been punched, after which an Operation Complete interrupt occurs. At this time the card subroutine checks for errors, informs the user if an error occurred (CARD1 only), and sets up to terminate (CARD1 only) or retry the operation. The character punched is the image of the leftmost 12 bits in the word.

Feed. Initiates a card feed cycle. This advances all cards in the machine to the next station, i.e., a card at the punch station advances to the stacker, a card at the read station advances to the punch station, and a card in the hopper advances to the read station. No data is read or punched as a result of a feed operation and no column interrupts occur. This effectively skips a card when used in conjuction with a Read or Punch function.

When the card advance is complete, an Operation Complete interrupt occurs. At this time the card subroutine checks for errors, informs the user if an error occurred (CARD1 only), and sets up to terminate (CARD1 only) or retry the operation.

Stacker Select. Selects stacker 2 for the card currently at the punch station. After the card passes the punch station, it is directed to stacker 2.

I/O Area Parameter

The I/O area parameter is the label of the control word that precedes the user's I/O area. The control word consists of a word count that specifies the number of columns of data to be read or punched, always starting the count at column 1. The word count must be in the range of 1-80.

Error Parameter

CARD0. CARD0 has no error parameter. If an error is detected while an operation complete interrupt is being processed, the subroutine loops (C/PT system) or will WAIT at $PST4+1 (DM2) with interrupt level 4 on, waiting for operator intervention. When the condition has been corrected, the 1442 made ready, and PROGRAM START pressed, the subroutine retries the operation.

CARD1. CARD1 has an error parameter. If an error is detected, the user can request the subroutine to terminate (clear subroutine-busy indicator and the interrupt level) or to loop (C/PT system) or WAIT at $PST4+1 (DM2) for operator intervention (interrupt level 4 on). See "Basic Calling Sequence".)

Protection of Input Data

Since the CARD subroutines read data directly into the user's I/O area, the user can manipulate the data before the entire card has been processed. This procedure is inherently dangerous because, if an error occurs, the data may be in error and error-recovery procedures will cause the operation to be tried again. The exit via the error parameter is the only method of informing the user that an error has occurred. Therefore, do not manipulate data before the entire card has been processed when using CARD0.

When using CARD1, the following precautions should be taken:

- Do not store converted data back into the read-in area.

- Do not take any irretrievable action based on the data until the card has been read correctly; i.e., be prepared to convert the data or perform the calculations a second time.

- When data manipulation is complete, check the user-assigned error indicator that is set when a branch to the user-written error subroutine occurs. The data conversion or calculations can then be reinitiated, if necessary.

Last Card

When the last card has been detected, a branch to the user error routine with /0000 in the Accumulator will occur. An operation requested after the last card has been fed from the hopper causes an exit to $PRET. When the 1442 is made ready and the PROGRAM START key is pressed, the last card will be processed.

2501 CARD READER SUBROUTINES (READ0 AND READ1)

These card subroutines, available only with the DM2 system, perform read and test functions relative to the IBM 2501 card reader.

READ0 Subroutine. READ0 is shorter than READ1, provides no error parameter, and is the standard subroutine for operation of the 2501 card reader. On an error, READ0 branches to $PSTY, then a WAIT for operation intervention will occur. The last card condition causes a branch to $PRET.

READ1 Subroutine. READ1 is used for operation of the 2501 card reader if a user error exit is required.

Calling Sequence

Label	Operation	F	T	Operands & Remarks
	LIBF			READa CALL CARD INPUT
	DC			/b000 CONTROL PARAMETER
	DC			IOAR I/O AREA PARAMETER
	DC			ERROR ERROR PARAMETER
	•			
	•			
	•			
ERROR	DC			*-* RETURN ADDRESS
	•			
	•			
	•			
	BSC	I		ERROR RETURN TO CALLER
	•			
	•			
	•			
IOAR	DC			f WORD COUNT
	BSS			h I/O AREA

where

a is 0 or 1,

b is the I/O function digit,

f is the number of columns to be read from the card,

h is the length of the I/O area. h must be equal to or greater than f.

The calling sequence parameters are described in the following paragraphs.

Control Parameter

This parameter consists of four hexadecimal digits as shown below:

```
                                1     2     3     4
                                ↑     ↑     ↑     ↑
I/O Function____________________|     |     |     |
Not Used______________________________|_____|_____|
```

I/O Function

The I/O function digit specifies the particular operation to be performed on the 2501 Card Reader. The functions, associated digital values, and required parameters are listed and described below.

Function	Digital Value	Required Parameters[1]
Test	0	Control
Read	1	Control, I/O Area, Error[2]

[1]Any parameter not required for a particular function must be omitted.
[2]The error parameter is not required for READ0.

Test. Branches to LIBF+2 if the previous operation has not been completed, to LIBF+3 if the previous operation has been completed.

Read. Reads one card and transfers a specified number of columns of data to the user's input area. The number of columns read (1-80) is specified by the user in the first location of the input area. The subroutine initiates the read function and returns control to the user's program.

When an Operation Complete interrupt occurs, the card subroutine checks for errors. If an error occurred, READ0 exits to $PST4; READ1 informs the user of the error and sets up to terminate or retry the operation.

The data in the user's input area is in IBM Card Code format; that is, each 12-bit column image is left-justified in one 16-bit word.

There is no separate feed function. However, a feed can be obtained by a read function with a word count of zero.

I/O Area Parameter

The I/O area parameter is the label on the control word that precedes the user's input area. The control word consists of a word count that specifies the number of columns of data to be read, always starting with column 1. The word count must be in the range of 0-80.

Error Parameter

READ0. READ0 has no error parameter. If an error is detected while an Operation Complete interrupt is being processed, the subroutine branches to $PST4, with interrupt level 4 on, waiting for operator intervention. When the condition has been corrected, the 2501 made ready, and PROGRAM START pressed, the subroutine attempts the operation again.

READ1. READ1 has an error parameter. If an error is detected, the user can request the subroutine to terminate (that is, to clear the subroutine's busy indicator and turn off the interrupt level) or retry. Prior to a retry, the subroutine checks to see if the unit is ready. If the unit is not ready, the subroutine branches to $PST4 with interrupt level 4 on, waiting for operator intervention.

Last Card

A read function requested after the last card has been fed from the hopper causes an exit to $PRET. When the reader is made ready and the PROGRAM START key pressed, the last card is read and fed into the stacker.

1442 CARD PUNCH SUBROUTINES (PNCH0 AND PNCH1)

These card subroutines, available only with the DM2 system, perform all I/O functions relative to the IBM 1442-5 Card Punch, that is, punch and feed. These subroutines may also be used with the 1442-6 or 1442-7 Card Read Punch for punch and feed functions.

PNCH0. The PNCH0 subroutine is shorter than PNCH1, provides no error parameter, and is the standard subroutine for operation of the 1442 card punch. On an error, PNCH0 branches to $PST4, then a WAIT for operator intervention will occur. The last card condition causes a branch to $PRET.

PNCH1. PNCH1 can be used for operation of the 1442 card punch if a user error exit is desired.

Calling Sequence

```
Label   Operation   F T   Operands & Remarks
        LIBF              PNCHa        CALL CARD OUTPUT
        DC                /b000        CONTROL PARAMETER
        DC                IOAR         I/O AREA PARAMETER
        DC                ERROR        ERROR PARAMETER
        .
        .
        .
ERROR   DC                *-*          RETURN ADDRESS
        .
        .
        .
        BSC         I     ERROR        RETURN TO CALLER
        .
        .
        .
IOAR    DC                f            WORD COUNT
        BSS               h            I/O AREA
```

where

a is 0 or 1,

b is the I/O function digit,

f is the number of columns to be punched into the card,

h is the length of the I/O area. h must be equal to or greater than f.

The calling sequence parameters are described in the following paragraphs.

Control Parameter

This parameter consists of four hexadecimal digits as shown below:

I/O Function

The I/O function digit specifies the particular operation to be performed on the 1442 Card Punch. The functions, associated digital values, and required parameters are listed and described below.

Function	Digital Value	Required Parameters[1]
Test	0	Control
Punch	2	Control I/O Area, Error[2]
Feed	3	Control, Error[2]

[1]Any parameter not required for a particular function must be omitted.
[2]The error parameter is not required for PNCH0.

Test. Branches to LIBF+2 if the previous operation has not been completed, to LIBF+3 if the previous operation has been completed.

Punch. Punches into one card the number of columns of data specified by the word count found at the beginning of the user's output area. As each column comes under the punch dies, a column interrupt occurs, the subroutine transfers a word from the user's output area to the punch, and then returns control to the user's program. The character punched is the image of the leftmost 12 bits in the word.

This sequence is repeated until the requested number of columns has been punched, after which an Operation Complete interrupt occurs. At this time the card subroutine checks for errors. If an error occurred, PNCH0 exits to $PST4; PNCH1 informs the user of the error and sets up to terminate or retry the operation.

Feed. Initiates a card feed cycle. This function advances all cards in the machine to the next station; that is, a card at the punch station advances to the stacker, a card at the read station advances to the punch station, and a card in the hopper advances to the read station. No data is punched as a result of a feed function and no column interrupts occur.

When the card advance is complete, an Operation Complete interrupt occurs. At this time the card subroutine checks for errors. If an error occurred, PNCH0 exits to $PST4; PNCH1 informs the user of the error and sets up to terminate or retry the operation.

I/O Area Parameter

The I/O area parameter is the label of the control word that precedes the user's output area. The control word consists of a word count that specifies the number of columns of data to be punched, always starting with column 1. The word count must be in the range of 1-80.

Error Parameter

PNCH0. PNCH0 has no error parameter. If an error is detected while an Operation Complete interrupt is being processed, the subroutine branches to $PST4 with interrupt level 4 on, waiting for operator intervention. When the condition has been corrected, the 1442 made ready, and PROGRAM START pressed, the subroutine retries the operation.

PNCH1. PNCH1 has an error parameter. If an error is detected, the user can request the subroutine to terminate (that is, to clear the subroutine-busy indicator and turn off the interrupt level) or retry. Prior to a retry, the subroutine checks to see if the unit is ready. If the unit is not ready, the subroutine branches to $PST4, with interrupt level 4 on, waiting for operator intervention.

DISK SUBROUTINES (C/PT SYSTEM)

The disk subroutines perform all reading and writing of data relative to disk storage. This includes the major functions: seek, read, and write, in conjunction with readback check, file protection, and defective cylinder handling.

DISK0. The DISK0 subroutine is the shortest version of the disk subroutine and can be used if not more than 320 words are to be read or written at one time.

DISK1. The DISK1 version is the standard subroutine for the disk and allows more than 320 words to be read or written; however, a full disk revolution might occur between sectors. DISK1 requires more core storage than DISK0.

DISKN. The DISKN subroutine minimizes extra disk revolutions in transferring more than 320 words. The DISKN subroutine requires more core storage than DISK1.

The major difference between DISK1 and DISKN is the ability of DISKN to read or write consecutive sectors on the disk without taking an extra revolution. If a full sector is written, the time in which the I/O command must be given varies. DISKN is programmed so that the extra revolution will not occur the majority of the time; DISK1 approximately 50 percent of the time.

All three disk subroutines have the same error-handling procedures.

Sector Numbering and File Protection

In the interest of providing disk features permitting versatile and orderly control of disk operations, programming conventions have been adopted concerning sector numbering, file protection, and defective cylinder handling. Successful use of the disk subroutines can be expected only if user programs are built within the framework of these conventions.

The primary concern behind these conventions is the safety of data recorded on the disk. To this end, the file-protection scheme plays a major role, but does so in a manner that is dependent upon the sector-numbering technique. The latter contributes to data safety by allowing the disk subroutine to verify the correct positioning of the access arm before it actually performs a write operation. This verification requires that sector identification be prerecorded on each sector and that subsequent writing to the disk be done in a manner that preserves the existing identification. The disk subroutines have been organized to comply with these requirements.

Sector Numbering. The details of the numbering scheme are as follows: each disk sector is assigned an address from the sequence 0,1,...,1623, corresponding to the sector position in the ascending sequence of cylinder and sector numbers from cylinder 0 sector 0 (outermost), through cylinder 202 sector 7 (innermost). The user can address cylinders 0 through 199. The remaining three cylinders are reserved for defective cylinder handling.

Each cylinder contains eight sectors and each sector contains 321 words. The sector address is recorded in the first word of each sector and occupies the rightmost eleven bit positions. Of these eleven positions, the three low-order positions identify the sector (0-7) within the cylinder. Utilization of this first word for identification purposes reduces the per sector availability of data words to 320; therefore, transmission of full sectors of data is performed in increments of 320 words. The sector addresses must be initially recorded on the disk by the user and are thereafter rewritten by the disk subroutines as each sector is written (see "Disk Initialization" in this section).

File Protection. File protection is provided to guard against the inadvertent destruction of previously recorded data. By having the write functions (except write immediate) uniformly test for the file-protect status of sectors that they are about to write, this control can be achieved.

This convention is implemented by assigning a file-protected area to each disk. The address of the first unprotected sector (0000-1623) on each disk is stored within the disk subroutine. Every sector below this one is file-protected, i.e., no writing is permitted below this address.

Defective Cylinder Handling

A defective sector is one in which, after ten retries, a successful writing operation cannot be completed. A cylinder having one or more defective sectors is defined as a defective cylinder. The disk subroutines can operate when as many as three cylinders are defective.

Since there are 203 cylinders on each disk, the subroutine can "overflow" the normally used 200 cylinders when defective cylinders are encountered (see "Effective Address Calculation" in this section).

The address of each defective cylinder is stored within the disk subroutines by the user (see "Disk Initialization" in this section).

If a cylinder becomes defective during an operation, the user can move the data in that cylinder and each higher-addressed cylinder into the next higher-addressed cylinder. Then the address of the new defective cylinder can be stored in DISKx +16, +17, or +18 and normal operation continued. Thus the user should not store the new defective cylinder address in DISKx and then continue normally because the effective sector address computation then yields a sector address eight higher than is desired (see "Effective Address Calculation" in this section).

If there are no defective cylinders, all three words in the defective cylinder table contain /0658. If, for example, only sector 0009 is defective, the table would contain /0008 (cylinder 1), /0658, and /0658.

Calling Sequence

Label	Operation	F	T	Operands & Remarks
	LIBF			DISKa CALL DISK I/O
	DC			/bcde CONTROL PARAMETER
	DC			IOAR I/O AREA PARAMETER
	DC			ERROR ERROR PARAMETER
	.			
	.			
	.			
ERROR	DC			*-* RETURN ADDRESS
	.			
	.			
	.			
	BSC	I		ERROR RETURN TO CALLER
	.			
	.			
	.			
IOAR	DC			f WORD COUNT
	DC			g SECTOR ADDRESS
	BSS			h I/O AREA

where

a is 0, 1, or N.

b is the I/O function digit,

c is in DISKN test function, the logical drive number. Otherwise c is 0.

d is the Seek option digit,

e is the Displacement option digit,

f is the number of words to be transferred to or from the disk,

g is the sector address at which the transfer is to begin,

h is the length of the I/O area. h must be equal to or greater than f.

The calling sequence parameters are described in the following paragraphs.

Control Parameter

This parameter consists of four hexadecimal digits as shown below:

1 — I/O Function
2 — Not Used
3 — Seek Option
4 — Displacement Option

I/O Function

The I/O function digit specifies the operation to be performed on disk storage. The functions, their associated digital value, and the required parameters are listed and described below.

Function	Digital Value	Required Parameters[1]
Test	0	Control, I/O Area
Read	1	Control, I/O Area, Error
Write without RBC	2	Control, I/O Area, Error
Write with RBC	3	Control, I/O Area, Error
Write Immediate	4	Control, I/O Area
Seek	5	Control, I/O Area, Error

[1]Any parameter not required for a particular function must be omitted.

Test. Branches to LIBF+3 if the previous operation has not been completed, to LIBF+4 if the previous operation has been completed.

Note: This function requires the I/O area parameter even though it is not used.

Read. Positions the access arm and reads data into the user's I/O area until the specified number of words has been transmitted. Although sector-identification words are read and checked for agreement with expected values, they are neither transmitted to the I/O data area nor counted in the number of words transferred.

If, during the reading of a sector, a read check occurs, up to ten retries are attempted. If the error persists, the function is temporarily discontinued, an error code is placed in the Accumulator, the address of the faulty sector is placed in the Extension, and an exit is made to the error subroutine specified by the error parameter.

Upon return from the error subroutine, that sector operation is reinitiated or the function is terminated, depending on whether the Accumulator is nonzero or zero.

Write With Readback Check. This function first checks whether or not the specified sector address is in a file-protected area. If it is, the subroutine places the appropriate error code in the Accumulator and exits to location /0028.

If the specified sector address is not in a file-protected area, the subroutine positions the access arm and writes the contents of the indicated I/O data area into consecutive disk sectors. Writing begins at the designated sector and continues until the specified number of words has been transmitted. A readback check is performed on the data written.

If any errors are detected, the operation is retried up to ten times. If the function still cannot be accomplished, an appropriate error code is placed in the Accumulator, the address of the faulty sector is placed in the Extension, and an exit is made to the error subroutine designated in the error parameter.

Upon return from this error subroutine, the same sector operation is reinitiated or the function is terminated depending upon whether the contents of the Accumulator is nonzero or zero.

As each sector is written, the subroutine supplies the sector-identification word. The identification word for the first sector is obtained from the I/O area, although it and subsequently generated identification words are not included in the word count. Writing less than 320 words on any sector sets the remaining words in that sector to zero.

Write Without Readback Check. This function is the same as the function described above except that no readback check is performed.

Write Immediate. Writes data with no attempt to position the access arm, check for file-protect status, or check for errors. Writing begins at the sector number specified by the rightmost three bits of the sector address. This function is provided to fulfill the need for more rapid writing to the disk than is provided in the previously described write functions. Primary application will be found in the "streaming" of data to the disk for temporary bulk storage.

As each sector is written, the subroutine supplies the sector-identification word. The identification word for the first sector is obtained from the I/O area, although it and subsequently generated identification words are not included in the word count. Writing less than 320 words sets the remainder of the sector to zero.

Seek. Initiates a seek as specified by the seek option digit. If any errors are detected, the operation is retried up to ten times.

Seek Option

If zero, a seek is executed to the cylinder whose sector address is in the disk I/O area control word; if nonzero, a seek is executed to the next cylinder toward the center of the disk, regardless of the sector address in the disk I/O area control word. This option is valid only when the seek function is specified.

The seek function requires that the user set up the normal I/O area parameter (see "I/O Area Parameter" in this section) even though only the sector address in the I/O area is used. The I/O area control (first) word is ignored.

Displacement Option

If zero, the sector address word contains the absolute sector identification; if nonzero, the file-protect address for the specified disk is added to bits 4-15 of the sector address word to generate the effective sector identification. The file-protect address is the sector identification of the first unprotected sector.

I/O Area Parameter

The I/O area parameter is the label of the first of two control words which precede the user's I/O area.

The first word contains a count of the number of data words that are to be transmitted during the disk operation. If the DISK1 or DISKN subroutine is used, this count need not be limited by sector or cylinder size, since these subroutines cross sector and cylinder boundaries, if necessary, in order to process the specified number of words. However, if the DISK0 subroutine is used, the count is limited to 320.

The second word contains the sector address where reading or writing is to begin. Bits 0-3 are used for device identification and must be zero. Bits 4-15 specify the sector address. Following the two control words is the user's data area.

Note: The I/O area parameters are not available to the user until the requested operation is completed. The word count and sector addresses may be altered during a requested disk operation but are restored at the completion of the operation.

Error Parameter

Refer to the section "Basic ISS Calling Sequence".

Important Locations

The relative locations within the DISK0, DISK1, and DISKN subroutines are defined as follows:

DISKx	+0 -	entry point from calling transfer vector when LIBF DISKx is executed.
	+2 -	loader stores address of first location (in the calling transfer vector) assigned to DISKx.
	+4 -	entry point from ILS handling Disk Storage interrupts.
	+7 -	area code for Disk Storage.
	+8 -	zero.
	+9 -	zero.
	+10 -	cylinder identification (bits 4-12) of the cylinder currently under the disk read/write heads (loaded as +202).
	+11 -	unused.
	+12 -	reserved.
	+13 -	sector address (bits 4-15) of the first non-file-protected sector for disk storage (loaded as 0).
	+14 -	reserved.
	+15 -	reserved.
	+16 -	sector address of the first defective cylinder for disk storage (loaded as +1624).
	+17 -	sector address of the second defective cylinder for disk storage (loaded as +1624).
	+18 -	sector address of the third defective cylinder for disk storage (loaded as +1624).

Effective Address Calculation

An effective disk address is calculated as follows:

1. Start with the user-requested sector address (found in the sector address word of the I/O area).

2. If the displacement option (found in the control parameter) is nonzero, add the sector address of the first non-file-protected sector (found in DISKx +13).

Note: This starting address will cause a preoperative error exit to location /0029 if over 1599.

3. If the resulting address is equal to or greater than the sector address of the first defective cylinder (found in DISKx +16), add 8.

4. If the resulting address is equal to or greater than that of the second defective cylinder (found in DISKx +17), add 8 more.

5. If the resulting address is equal to or greater than that of the third defective cylinder (found in DISKx +18), add 8 more.

The address obtained from steps 1-5 is the effective sector address.

Disk Initialization

It is the user's responsibility to correctly load DISKx +13, +16, +17, and +18 at execution time and whenever a new disk is initialized. The following programs can be used to perform these functions.

Disk Pack Initialization Routine (DPIR). The functions of this program are to write sector addresses on a disk, to detect any defective cylinders, and to store defective cylinder information, file-protect addresses, and a disk label in sector 0 of the disk. The operating procedures for DPIR are located in the publication IBM 1130 Card/Paper Tape Programming System Operator's Guide.

Set Pack Initialization Routine (SPIR0, SPIR1, and SPIRN). The function of these subroutines is to store defective cylinder information and the file-protect address from sector 0 of the disk into the appropriate DISKx subroutine.

If the above subroutines are not used, the starting address of the DISKx routine can be loaded into an index register for easy use in reaching the specified locations:

Label	Operation	F	T	Operands & Remarks
	LD			LIBF
	SLA			8 EXPAND MODIFIER INTO 16
	SRT			8 BITS WITH SIGN
	STX		3	LOAD+1
	A			LOAD+1 ADD IN TV ADDRESS
	A			DØØØ2 ADD CONSTANTS TO REACH
	STO			LOAD+1 THIRD WORD OF DISKx SLOT
LOAD	LDX	I	2	Ø XR2=DISKx
	•			•
	•			•
	•			•
DØØØ2	DC			+2
LIBF	BSI		3	n SOURCE= LIBF DISKx
	•			•
	•			•
	•			•
C+n	DC			Ø LOAD AS CALLING TV (C=XR3)

The SPIR is a special-purpose utility subroutine. It is not called by LIBF as are the other disk subroutines described in this section. SPIR0 must be used if DISK0 is called, SPIR1 if DISK1 is called, or SPIRN if DISKN is called.

Note: In no case should SPIR be used with the DM2 System.

The SPIR reads sector 0000 from the disk and stores the first four words into the disk ISS that is in core. Therefore, the SPIR subroutine should be called before any calls are made to the disk ISS.

The calling sequence for SPIR is as follows:

```
CALL   SPIRx
 DC    /0000
```

The four words read from sector 0000 are described under "Disk Pack Initialization Routine" in the publication IBM 1130 Card/Paper Tape Programming System Operator's Guide.

DISK SUBROUTINES (DM2 SYSTEM)

All disk subroutines used by the DM2 system (including DISKZ) reside in the IBM System area on the monitor disk. The disk subroutines are stored in a special core image format in this area rather than in the System Library, since the DM2 system always requires a disk I/O subroutine. The required version is fetched by the Core Image Loader just prior to execution.

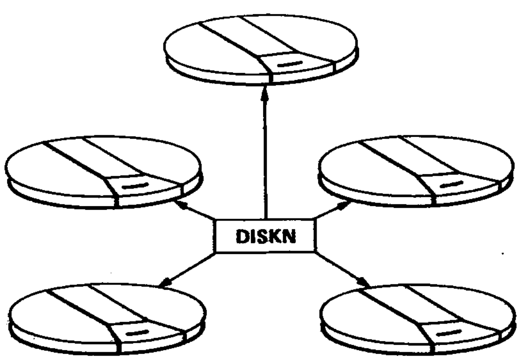
The disk subroutines used with the Monitor system are DISKZ, DISK1, and DISKN.

DISKZ. DISKZ is intended for use in a FORTRAN environment in which FORTRAN I/O is used. DISKZ makes no preoperative parameter checks and offers no file protection. It is the shortest of the three disk I/O subroutines and requires a special calling sequence (see "DISKZ-Disk I/O Subroutine"). This calling sequence can also be used with DISK1 and DISKN. DISKZ is also used by the RPG disk subroutines.

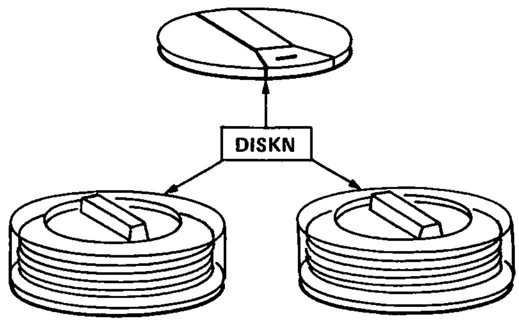
DISK1. DISK1 is intended for use by Assembler language programs in which the core storage requirement is of more importance than the execution time. DISK1 is longer than DISKZ but is the shorter of the two subroutines intended for use in Assembler language programs (DISK1 and DISKN). However, DISK1 does not minimize extra disk revolutions when transferring more than 320 words.

DISKN. DISKN minimizes extra disk revolutions in transferring more than 320 words. It provides all the functions DISK1 does and also operates as many as 5 drives simultaneously.

Two versions of DISKN are distributed with the Disk Monitor System. Both versions are called by the same calling sequence. The difference between them is the way they control disk drives. One version of DISKN, shown in the next drawing, can control as many as 5 single-disk drives simultaneously. This version of DISKN is for systems having only 2315 Disk Cartridges (mounted in 2310 Disk Storage Drives and/or the 1131 CPU).



The other version of DISKN, shown in the next drawing, can simultaneously control a single-disk drive in the 1131 CPU and two 2311 Disk Storage Drives (only one of the disks in each pack). This version of DISKN is for systems having 1316 Disk Storage Packs (mounted in 2311 Disk Storage Drives), and--optionally--a 2315 Disk Cartridge mounted in the 1131 CPU.



During loading of the Disk Monitor System, the 2310 version of DISKN is automatically placed into the IBM System Area on disk. If your system contains 2311s, however, you must replace this version with the 2311 version of DISKN before you load the Disk Monitor System card deck. (See "Monitor System Initial Load and System Reload" in IBM 1130 Disk Monitor System, Version 2, Programmer's and Operator's Guide.)

Note: Both DISK1 and DISKN can be specified on the Monitor XEQ record for use with FORTRAN programs. However, they offer no real advantage over DISKZ if they are called by the disk FORTRAN I/O subroutine.

One of the major differences among the disk subroutines is the ability to read or write consecutive sectors on the disk without taking extra revolutions. If full sectors are written, the time in which the I/O command must be given varies. DISKN is programmed so that transfers of more than 320 words are made with a minimum number of extra revolutions occuring between sectors.

DISK1 and DISKN have the same error-handling procedures.

Note: In the DM2 system, the disk I/O subroutines are not stored in the System Library; consequently they do not have LET entries.

Sector Numbering and File Protection

In the interest of providing disk features permitting versatile and orderly control of disk operations, programming conventions have been adopted concerning sector numbering, file protection, and defective sector handling. Successful use of disk I/O subroutines can be expected only if user programs are built within the framework of these conventions. The primary concern behind the conventions is the safety of data recorded on the disk. To this end, the file-protection scheme plays a major role, but does so in a manner that is dependent upon the sector-numbering technique. The latter contributes to data safety by allowing the disk I/O subroutine to verify the correct positioning of the access arm before it actually performs a write operation. This verification requires that sector identification be prerecorded on each sector and that subsequent writing on the disk be done in a manner that preserves the existing identification. The disk I/O subroutines support these requirements.

Sector Numbering. Each disk sector is assigned an address from the sequence 0, 1, ...,1623, corresponding to the sector position in the ascending sequence of cylinder and sector numbers from cylinder 0, sector 0 (outermost), through cylinder 202, sector 7 (innermost). The user can address cylinders 0 through 199. The remaining three cylinders are reserved for defective cylinder handling.

Each cylinder contains eight sectors and each sector contains 321 words, counting the sector address. The sector address is recorded in the first word of each sector and occupies the rightmost eleven bit positions. Of these eleven positions, the three low-order positions identify the sector (0-7) within the cylinder. Utilization of this first word for identification purposes reduces the per sector availability of data words to 320; therefore, transmission of full sectors of data is performed in increments of 320 words.

Sector addresses must be initially recorded on the disk by the user (via DISC or DCIP: see IBM 1130 Disk Monitor System, Version 2, Programmer's and Operator's Guide), and are thereafter rewritten by the disk I/O subroutines as each sector is written.

Note: Although not actually written on the disk, the logical drive code must be part of the sector address parameter (bits 1-3) which is stored in the second word of the I/O area. Bit 0 must always be zero.

File Protection. File protection is provided to prohibit the inadvertent destruction of previously recorded data. This control is achieved by having all write functions (except write immediate) test for the file-protection status of sectors they are about to write.

Each cartridge has a file-protect address in COMMA. This address is the address of the first unprotected sector, i.e., the address of the beginning of Working Storage. Every sector, from sector 0 up to the sector address maintained in COMMA, is file-protected. The initial assignment of the file-protect address is performed by the disk initialization program DCIP or DISC: see IBM 1130 Disk Monitor System, Version 2, Programmer's and Operator's Guide. Subsequent updating of the file-protect address is performed by the Monitor programs.

Defective Sector Handling. A defective sector is a sector on which a read or write function cannot be successfully completed during initialization of the cartridge. A cylinder having one or more defective sectors is defined as a defective cylinder. The disk I/O subroutines can accommodate as many as three defective cylinders per cartridge. Since there are 203 cylinders on each disk, the disk I/O subroutines can "overflow" the 200 cylinders normally used when defective cylinders are encountered (see "Effective Address Calculation" in this section).

Calling Sequence

Label	Operation	F	T	Operands & Remarks	
	LIBF			DISKa	CALL DISK I/O
	DC			/bØde	CONTROL PARAMETER
	DC			IOAR	I/O AREA PARAMETER
	DC			ERROR	ERROR PARAMETER
	•				
	•				
	•				
ERROR	DC			*-*	RETURN ADDRESS
	•				
	•				
	•				
	BSC	I		ERROR	RETURN TO CALLER
	•				
	•				
	•				
IOAR	DC			f	WORD COUNT
	DC			g	SECTOR ADDRESS
	BSS			h	I/O AREA

where

a is 1 or N. Note that LIBF DISK0 is equivalent to LIBF DISK1.

b is the I/O function digit,

d is the Seek option digit,

e is the Displacement option digit,

f is the number of words to be transferred to or from the disk,

g is the sector address, including the logical drive code, at which the transfer is to begin,

h is the length of the I/O area. h must be equal to or greater than f.

Control Parameter

This parameter consists of four hexadecimal digits, shown below:

```
                                   1    2    3    4
I/O Function_______________________|    |    |    |
                                        |    |    |
Logical Drive Code                      |    |    |
 (DISKN Test function Only)_____________|    |    |
                                             |    |
Seek Option__________________________________|    |
                                                  |
Displacement Option_______________________________|
```

I/O Function

The I/O function digit specifies the operation to be performed on disk storage. The functions, their associated digital value, and the required parameters are listed and described below.

Function	Digital Value	Required Parameters[1]
Test	0	Control, I/O Area
Read	1	Control, I/O Area, Error
Write without RBC	2	Control, I/O Area, Error
Write with RBC	3	Control, I/O Area, Error
Write Immediate	4	Control, I/O Area
Seek	5	Control, I/O Area, Error

[1]Any parameter not required for a particular function must be omitted.

Test. Branches to LIBF+3 if the previous operation on the drive has not been completed, to LIBF+4 if the previous operation has been completed.

Note: This function requires the I/O area parameter even though it is not used.

Read. Positions the access arm and reads data into the user's I/O area until the specified number of words has been transmitted. Although sector identification words are read and checked for agreement with expected values, they are neither transmitted to the I/O area nor counted in the number of words transferred.

If, during the reading of a sector, a read check occurs, up to 16 retries are attempted. If the error persists, the function is temporarily discontinued, an error code is placed in the Accumulator, the address of the faulty sector is placed in the Extension, and an exit is made to the error subroutine specified by the error parameter.

Upon return from the error subroutine, the operation is either reinitiated or terminated, depending on whether the Accumulator is nonzero or zero, respectively.

Write With Readback Check. Checks whether or not the specified sector address is in a file-protected area. If it is, the subroutine places the appropriate error code in the Accumulator and exits to $PRET.

If the specified sector address is not in a file-protected area, the subroutine positions the access arm and writes the contents of the indicated I/O area onto the disk. Writing begins at the designated sector and continues until the specified number of words have been transmitted. A readback check is performed on the data written.

Writing less than 320 words on any sector sets the remaining words in that sector to zero.

If any errors are detected, the operation is retried up to 16 times. If the function cannot be accomplished, an appropriate error code is placed in the Accumulator, the address of the faulty sector is placed in the Extension, and an exit is made to the error subroutine designated by the error parameter.

Upon return from this error subroutine, the operation is either reinitiated or terminated, depending upon whether the Accumulator is nonzero or zero, respectively.

As each sector is written, the subroutine supplies the sector-identification word. The identification word for the first sector is obtained from the I/O area, although it and subsequently generated identification words are not included in the word count.

Write Without Readback Check. Functions the same as Write With Readback Check except that no readback check is performed.

Write Immediate. Writes data with no attempt to position the access arm, check for file-protect status, or check for errors. Writing begins at the sector number specified in the user's I/O area. This function provides more rapid writing to the disk than is provided in the previously described Write functions; it provides, for example, the ability to "stream" data to the disk for temporary bulk storage or to write addresses in Working Storage (see "System Library Mainline Programs (DM2 System) ADRWS").

Writing less than 320 words on any sector sets the remaining words in that sector to zero.

As each sector is written, the subroutine supplies the sector-identification word. The identification word for the first sector is obtained from the I/O area, although it and subsequently generated identification words are not included in the word count.

Seek. Initiates a seek as specified by the seek option digit. If any errors are detected, the operation is retried up to 16 times.

The seek function requires that the user set up the normal I/O area parameters (see "I/O Area Parameter" in this section) even though only the sector address in the I/O area is used.

Logical Drive Code. Digit 2 defines the logical drive code (0, 1, 2, 3, or 4). This digit is used only with the DISKN test function.

Seek Option. If digit 3 of the control parameter is zero, a seek is executed to the cylinder whose sector address is in the I/O area; if nonzero, a seek is executed to the next nondefective cylinder toward the center, regardless of the sector address in the I/O area. This seek to the next nondefective cylinder must be taken into consideration when planning for the "streaming" of data. This option is valid only when the seek function is specified.

Displacement Option. If digit 4 of the control parameter is zero, the sector address word contains the absolute sector identification; if nonzero, the file-protect address for the specified cartridge is added to bits 4-15 of the sector address word to generate the effective sector identification. The file-protect address is the sector identification of the first unprotected sector, i.e., the address of the first sector of Working Storage.

I/O Area Parameter

The I/O area parameter is the label of the first of two control words which precede the user's I/O area. The first word contains the number of data words that are to be transferred during the disk operation. This number need not be limited by sector or cylinder size, since the subroutines cross sector and cylinder boundaries, if necessary, in order to transmit the specified number of words.

The second word contains the sector address at which reading or writing is to begin. Bit 0 must be zero. Bits 1-3 are the device identification (logical drive code) and must be 0, 1, 2, 3, or 4. Bits 4-15 specify the sector address. The user's I/O area follows the two control words.

Note: The I/O area parameters are not available to the user until the requested operation is completed. The word count and sector addresses may be altered during a requested disk operation but are restored at the completion of the operation.

Error Parameter

If an error is detected, the user can request the subroutine to terminate (that is, to clear the subroutine's busy indicator and turn off interrupt level 2) or to branch to $PST2, with interrupt level 2 on, waiting for operator intervention.

Effective Address Calculation

An effective disk address is calculated as follows:

1. Obtain the sector address found in the sector address word of the I/O area.

2. If the displacement option digit in the control parameter is nonzero, add the sector address of the first sector that is not file-protected.

Note: This address causes an exit to $PRET if it exceeds 1599.

3. If the resultant address is equal to or greater than the sector address of the first defective cylinder, add 8.

4. If the resultant address is equal to or greater than that of the second defective cylinder, add 8 more.

5. If the resultant address is equal to or greater than that of the third defective cylinder, add 8 more.

The address obtained from steps 1-5 is the effective sector address. Defective cylinders are handled in this manner for all operations, including seek and write immediate.

Monitor Entry Point

Both DISK1 and DISKN can be entered by a BSI L /00F2, the monitor entry point (see calling sequence of DISKZ). This entry point is used by the system programs and by FORTRAN programs when DISK1 or DISKN is specified in the XEQ record.

Reading begins at the designated sector where the access arm reads data into the user's I/O area until the specified number of words has been transmitted.

Writing begins at the designated sector and continues until the specified number of words have been transmitted. A readback check is performed on the data written on the disk. When DISK1 and DISKN are entered via /00F2, however, there is no check for writing in the file-protect area.

There is no possibility of performing a seek operation when using the monitor entry point. A word count of zero will result in a preoperative error wait. All postoperative errors will cause a branch to $PST2 (see Appendix B).

Disk Initialization

Before the DM2 system is stored on a cartridge, the Disk Cartridge Initialization Program (DCIP) must be executed. This program writes sector addresses on the disk cartridge, detects any defective cylinders, stores defective cylinder information and a cartridge ID in sector 0 of cylinder 0, and initializes DCOM. The operating procedure for DCIP is listed in the publication IBM 1130 Disk Monitor System, Version 2, Programmer's and Operator's Guide.

DISKZ - DISK I/O SUBROUTINE

The DISKZ subroutine offers no file protection, no preoperative parameter checks, no write immediate function, and no write without readback check function. It is intended for use by the DM2 programs, RPG programs, and FORTRAN programs in which disk FORTRAN I/O is used. Although DISKZ has many of the characteristics of an ISS, it is assembled as though it were a mainline and is stored in a special Core Image format in the System Device Subroutine area.

Calling Sequence

Label	Operation	F	T	Operands & Remarks
	LDD			LIST LOAD PARAMETERS IN ACC, EXT
	BST		L	DZ000 BRANCH TO DISKZ
	.			
	.			
	.			
	BSS	E		0
LIST	DC			/000a I/O FUNCTION PARAMETER
	DC			IOAR I/O AREA PARAMETER
	.			
	.			
	BSS	E		0
IOAR	DC			b WORD COUNT
	DC			c SECTOR ADDRESS
	BSS			d I/O AREA
	.			
	.			
	.			
DZ000	EQU			/00F2

where

a is the I/O function digit: 0 indicates a read, 1 a write.

b is the number of words to be transferred to or from the disk,

c is the sector address at which the transfer is to begin,

d is the length of the I/O area. d must be equal to or greater than b.

The word count (first word of the buffer) must be nonnegative and must be on an even core boundary. The sector address must be the second word of the buffer. The logical drive code (0, 1, 2, 3, or 4), as defined by the // JOB DM2 control record, is in bits 1-3 of the sector address. Bit zero is always zero.

A word count of zero indicates a seek to the cylinder denoted in the sector address. File protection is not provided. If the access arm is not positioned at the cylinder addressed, DISKZ seeks to that cylinder before performing the requested function. A read follows each seek to verify that the seek was successful. No buffer is required for this read.

<u>Buffer Size</u>. Unlimited

<u>Operation</u>. DISKZ performs read, seek, and write with readback check functions. Each function returns control to the user after it has been initiated. To determine the completion of a disk operation, the user may test $DBSY (location /00EE in COMMA) until it is cleared to zero. DISKZ itself tests this word before initiating an operation. Following a write, this subroutine performs a readback check on the data just written. If it detects an error, it reexecutes the write. Similarly, if a sector is not located or if an error is detected during a read, DISKZ repeats the operation. All operations are attempted 16 times before DISKZ indicates an unrecoverable error.

If a partial sector (less than 320 words) is written, the remaining words of the sector are set to zero.

<u>Subroutines Required</u>. No other subroutines are required by DISKZ.

<u>Note</u>: It is important to realize that the DISKZ subroutine is designed to operate in an error-free environment; it is not recommended for general usage. The user should therefore use DISK1 or DISKN whenever possible.

1132 PRINTER SUBROUTINE (PRNT1)

The printer subroutine PRNT1 handles all print and carriage control functions relative to the IBM 1132 Printer (see also "1132 Printer/Synchronous Communications Adapter Subroutine (PRNT2)"). Only one line of data can be printed, or one carriage operation executed, with each call to the printer subroutine. The data in the output area must be in EBCDIC form, packed two characters per computer word. Any code other than those defined for the 1132 will be interpreted by the PRNT1 subroutine as a blank. (See "Appendix D. Character Code Chart".)

Calling Sequence

Label	Operation	F	T	Operands & Remarks
	LIBF			PRNT1 CALL PRINTER OUTPUT
	DC			/bcdØ CONTROL PARAMETER
	DC			IOAR I/O AREA PARAMETER
	DC			ERROR ERROR PARAMETER
	•			
	•			
	•			
ERROR	DC			*-* RETURN ADDRESS
	•			
	•			
	•			
	BSC	I		ERROR RETURN TO CALLER
	•			
	•			
	•			
IOAR	DC			f WORD COUNT
	BSS			h I/O AREA

where

b is the I/O function digit,

c is the "immediate" carriage operation digit,

d is the "after-print" carriage operation digit,

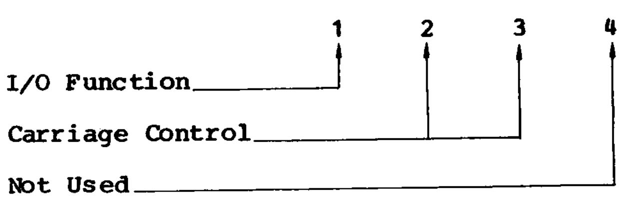
f is number of words to be printed on the 1132 Printer,

h is the length of the I/O area. h must be equal to or greater than f.

The calling sequence parameters are described in the following paragraphs.

Control Parameter

This parameter consists of four hexadecimal digits which are used as shown below.



I/O Function

The I/O function digit specifies the operation to be performed on an 1132 Printer. The functions, their associated digital values, and the required parameters are listed and described below.

Function	Digital Value	Required Parameters[1]
Test	0	Control
Print	2	Control, I/O Area, Error
Control Carriage	3	Control
Print Numeric	4	Control, I/O Area, Error

[1] Any parameter not required for a particular function must be omitted.

Test. Branches to LIBF+2 if the previous operation has not been completed, to LIBF+3 if the previous operation has been completed.

Print. Prints characters from the user's I/O area, checking for channel 9 and 12 indications. If either of these conditions is detected, the subroutine branches to the user's error subroutine after the line of data has been printed (see Appendix B for error codes). Upon return from this error subroutine, a skip to channel 1 is initiated or the function is terminated, depending upon whether the Accumulator is nonzero or zero.

Control Carriage. Controls the carriage as specified by the carriage control digits listed in Figure 7.

Print Numeric. Prints only numerals and special characters from the user's I/O area and checks for channel 9 and channel 12 indications. See "Print" above.

Carriage Control. Digits 2 and 3 specify the carriage control functions listed in Figure 7. An "immediate" request is executed before the next print operation; an "after-print" request is executed after the next print operation and replaces the normal space operation.

If the I/O function is print, only digit 3 is examined; if the I/O function is control, and digits 2 and 3 both specify carriage operations, only digit 2 is used.

If channel 9 or channel 12 is encountered during a carriage control function, a branch is made to the user's error subroutine at completion of the next print function.

Note: An after-print request will be lost if it is followed by an immediate request or by a print with spacing suppressed. If a series of after-print requests is given, only the last one will be executed. A skip operation must not be less than four lines.

Digit #2: Immediate Carriage Operations
Print Functions Not Used **Control Function** 1 - Immediate Skip To Channel 1 2 - Immediate Skip To Channel 2 3 - Immediate Skip To Channel 3 4 - Immediate Skip To Channel 4 5 - Immediate Skip To Channel 5 6 - Immediate Skip To Channel 6 9 - Immediate Skip To Channel 9 C - Immediate Skip To Channel 12 D - Immediate Space Of 1 E - Immediate Space Of 2 F - Immediate Space Of 3
Digit #3: After-Print Carriage Operations
Print Functions 0 - Space One Line After Printing 1 - Suppress Space After Printing **Control Function** 1 - Skip After Print To Channel 1 2 - Skip After Print To Channel 2 3 - Skip After Print To Channel 3 4 - Skip After Print To Channel 4 5 - Skip After Print To Channel 5 6 - Skip After Print To Channel 6 9 - Skip After Print To Channel 9 C - Skip After Print To Channel 12 D - Space 1 After Print E - Space 2 After Print F - Space 3 After Print

Figure 7. Carriage Control Operations for 1132 Printer

I/O Area Parameter

The I/O area parameter is the label of the control word that precedes the user's I/O area. The control word consists of a word count that specifies the number of computer words of data to be printed. The data must be in EBCDIC format, packed two characters per computer word. The word count must be in the range of 1-60. (See "Descriptions of Data Codes".)

Error Parameter

See "Basic ISS Calling Sequence".

1132 PRINTER/SYNCHRONOUS COMMUNICATIONS ADAPTER SUBROUTINE (PRNT2)

The printer subroutine PRNT2 is an additional printer subroutine for the IBM 1132 Printer, specifically provided to permit concurrent operation of the 1132 and the Synchronous Communications Adapter. PRNT2 handles all print and carriage control functions related to the 1132.

Only one line of data can be printed, or one carriage operation executed, with each call to the printer subroutine. The data in the output area must be in EBCDIC form, packed two characters per word. Any code other than those defined for the 1132 will be interpreted by the PRNT2 subroutine as a blank.

Restriction. The PRNT1 and PRNT2 subroutines are mutually exclusive; i.e., both subroutines can not be in core at the same time. Thus, if the Synchronous Communications Adapter is in operation, the PRNT2 subroutine must be used for concurrent operation of the 1132 Printer. If the PRNT2 subroutine is required in a core load for the concurrent operation of the 1132 Printer and the Adapter, all IBM- and user-written programs in that core load using the PRNT1 subroutine must be modified to use the PRNT2 subroutine.

Calling Sequence

Label	Operation	F	T	Operands & Remarks
	LIBF			PRNT2 CALL PRINTER OUTPUT
	DC			/bcdd CONTROL PARAMETER
	DC			IOAR I/O AREA PARAMETER
	DC			ERROR ERROR PARAMETER
	.			
	.			
	.			
ERROR	DC			*-* RETURN ADDRESS
	.			
	.			
	.			
	BSC	I		ERROR
	.			
	.			
	.			
IOAR	DC			f WORD COUNT
	BSS			h I/O AREA

where

b is the I/O function digit,

c is the "immediate" carriage operation digit,

d is the "after-print" carriage operation digit, f is the number of words to be printed on the 1132 Printer,

h is the length of the I/O area. h must be equal to or greater than f.

The calling sequence parameters are described in the following paragraphs.

Control Parameter

The control parameter consists of four hexadecimal digits which are used as shown below:

```
                                  1     2     3     4
                                  |     |     |     |
I/O Function ---------------------+     |     |     |
                                        |     |     |
Carriage Control -----------------------+-----+     |
                                                    |
Not Used -------------------------------------------+
```

I/O Function

The I/O function digit specifies the operation to be performed on the 1132 Printer. The functions, their associated digital values, and the required parameters are listed and described below.

Function	Digital Value	Required Parameters[1]
Test	0	Control
Print	2	Control, I/O Area, Error
Control Carriage	3	Control
Print Numeric	4	Control, I/O Area, Error

[1] Any parameter not required for a particular function must be omitted.

Test. Branches to LIBF+2 if the previous operation has not been completed, to LIBF+3 if the previous operation has been completed.

Print. Prints characters from the user's I/O area; checks for channel 9 and 12 indications. If either of these conditions is detected, the subroutine branches to the user's error routine after the line of data has been printed (see Appendix B for error codes). Upon return from this error routine, a skip to channel 1 is initiated or the operation is terminated, depending upon whether the Accumulator is nonzero or zero.

Control Carriage. Controls the carriage as specified by the carriage control digits listed in Figure 7.

Print Numeric. Prints only numerals and special characters from the user's I/O area and checks for channel 9 and 12 indications. (See "Print" above.)

Carriage Control. Digits 2 and 3 specify the carriage control operations listed in Figure 7. An "immediate" request is executed before the next print operation; an "after-print" request is executed after the next print operation and replaces the normal space operation.

If the I/O function is Print, only digit 3 is examined; if the I/O function is Control Carriage, and digits 2 and 3 both specify carriage operations, only digit 2 is used.

Carriage control functions do not check for channel 9 and channel 12 indications.

I/O Area Parameter

The I/O area parameter is the label of the control word that precedes the user's I/O area. The control word consists of a word count that specifies the number of words of data to be printed. The data must be in EBCDIC format, packed two characters per word. The word count must be in the range of 1-60.

Error Parameter

See "Basic ISS Calling Sequence".

1403 PRINTER SUBROUTINE (PRNT3)

The printer subroutine PRNT3, available only with the DM2 system, handles all print and carriage control functions relative to the 1403 Printer. Only one line of data can be printed and/or one carriage operation executed with each call to the printer subroutine.

The data in the output area must be in the 1403 character code, as defined in "Descriptions of Data Codes", and packed two characters per word. Each data code consists of seven bits and the total number of bits should always be a valid number. The first bit is the parity bit. If the remaining six bits correspond to a valid

1403 code, that character will be printed. A branch to the user error routine will or will not be made depending upon the validity of the parity bit. The user can specify a retry of the operation, if desired.

Calling Sequence

```
Label   Operation  F T  Operands & Remarks

        LIBF            PRNT3       CALL PRINTER OUTPUT
        DC              /bcdØ       CONTROL PARAMETER
        DC              IOAR        I/O AREA PARAMETER
        DC              ERROR       ERROR PARAMETER
        .
        .
        .
ERROR   DC              *-*         RETURN ADDRESS
        .
        .
        .
        BSC        I    ERROR       RETURN TO CALLER
        .
        .
        .
IOAR    DC              f           WORD COUNT
        BSS             h           I/O AREA
```

where

b is the I/O function digit,

c is the "immediate" carriage operation digit,

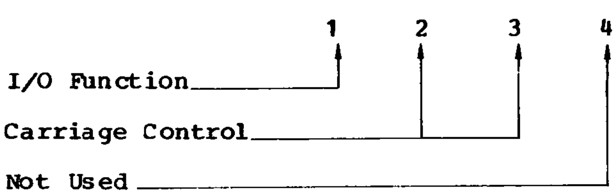
d is the "after-print" carriage operation digit,

f is the number of words to be printed on the 1403 Printer,

h is the length of the I/O area. h must be equal to or greater than f.

Control Parameter

This parameter consists of four hexadecimal digits which are used as shown below.



I/O Function

The I/O function digit specifies the operation to be performed on the 1403 Printer. The functions, their associated digital values, and the required parameters are listed and described below.

Function	Digital Value	Required Parameters[1]
Test	0	Control
Print	2	Control, I/O Area, Error
Control Carriage	3	Control

[1] Any parameter not required for a particular function must be omitted.

Test. Branches to LIBF+2 if the previous operation has not been completed, to LIBF+3 if the previous operation has been completed.

Print. Prints characters from the user's I/O area, checking for channel 9 and 12 and error indications. If any of these conditions are detected, the subroutine branches to the user's error subroutine after the line of data has been printed with an error code in the Accumulator (see Appendix B). Upon return from this error subroutine, a skip to channel 1 is initiated and the function is reinitiated or terminated, depending upon the error code and whether the Accumulator is nonzero or zero.

Control Carriage. Controls the carriage as specified by the carriage control listed in Figure 8.

Carriage Control. Digits 2 and 3 specify the carriage control functions listed in Figure 8. An "immediate" request is executed before the next print operation; an "after-print" request is executed after the next print operation and replaces the normal space operation.

If the function is print, only digit 3 is examined; if the function is control, and digits 2 and 3 both specify carriage operations, only digit 2 is used.

Carriage control functions do not check for channel 9 or channel 12 indications.

Note: An "after-print" request is lost if it is followed by an "immediate" request. If a series of "after-print" requests is given, only the last one is executed.

Digit #2: Immediate Carriage Operations
<u>Print Functions</u> Not Used <u>Control Function</u> 1 - Immediate Skip To Channel 1 2 - Immediate Skip To Channel 2 3 - Immediate Skip To Channel 3 4 - Immediate Skip To Channel 4 5 - Immediate Skip To Channel 5 6 - Immediate Skip To Channel 6 7 - Immediate Skip To Channel 7 8 - Immediate Skip To Channel 8 9 - Immediate Skip To Channel 9 A - Immediate Skip To Channel 10 B - Immediate Skip To Channel 11 C - Immediate Skip To Channel 12 D - Immediate Space Of 1 E - Immediate Space Of 2 F - Immediate Space Of 3
Digit #3: After-Print Carriage Operations
<u>Print Functions</u> 0 - Space One Line After Printing 1 - Suppress Spaces After Printing <u>Control Function</u> 1 - Skip After Print To Channel 1 2 - Skip After Print To Channel 2 3 - Skip After Print To Channel 3 4 - Skip After Print To Channel 4 5 - Skip After Print To Channel 5 6 - Skip After Print To Channel 6 7 - Skip After Print To Channel 7 8 - Skip After Print To Channel 8 9 - Skip After Print To Channel 9 A - Skip After Print To Channel 10 B - Skip After Print To Channel 11 C - Skip After Print To Channel 12 D - Space 1 After Print E - Space 2 After Print F - Space 3 After Print

Figure 8. Carriage Control Operations for 1403 Printer

Note: A skip operation must not be less than two lines.

I/O Area Parameter

The I/O area parameter is the label of the control word that precedes the user's I/O area. The control word consists of a word count that specifies the number of words of data to be printed. The data must be in 1403 Printer code, packed two characters per word. The word count must be in the range of 1-60.

Error Parameter

See "Basic ISS Calling Sequence".

KEYBOARD/CONSOLE PRINTER

There are two ISSs for the transfer of data to and from the Console Printer and the Keyboard.

TYPE0

The TYPE0 Subroutine handles input and output.

WRTY0

The WRTY0 Subroutine handles output only. If a program does not require keyboard input, it is advantageous to use the WRTY0 subroutine because it occupies less core storage than the TYPE0 subroutine.

Only the TYPE0 subroutine is described below; the WRTY0 subroutine is identical, except that it does not allow the read-print function.

Calling Sequence

Label	Operation	F	T	Operands & Remarks
	LIBF			TYPEØ CALL PRINTER I/O
	DC			/bØØØ CONTROL PARAMETER
	DC			IOAR I/O AREA PARAMETER
	•			
	•			
	•			
IOAR	DC			f WORD COUNT
	BSS			h I/O AREA

where

b is the I/O function digit,

f is the number of characters to be printed on the console printer for read-print operations and is 1/2 the number of characters to be printed on a print operation.

h is the length of the I/O area. h must be equal to or greater than f.

Control Parameter

This parameter consists of four hexadecimal digits, as shown below:

```
                         1    2    3    4
                         |    |    |    |
I/O Function_____________|    |    |    |
                              |    |    |
Not Used______________________|____|____|
```

I/O Function

The I/O function digit specifies the operation to be performed on the Keyboard and/or Console Printer. The function, their associated digital values, and the required parameters are listed and described below.

Function	Digital Value	Required Parameters[1]
Test	0	Control
Read-Print	1	Control, I/O Area
Print	2	Control, I/O Area

[1] Any parameter not required for a particular function must be omitted.

Test. Branches to LIBF+2 if the previous operation has not been completed, to LIBF+3 if the previous operation has been completed.

Read-Print. Reads from the Keyboard and prints the requested number of characters on the Console Printer. The operation sequence is as follows:

1. The calling sequence is analyzed by the call portion of the subroutine, which then unlocks the keyboard.
2. When a key is pressed, a character interrupt signals the interrupt response portion that a character is ready to be read into core storage.
3. The interrupt response portion converts the keyboard data to Console Printer Code (see "Descriptions of Data Codes"). Each character is printed as it is read; the Keyboard is then unlocked for entry of the next character.
4. Printer interrupts occur whenever the Console Printer has completed a print operation. When the interrupt is received, the subroutine checks to determine if the final character has been read and printed. If so, the operation is considered complete. In the C/PT system, if the Console Printer becomes not-ready during printing, the subroutines loop, waiting for the Console Printer to become ready. In the DM2 system they trap to $PRET or $PST4 (see "Descriptions of Data Codes").
5. Steps 2 through 4 are repeated until the specified number of characters have been read and printed. The characters read into the I/O area are identical to IBM Card Code; that is, each 12-bit image is left-justified in one 16-bit word.

Print. Prints the specified number of characters on the Console Printer. A printer interrupt occurs when the Console Printer has completed a print operation. When an interrupt is received, the character count is checked. If the specified number of characters has not been written, printing is initiated for the next character. This sequence continues until the specified number of characters has been printed. Data to be printed must be in Console Printer code (see "Descriptions of Data Codes"), packed two characters per 16-bit word. Control characters can be embedded in the message where desired.

In read-print and print operations, printing begins where the printing element is positioned; that is, carrier return to a new line is not automatic when the subroutine is called.

Keyboard Functions

Keyboard functions provide for control by the TYPE0 subroutine and by the operator.

TYPE0 Subroutine Control

Three keyboard functions are recognized by the TYPE0 subroutine.

Backspace. The operator presses the backspace key whenever the previous character is in error. The interrupt response portion senses the control character, backspaces the Console Printer, and prints a slash (/) through the character in error. In addition, the subroutine prepares to replace the incorrect character in the I/O area with the next character.

If the backspace key is pressed twice, the character address is decremented by +2, but only the last graphic character is slashed. For example, if ABCDE was entered and the backspace key pressed three times, the next graphic character to be entered replaces the C but only the E is slashed. If XYZ is the new entry, the printout shows ABCD/EXYZ, but the buffer contains ABXYZ.

Erase Field. When the interrupt response portion recognizes the erase field control character, it assumes that the entire message is in error and is to be entered again. The subroutine prints two slashes on the Console Printer, restores the carrier to a new line, and prepares to replace the old message in the I/O area with a new message.

The old message in the I/O area is not cleared. Instead, the new message overlays the old, character by character. If the old message is longer than the new, the remainder of the old message follows the NL (new-line) character terminating the new message.

End of Message. When the interrupt-response portion recognizes the end-of-message (EOF) control character, it assumes the message has been completed, stores an NL character in the I/O area, and terminates the operation.

Operator Request Function (C/PT System)

By pressing the interrupt request key (INT REQ) on the Keyboard, the operator can inform the program that he wishes to enter data from the Keyboard or the Console Entry switches. The interrupt that results causes the TYPE0 or WRTY0 subroutine to execute an indirect BSI instruction to core location /002C, where the user must have previously stored the address of an interrupt request subroutine. Bit 1 of the Accumulator contains the Keyboard/Console Printer identification bit, that is, the device status word, shifted left two bits.

The user's interrupt request subroutine must return to the ISS subroutine via the return link. The user's subroutine is executed as a part of the interrupt handling. The interrupt level remains on until control is returned to the ISS subroutine (see "General Error-Handling Procedures, Postoperative Checks").

Operator Request Function (DM2)

By pressing the Interrupt Request key (INT REQ) on the keyboard, the operator can inform the program that he wishes to enter data from the keyboard or the Console Entry switches. The interrupt that results causes the ILS04 or ILSX4 subroutine to execute a BSI I $IREQ instruction. $IREQ is initialized with the address $I420 in Resident Monitor. This allows the operator to terminate the job by pressing INT REQ key. If the user wants control, $IREQ must be set to the user Interrupt Service subroutine. This subroutine can set indicators or read the Console Entry switches. If keyboard input/output is desired, only one call to ISS can be made. The user-written subroutine must return to exit address plus one, in ILS04 or ILSX4. This is to turn off the interrupt and return to the program that was interrupted. In no case should the user perform an XIO sense Keyboard/Console with reset.

I/O Area Parameter

The I/O area parameter is the label of the control word that precedes the user's I/O area. The control word consists of a word count that specifies the number of words to be read or printed. This word count is equal to the number of characters if the read-print function is requested and is equal to 1/2 the number of characters if the print function is requested.

PAPER TAPE SUBROUTINES (C/PT SYSTEM)

The paper tape subroutines, PAPT1 and PAPTN, handle the transfer of data from the IBM 1134 Paper Tape Reader to core storage and from core storage to the IBM 1055 Paper Tape Punch. Any even number of characters can be transferred via one calling sequence.

The PAPTN subroutine must be used if simultaneous reading and punching are desired.

The PAPT1 subroutine can operate both devices, but only one at a time.

When called, the paper tape subroutine starts the reader or punch and then, as interrupts occur, transfers data to or from the user's I/O area. Input data is packed two characters per computer word by the subroutine; output data must already be in the packed format when the subroutine is called for a punch function.

Calling Sequence

Label	Operation	F	T	Operands & Remarks
	LIBF			PAPTa CALL PAPER TAPE I/O
	DC			/bcØe CONTROL PARAMETER
	DC			IOAR I/O AREA PARAMETER
	DC			ERROR ERROR PARAMETER
	.			
	.			
	.			
ERROR	DC			*-* RETURN ADDRESS
	.			
	.			
	.			
	BSC	I		ERROR RETURN TO CALLER
	.			
	.			
	.			
IOAR	DC			f WORD COUNT
	BSS			h I/O AREA

where

a is a 1 or N,

b is the I/O function digit,

c is a check digit,

e is a device-identification digit,

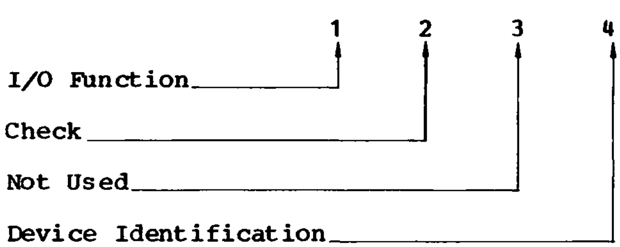
f is the number of words to be read from or punched into paper tape,

h is the length of the I/O area. h must be equal to or greater than f.

The parameters used in the above calling sequence are described in the following paragraphs.

Control Parameter

This parameter consists of four hexadecimal digits, as shown below:



I/O Function

The I/O function digit specifies the operation to be performed on a paper tape attachment. The functions, their associated digital value, and the required parameters are listed and described below.

Function	Digital Value	Required Parameters*
Test	0	Control
Read	1	Control, I/O Area, Error
Punch	2	Control, I/O Area, Error

*Any parameter not required for a particular function must be omitted.

Test. Branches to LIBF+2 if the previous operation has not been completed, to LIBF+3 if the previous operation has been completed.

Read. Reads paper tape characters into the specified number of words in the I/O area. Initiating reader motion causes an interrupt to occur when a character can be read into core. If the specified number of words has not been read, or the stop character has not been read (see "Check" in this section), reader motion is again initiated.

Punch. Punches paper tape characters into the tape from the words in the I/O area. Each character punched causes an interrupt which indicates that the next character can be accepted. The operation is terminated by transferring either a stop character or the specified number of words.

Check Digit

The check digit specifies whether or not word count checking is desired while completing a read or punch operation as shown below:

0 Check
1 No Check

Check. This function should be used with the Perforated Tape and Transmission Code (PTTC/8) only (see "Descriptions of Data Codes"). The PTTC/8 code for DEL is used as the delete character when reading. The delete character is not placed in the I/O area and therefore does not enter into the count of the total number of words to be read.

The PTTC/8 code for NL is used as the stop character when doing a read or punch. On a read operation, the NL character is transferred into the I/O area. On a punch operation, the NL character is punched into the paper tape.

When the NL character is encountered before the specified number of words has been read or punched, the operation is terminated. When the specified number of words has been read or punched, the operation is terminated, even though a NL character has not been encountered.

No Check. The read or punch function is terminated when the specified number of words has been read or punched. No checking is done for a delete or stop character.

Device Identification

When the test function is specified, the PAPTN subroutine must be told which device (reader or punch) is to be tested for an Operation Complete indication. (Remember that both the reader and the punch can operate simultaneously.) Therefore, the device identification is used only for the test function in the PAPTN subroutine. If the device-identification digit is a 0, the subroutine tests for a Reader Complete indication; if it is a 1, the subroutine tests for a Punch Complete indication.

I/O Area Parameter

The I/O area parameter is the label of the control word that precedes the user's I/O area. It consists of a word count that specifies the number of words to be read into or punched from core. Since characters are packed two per word in the I/O area, this count is one-half the maximum number of characters transferred. Because an entire eight-bit channel image is transferred by the subroutine, any combination of channel punches is acceptable. The data can be a binary value or a character code. The code most often used is the PTTC/8 code. (See "Descriptions of Data Codes".)

Error Parameter

See "Basic ISS Calling Sequence".

PAPER TAPE SUBROUTINES (DM2 SYSTEM)

The paper tape subroutines, PAPT1, PAPTN, and PAPTX, handle the transfer of data from the IBM 1134 Paper Tape Reader to core storage and from core storage to the IBM 1055 Paper Tape Punch. Any even number of characters may be transferred via one calling sequence (PAPTX also allows an odd character count).

The PAPTN or PAPTX subroutine must be used if simultaneous reading and punching are desired. The PAPT1 subroutine will operate both devices but only one at a time. The PAPT1 and PAPTN subroutines use only a word count, reading and punching an even number of characters; PAPTX can use a word count or character count, permitting an odd number of characters to be read or punched. PAPTX allows the user to start punching from or reading into the left or right half of a word. One-frame records can be written on tape.

When called, the paper tape subroutine starts the reader or punch and then, as interrupts occur, transfers data to or from the user's I/O area. The data is packed two characters per computer word by the subroutine when reading, and must be in that form when the subroutine is called for a punch function.

Calling Sequence

Label	Operation	F	T	Operands	Remarks
	LIBF			PAPTa	CALL PAPER TAPE I/O
	DC			/bcde	CONTROL PARAMETER
	DC			IOAR	I/O AREA PARAMETER
	DC			ERROR	ERROR PARAMETER
	•				
	•				
	•				
ERROR	DC			*-*	RETURN ADDRESS
	•				
	•				
	•				
	BSC	I		ERROR	RETURN TO CALLER
	•				
	•				
	•				
IOAR	DC			f	WORD COUNT
	BSS			h	I/O AREA

where

a is 1, N, or X,

b is the I/O function digit,

c is a check digit,

d is the character mode digit,

e is a device identification digit,

f is the number of words to be read from or punched into paper tape,

h is the length of the I/O area. h must be equal to or greater than f.

The parameters used in the above calling sequence are described in the following paragraphs.

Control Parameter

This parameter consists of four hexadecimal digits which are used as shown below:

```
                               1     2     3     4
I/O Function ------------------+     |     |     |
Check -------------------------------+     |     |
Character Mode ----------------------------+     |
Device Identification ---------------------------+
```

I/O Function

The I/O function digit specifies a particular operation performed on the 1134/1055 Paper Tape attachment. The functions, associated digital values and required parameters are listed and described below.

Function	Digital Value	Required Parameters
Test	0	Control
Read	1	Control, I/O Area, Error
Punch	2	Control, I/O Area, Error

[1]Any parameter not required for a particular function must be omitted.

Test. Branches to LIBF+2 if the previous operation has not been completed, to LIBF+3 if the previous operation has been completed.

Read. Reads paper tape characters into the specified number of words in the I/O area. Initiating reader motion causes an interrupt to occur when a character can be read into core. If the specified number of words has not been read or the stop character has not been read (see "Check" in this section), reader motion is again initiated.

Punch. Punches paper tape characters into the tape from the words in the I/O area. Each character punched causes an interrupt which indicates that the next character can be accepted. The operation is terminated either by encountering a stop character (see "Check" in this section) or by transferring the requested number of words.

Check Digit

The check digit specifies whether or not checking is desired while doing a read or punch operation.

0 Check
1 No Check

No Check. The read or punch function is terminated when the specified number of words or characters has been read or punched. No check is made for a delete or stop character.

Check. This function should be used with the Perforated Tape and Transmission (PTTC/8 Code only (see "Descriptions of Data Codes"). The PTTC/8 code for DEL will be used as the delete character when doing a read. The delete character is not placed in the I/O area and therefore is not included in the word or character count.

The PTTC/8 code for NL will be used as the stop character when doing a read or punch. On a read operation, the NL character is transferred into the I/O area and causes the operation to be terminated. On a punch operation, the NL character is punched in the paper tape and causes the operation to be terminated.

When the NL character is encountered before the specified number of words has been read or punched, the operation is terminated. When the specified number of words has been read or punched, the operation is terminated even though an NL character has not been encountered.

Character Mode

This digit is examined by the PAPTX subroutine

- If it is zero, the first word of this I/O area is interpreted as a word count.
- If it is nonzero, the first word of the I/O area is interpreted as a character count:

  If the character mode digit is nonzero and even, the first character will be read into or punched from bits 0-7 of the first data word. Bits 8-15 of the last data word will not be altered if the character count is odd.

  If the character mode digit is nonzero and odd, the first character will be read into or punched from bits 8-15 of the first data word. Bits 0-7 of the first data word will not be altered. If the character count is even, bits 8-15 of the last data word will not be altered.

Device Identification

When the test function is specified, the PAPTN and PAPTX subroutines must be told which device (reader or punch) is to be tested for an Operation Complete indication. (Remember that both the reader and the punch can operate simultaneously.) Therefore, the device-identification digit is used for the test function in the PAPTN and PAPTX subroutines only; if it is a 0, the subroutine tests for a Reader Complete indication; if it is a 1, the subroutine tests for a Punch Complete indication.

I/O Area Parameter

The I/O area parameter is the label of the control word that precedes the user's I/O area. The word count specifies the number of words to be read into or punched from the user's I/O area. Since characters are packed two per word in the I/O area, this count is 1/2 the maximum number of characters transferred. The character count, used only by the PAPTX subroutine if the character mode is nonzero is the maximum number of characters to be read or punched.

Because an entire 8-bit channel image is transferred by the subroutine, any combination of channel punches is acceptable. The data may be a binary value or a character code. The code most often used is the PTTC/8 code (see "Descriptions of Data Codes").

Error Parameter

See "Basic ISS Calling Sequence".

PLOTTER SUBROUTINE (PLOT1)

The Plotter subroutine converts hexadecimal digits in the user's output area into actuating signals that control the movement of the plotter recording pen. Each hexadecimal digit in the output area is translated into a plotter operation that draws a line segment or raises or lowers the recording pen. The amount of data that can be recorded with one calling sequence is limited only by the size of the corresponding output area.

Calling Sequence

Label	Operation	F	T	Operands & Remarks
	LIBF			PLOT1 CALL PLOTTER OUTPUT
	DC			/b000 CONTROL PARAMETER
	DC			IOAR I/O AREA PARAMETER
	DC			ERROR ERROR PARAMETER
	.			
	.			
	.			
IOAR	DC			f WORD COUNT
	BSS			h I/O AREA

where

b is the I/O function digit,

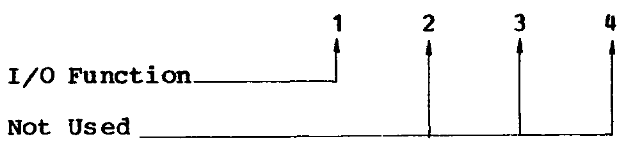
f is the number of words of plotter data,

h is the length of the I/O area. h must be equal to or greater than f.

The calling sequence parameters are described in the following paragraphs.

Control Parameter

This parameter consists of four hexadecimal digits, as shown below:



I/O Function

The I/O function digit specifies the operation to be performed on the 1627 Plotter. The functions, their associated digital value, and the required parameters are listed and described below.

Function	Digital Value	Required Parameters[1]
Test	0	Control
Write	1	Control, I/O Area, Error

[1]Any parameter not required for a particular function must be omitted.

Test. Branches to LIBF+2 if the previous operation has not been completed, to LIBF+3 if the previous operation has been completed.

Write. Changes hexadecimal digits in the output area into signals that actuate the plotter. Figure 9 lists the hexadecimal digits and the plotter actions they represent. Figure 10 shows the binary and hexadecimal configurations for drawing the letter E.

I/O Area Parameter

The I/O area parameter is the label of the control word that precedes the user's I/O area.

The control word consists of a word count that specifies the number of computer words of data to be used.

Error Parameter

This parameter is not used but must be included because the subroutine will return to LIBF+4. (See "Basic ISS Calling Sequence".)

PLOTTER SUBROUTINE (PLOTX)

The PLOTX subroutine converts the hexadecimal digit in the parameter into a control word. The control word is stored in a buffer inside the PLOTX subroutine. One digit is transferred with each calling sequence. When the plotter is ready to accept control, the movement of the plotter recording pen is controlled by the words in the PLOTX buffer.

Hexadecimal Digit	Plotter Action (See Diagram Below)
0	Pen Down
1	Line Segment= +Y
2	Line Segment= +X, +Y
3	Line Segment= +X
4	Line Segment= +X, -Y
5	Line Segment= -Y
6	Line Segment= -X, -Y
7	Line Segment= -X
8	Line Segment= -X, +Y
9	Pen Up
A	Repeat the previous pen motion the number of times specified by the next digit (Maximum-15 times)
B	Repeat the previous pen motion the number of times specified by the next two digits (Maximum-255 times)
C	Repeat the previous pen motion the number of times specified by the next three digits (Maximum-4095 times)
D	Not Used
E	Not Used
F	Not Used

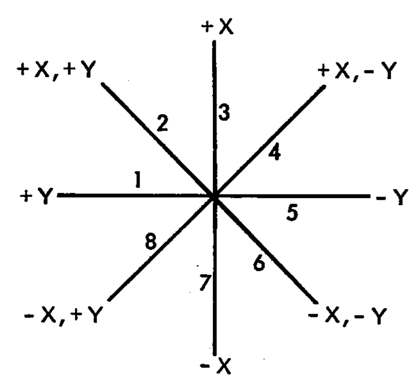


Figure 9. PLOT1 Control Digits

Binary	Hexadecimal
0000011100010001	0711
0011101000100101	3A25
1001000100000011	9103
1010001001010101	A255
0111100111111111	79FF

Figure

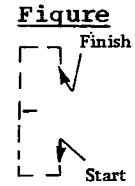


Figure 10. PLOT1 Example

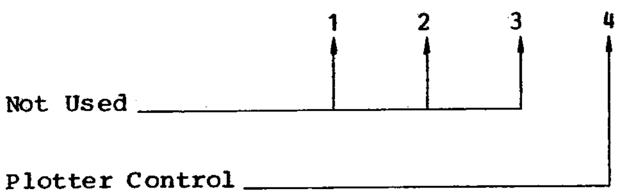
Calling Sequence

```
Label    Operation   F T   Operands & Remarks
         LIBF              PLOTX      CALL PLOTTER OUTPUT
         DC                /000e      CONTROL PARAMETER
```

where e is the plotter control digit.

Control Parameter

This parameter consists of four hexadecimal digits:



Plotter Control

The plotter control digit specifies the recording pen action to be taken. This digit is expressed in hexadecimal.

Hexadecimal Digit	Plotter Action
0	Pen down
1	Line segment = +Y
2	Line segment = +X,+Y
3	Line segment = +X
4	Line segment = +X,-Y
5	Line segment = -Y
6	Line segment = -X,-Y
7	Line segment = -X
8	Line segment = -X,+Y
9	Pen up
A-F	Not used

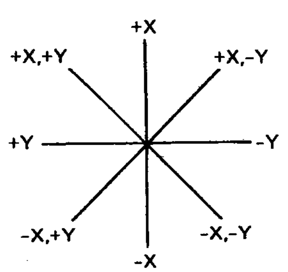


Figure 10.1 PLOTX Control Digits

If there is no room in the buffer for the control digit, the subroutine will loop until there is room.

If the plotter is in a not-ready, not-busy condition, the subroutine exits to $PRET where the program goes into a wait condition until operator intervention. If the plotter becomes not ready while executing the PLOTX subroutine commands, PLOTX exits to $PST3 where the program goes into a wait condition until the operator intervenes.

The PLOTX subroutine has no error-handling capabilities.

1231 OPTICAL MARK PAGE READER SUBROUTINE (OMPR1)

The Optical Mark Page Reader subroutine OMPR1 handles the reading of paper documents eight and one-half inches wide by eleven inches long by the 1231 Optical Mark Page Reader. A maximum of 100 words from one page can be read with one call to the subroutine.

When called to perform a read function, OMPR1 performs a feed function and reads a page into core storage according to the Master Control Sheet (see the publication IBM 1231, 1232 Optical Mark Page Readers, GA21-9012), and the setting of the switches on the reader. Other functions performed by OMPR1 are feed, stacker select, and disconnect.

Calling Sequence

Label	Operation	F	T	Operands & Remarks
	LIBF			OMPR1 CALL OPT MARK PAGE INPUT
	DC			/bc0e CONTROL PARAMETER
	DC			IOAR I/O AREA PARAMETER
	DC			ERROR ERROR PARAMETER
	•			
	•			
	•			
ERROR	DC			*-* RETURN ADDRESS
	•			
	•			
	•			
	BSC	I		ERROR RETURN TO CALLER
	•			
	•			
	•			
IOAR	BSS			h I/O AREA

where

b is the I/O function digit,

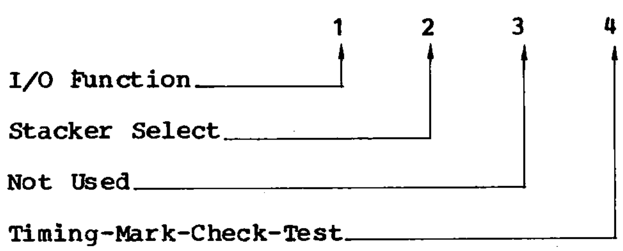
c is the stacker select digit,

e is the timing-mark-check-test digit,

h is the length of the I/O area. h must be equal to or greater than the number of words designated to be read on the Master Control Sheet.

Control Parameter

This parameter consists of four hexadecimal digits:



I/O Function

The I/O function digit specifies the operation to be performed on the 1231 reader. The functions, their associated digital values, and the required parameters are:

Function	Digital Value	Required Parameters[1]
Test	0	Control
Read	1	Control, I/O Area, Error
Feed	3	Control
Disconnect	4	Control
Stacker Select	5	Control

[1]Any parameter not required for a particular function must be omitted.

Test. Branches to LIBF+2 if the previous operation has not been completed, to LIBF+3 if the previous operation has been completed.

The operation to be tested is specified by the fourth digit of the control parameter. A zero value in digit 4 specifies a normal device-busy test; that is, a test to determine if there is an operation in progress for which no operation complete interrupt has occurred. The subroutine is "not busy" once the Operation Complete interrupt takes place. A value of one for digit 4 specifies a Timing-Mark-Check-Busy test. This test indicates a "busy" condition as long as the Test-Timing-Mark-Check indicator in the Device Status Word is on. If the user wishes to run with the Timing Mark Switch set on, it is recommended that digit 4 be set to one when performing a test function.

A test function must not directly follow a feed function.

Read. Reads words or segments (response positions 1-5 or 6-10 of any word) from a document page into core storage starting at the I/O area address. The first call to OMPR1 in a program must be a read function. The read feeds the document before reading. When a read function follows a feed, the read begins with the document started by the feed. The number of bits per word read and the number of words per document read depends upon the way in which the Master Control Sheet is programmed (see the publication IBM 1231 Optical Mark Page Readers, GA21-9012). OMPR1 reads a maximum of 100 words. Any word not programmed to be read (mark positions 8 or 18 not penciled on the Master Control Sheet) is skipped. Digit 2 of the control parameter specifies whether or not the document being read is to be stacker-selected. If digit 2 is set to one, the document is stacker-selected; if digit 2 is set to zero, it is not.

Note: On a feed, or feed as the result of a read, the document is fed from the hopper, the selected data is read into a delay line (and read out on a read), and the document continues through the machine to the stacker.

Feed. Initiates a feed cycle. This function advances a document from the hopper through the read station and into the stacker. Selected information from the document is stored in a delay line. A read function following a feed causes this data to be read. If a feed function is followed by another feed function without an intervening read function, the data read from the document corresponding to the first feed is overlaid in the delay line by the data read from the second document. The first call to OMPR1 in a program must not be a feed function.

A feed function must not be followed directly by a test function.

Disconnect. Terminates the read function on the data currently being read from the delay line. The subroutine-busy indicator is cleared.

Note: If the last document in the hopper is disconnected the hopper empty condition will not be detected.

Stacker Select. Performs a stacker select on the sheet currently being read (and fed), providing the stacker select function is requested while the "OK to select" bit (bit 5) is on in the Device Status Word (DSW). This bit remains on until 50 milliseconds after the read operation is completed. If the request to select arrives too late, the sheet falls in the normal stacker.

I/O Area Parameter

The I/O area parameter is the label of the user's I/O area.

Error Parameter

There is an error parameter for the read function only. Exits are made to the user's error subroutine when the following conditions are detected:

- Master Control Sheet Error
- Timing Mark Error
- Read Error
- Hopper Empty
- Document Selected

See "Basic ISS Calling Sequence" and Appendices B and C.

Feed Check

If a feed check is detected during a read or feed operation, exit is made to $PST4 with an error code of /A002 or /A003. After making device ready and depressing start key, OMPR1 will reinitiate the operation if error code was /A003. No stacker select will be performed on a reinitiated operation. If error code was /A002, the last document has already been processed and the operation is not reinitiated.

2250 DISPLAY UNIT MODEL 4 I/O SUBROUTINE (DSPYN)

The 2250 I/O subroutine, DSPYN, contains the 2250 Interrupt Service Subroutine. DSPYN controls the interrupt-handling services for the 2250 Display Unit, Model 4. The 2250 ISS contains facilities for handling attentions (graphic interrupts) from four sources; the alphameric keyboard, the programmed function keyboard, the light pen, and the graphic program itself. The DSPYN subroutine is part of the 1130/2250 Graphic Subroutine Package. A complete description of the DSPYN I/O functions can be found in IBM 1130/2250 Graphic Subroutine Package for Basic FORTRAN IV, GC27-6934.

RPG Subroutines (DM2 System)

The DM2 System Library contains a group of subroutines that perform functions required by the RPG Compiler and application programs. These subroutines are divided into two groups, Disk I/O and RPG Object Time Subroutines. The Disk I/O subroutines are available to Assembler language programmers. The other RPG subroutines are for system use only. All RPG subroutines are listed in Figure 24, Appendix A.

Disk File Management Subroutines (DM2 System)

Supplied with 1130 RPG is a group of disk I/O subroutines that will handle all disk file functions. These subroutines can be used by Assembler language programmers directly and are wholly independent of RPG. The subroutines provided are Direct Access, Sequential Access, and Indexed Sequential Access Method (ISAM). The subroutines are stored in the System Library.

Disk I/O Subroutines

The key to the use of the Disk I/O subroutines is an understanding of the basic principles of disk file organization and disk file processing.

FILE ORGANIZATION

File organization is the method of arranging data records on a direct access storage device, i.e., building the file.

The two types of file organization available with DM2 are sequential and indexed sequential (ISAM).

Sequential File Organization

A sequentially organized file is one in which records are placed on the disk in the same order they are read in, one after another. Card files are always organized this way. That is, record six cannot be written until record five is written, record five until record four, etc.

Sequential files on disk may be processed sequentially or randomly.

Indexed Sequential (ISAM) File Organization

An indexed sequential file is one in which records are placed on the disk in ascending collating sequence by record key. This key may be a part number, man-number or any other identifying information that is present in the records on the file. In addition, the indexed sequential file uses an index to locate desired records. Each index entry contains a cylinder address and the highest record key on that cylinder. All index entries are formed into an index table. For cylinders that have overflowed, the index entry also contains the overflow sector address and key of the first sector overflowed from that cylinder.

Index tables are analogous to the index card file in a library. If you know the name of a book (record key), you can look in the card file (index table) until you find the card (entry) for that book. On the card you will find a number (cylinder address) where the book (record) is located. You go to the shelf (seek) and find the number (cylinder address) you are looking for. Now you can search for the particular book (record) by title (record key).

Record on an indexed sequential organized file may be processed sequentially or randomly.

FILE PROCESSING

File processing is the method of retrieving data records from the file, i.e., using the file. Four methods of file processing are available with DM2 RPG:

1. Sequential processing of sequentially organized files.
2. Random processing of sequentially organized files.
3. Sequential processing of indexed sequential organized (ISAM) files.
4. Random processing of indexed sequential organized (ISAM) files.

Sequential Processing (Sequential Files)

All records in the file are processed in order starting with the first physical record in the file.

Random Processing (Sequential Files)

In random processing the records in a file can be processed in any order. To find a record in a sequentially organized file, the record number must be supplied to the program. The record number indicates the relative position (sequential location) of the record in the file. The disk I/O routine calculates the sector address from the record number and reads the proper record.

Sequential Processing (Indexed Sequential Files)

All records in an ISAM file are available in a sequence determined by record key. Processing may start at the beginning of the file or at any point within the file.

Random Processing (Indexed Sequential Files)

In random processing the records in a file can be processed in any order. To find a random record in an ISAM file, the file index is searched using the record's key. The matching entry in the index points to the cylinder containing the record. That cylinder is then searched for the desired record. The match is again by record key. This kind of processing may be called processing in a random sequence with record keys.

SEQUENTIALLY ORGANIZED DISK ROUTINES

The sequential disk I/O subroutines provided with RPG are sequential access and direct access. A sequentially organized file is built using the sequential access routine or the direct access routine. It may be processed by either the sequential access routine or the direct access routine.

Space for the file is initially established on the disk by using a DUP STOREDATA function. STOREDATA sets aside a specified number of sectors for the file and enters the file name in LET or FLET. This file name must be used in all future references to this file.

Calculating File Size

The number of sectors needed for a file depends on record size and number of records. The records are fixed length and can be defined as any size between 320 words (640 characters) and 1 word (2 characters). Note that records cannot extend across sector boundaries. Thus a 320-word record (one sector) and a 161-word record would each require one sector of disk space. Careful planning is required in calculating optimum record size for your file. When calculating file size, always add one record for the end of file record.

To change record sizes or add records to a sequential file the file must be rebuilt. If the revised file requires additional sectors it must be redefined (*DELETE and *STOREDATA), and rebuilt.

Sequential Files	
Ranges of Record Lengths (in characters)	Records per Sector
1-2	320
3-4	160
5-6	106
7-8	80
9-10	64
11-12	53
13-14	45
15-16	40
17-18	35
19-20	32
21-22	29
23-24	26
25-26	24
27-28	22
29-30	21
31-32	20
33-34	18
35-36	17
37-40	16
41-42	15
43-44	14
45-48	13
49-52	12
53-58	11
59-64	10
65-70	9
71-80	8
81-90	7
91-106	6
107-128	5
129-160	4
161-212	3
213-320	2
321-640	1

Figure 10.2 Space Utilization for Various Size Records for Sequential Files.

Sequential Access Routine

This routine allows the programmer to store, retrieve and/or update records on a sequentially organized disk file. The space for the file must have been previously defined by the DUP function STOREDATA.

The sequence of events on a sequential access is open the file, perform the function and close the file. To accomplish these objectives the sequential access routine has three entry points:

SEQOP - open the file
SEQIO - read or write a record
SEQCL - close the file

The sequential access routine is a part of the System Library. It is called by a LIBF. One parameter must be passed to the routine on each call and that parameter is the address of the Disk File Information (DFI) table. This parameter must immediately follow the LIBF statement.

The coding required to process a data file using the sequential access routine is as follows:

```
START
        :           (USER CODE)
      LIBF    SEQOP       OPEN SEQUENTIAL FILE
      DC      DFITB       DFI ADDRESS (REQUIRED)
      LD      DFITB+9     LOAD RETURN CODE
      BN      ERRTN       GO TO ERROR ROUTINE IF NEG
        :
      LIBF    SEQIO       READ OR WRITE RECORD
      DC      DFITB       DFI ADDRESS (REQUIRED)
      LD      DFITB+9     LOAD RETURN CODE
      BN      ERRTN       GO TO ERROR ROUTINE IF NEG
        :
      LIBF    SEQCL       CLOSE SEQUENTIAL FILE
      DC      DFITB       DFI ADDRESS (REQUIRED)
      LD      DFITB       LOAD RETURN CODE
      BN      ERRTN       GO TO ERROR ROUTINE IF NEG
        :
* DFI TABLE FOR SEQUENTIAL ACCESS FILE
DFITB DSA     FILEA       USER FILE
        :
ERRTN EQU     *           ERROR ROUTINE
        :
      END     START
```

Disk File Information (DFI) Table. A file to be processed by the sequential access routine must be described using a DFI table which is 11 words long. (These words are numbered 0-10.) The DFI table has nine entries, six of which must be filled in by the user. The remaining three entries must be initialized to zero by the user and are filled in by the program during execution.

Figure 11 shows the DFI table for the sequential access routine.

Operation of the Sequential Access Routine. When the routine is entered at the open entry point SEQOP, it checks the validity of the DFI table entries, sets pointers and switches to be used internally by the routine, and sets the return code in the DFI table to the code for file open. For an output function, SEQOP places the address of the record being processed in the DFI table. The routine is then entered at SEQIO to perform the required processing functions.

When the routine is entered at SEQCL, it writes the last sector of data and an end-of-file record (for output files) and sets the return code to the code for file closed. The end-of-file record contains a / (slash) and an * (asterisk) in the first word. The remainder of the end-of-file record is set to binary zeros.

The sequential access routine returns to the statement immediately following the parameter that follows the LIBF to the routine for any of the three entry points.

Direct Access Routine

This routine allows the programmer to retrieve and/or update records on a sequentially organized disk file. The records are accessed by record number relative to the beginning of the file, i.e., the first record in a file is record 1, the second record 2, etc.

The sequence of events on a direct access is open the file, perform the function, and close the file. To accomplish these objectives the direct access routine has three entry points:

DAOPN - open the file
DAIO - read or write a record
DACLS - close the file

The direct access routine is a part of the System Library. It is called by a LIBF. One parameter must be passed to the routine on each call and that parameter is the address of the Disk File Information (DFI) table. This parameter must immediately follow the LIBF statement.

The coding required to process a data file using the direct access routine is as follows:

```
START
        :           (USER CODE)
      LIBF    DAOPN       OPEN DIRECT ACCESS FILE
      DC      DFI2        DFI ADDRESS (REQUIRED)
      LD      DFI2+9      LOAD RETURN CODE
      BN      ERROR       GO TO ERROR ROUTINE IF NEG
        :
      LIBF    DAIO        READ OR WRITE RECORD
      DC      DFI2        DFI ADDRESS (REQUIRED)
      LD      DFI2+9      LOAD RETURN CODE
      BN      ERROR       GO TO ERROR ROUTINE IF NEG
        :
      LIBF    DACLS       CLOSE DIRECT ACCESS FILE
      DC      DFI2        DFI ADDRESS (REQUIRED)
      LD      DFI2+9      LOAD RETURN CODE
      BN      ERROR       GO TO ERROR ROUTINE IF NEG
        :
* DFI TABLE FOR DIRECT ACCESS FILE
DFI2  DSA     FILEA       USER FILE
        :
ERROR EQU     *           ERROR ROUTINE
        :
      END     START
```

Disk File Information (DFI) Table. A file to be processed by the direct access routine must be described using a DFI table which is 11 words long. (These words are numbered 0-10.) The DFI table has nine entries, seven of which must be filled in by the user. The remaining two entries must be initialized to zero by the user and are filled in by the program during execution.

Word	Entry	Meaning
0,1,2	DSA	The first entry in a DFI table is always a DSA statement. The DSA statement allows the programmer to refer symbolically to a disk-stored data file without knowing its actual location. The label is defined as the current value of the Location Assignment Counter when the DSA statement is encountered. The operand is the name of the data file. Further information on DSA may be found in IBM 1130/1800 Assembler Language. Note: The first word of the DSA instruction is used by the sequential access routine as an update-write switch.
3	DC /0XXX	XXX equals the number of records per sector. This figure is calculated by dividing 320 by the length of a record and ignoring the remainder. The maximum entry is /0140 (320 one-word records). The entry in this word must indicate the maximum number of records of X size that will fit on a sector. For example, if the entries in words 3 and 4 of this table indicate 31 ten-word records, a terminal return code of /8014, number of records per sector not maximum, will occur during program execution. 32 ten-word records would have to be defined to use all available disk space.
4	DC /0XXX	XXX equals the length of the record in words. The maximum entry is /0140 (one 320-word record).
5	DC /000X	Read/Write indicator. For read, set X to zero. For write, set X to one. For an update, set X to zero prior to the read and one prior to the write.
6	DC LABEL	The address of the data buffer. This address must be on an even word boundary. The length of the data buffer required by the program is calculated by multiplying the number of records per sector (word 3 of this table) by the record length (word 4 of this table) and adding 2. The maximum length of the data buffer is 322 words.
7	DC .X	Function indicator. X equals I for input, O for output and U for update. The specified character is assembled as right-justified EBCDIC. From the time a file is opened until it is closed this word must not be changed.
8	DC /0000	Record number. This word must be reserved by the user and is filled in by the subroutine. It will contain the record number of the record being processed.
9	DC /0000	Return code. This position must be reserved by the user. After each LIBF to any of the three entry points in the sequential access routine it should be checked for the return code.[1]
10	DC /0000	Record address. This word must be reserved by the user. It will contain the address of the record being processed.

[1] Return codes for sequential access are as follows:

Hexadecimal Number	Meaning
5555	File is open
8010	Disk file is full
8011	Write indicator with input file
8012	Read indicator with output file
8013	Record size exceeds sector size
8014	Number of records per sector not maximum
8015	File accessed when not open
8016	Buffer not on even-word boundary
8017	Write before read (UPDATE file)
FFFF	End of file
0FFF	File is closed

All 8XXX return codes except 8017 are terminal arrors. The file must be reopened to allow program to retry the operation. Processing will again start at the first record.

FFFF is a terminal error in the sense that it allows no further processing of the file. It does not, however, prevent the file from being closed in the normal manner.

Figure 11. Disk File Information Table for Sequential Access

Figure 12 shows the DFI table for the direct access routine.

Operation of the Direct Access Routine. When the routine is entered at the open entry point DAOPN, it checks the validity of the DFI table entries, sets pointers and switches to be used internally by the routine and sets the return code in the DFI table to the code for file open.

The routine is then entered at DAIO to perform the required processing functions.

When the routine is entered at DACLS, it sets the return code in the DFI table to the code for file closed.

The direct access routine returns to the statement immediately following the parameter that follows the LIBF to the routine for any of the three entry points.

INDEXED SEQUENTIAL ORGANIZED (ISAM) DISK ROUTINES

The indexed sequential disk I/O subroutines provided with RPG are ISAM load, ISAM add, ISAM sequential and random.

Indexed sequential organization gives the programmer a great deal of flexibility in the operations he can perform on a file. He can read or write records whose keys are in ascending collating sequence. He can read and update random records. (This method is not suggested if a large portion of the file is being processed since reading records in this manner is slower than reading according to a collating sequence. The index must be searched for the pointer to each record.) New records can be added to ISAM files. The add routine locates the proper positions for the new record in the file and updates the index accordingly.

ISAM has these advantages:

- It is a file management system specifically designated for direct access storage devices.
- It permits files to be processed in random or sequential order.
- It processes records directly in the I/O area.
- It establishes an index allowing ease of access to any record on the file.
- It uses an efficient chaining method to allow new records to be added to a file.
- It prevents records from being lost if a disk error occurs during an add operation.

ISAM has these restrictions:

- Records must be presorted in ascending collating key sequence before they are loaded on the file.
- Only one I/O area is permitted when a file is loaded or processed.
- All records must contain key areas starting in word one of the record, and all the key areas must be the same length.
- All records on a file must be the same length.
- Only one ISAM function can be performed on an ISAM file in one run. Hence, records cannot be both processed and added in the same run.
- The entire area for an ISAM file must be on one disk.

Contents of an ISAM File

An ISAM file comprises the following: file label, file index, prime data area, overflow area.

The relative position of these components within the ISAM file is as follows:

File Label	Index	Prime Data Area	Overflow Area

Word	Entry	Meaning
0,1,2	DSA	The first entry in a DFI table is always a DSA statement. The DSA statement allows the programmer to refer symbolically to a disk-stored data file without knowing its actual location. The label is defined as the current value of the Location Assignment Counter when that DSA statement is encountered. The operand is the name of the data file. For more information on DSA see IBM 1130/1800 Assembler Language.
3	DC /0XXX	XXX equals the number of records per sector. This entry must be the same as the number of records per sector on the file you are accessing.
4	DC /0XXX	XXX equals the length of the record in words. This entry must be the same as the length of the records on the file you are accessing.
5	DC /000X	Read/Write indicator. For read, set X to zero. For an update, set X to zero prior to the read and one prior to the write.
6	DC LABEL	The address of the data buffer. This address must be on an even word boundary. The length of the data buffer required is calculated by multiplying the number of records per sector (word 3 of this table) by the record length (word 4 of this table) and adding 2. The maximum length of the data buffer is 322 words.
7 8	DC /0XXX DC /XXXX	Record number. Word 7 and 8 must contain the number of the record on which the operations are to be performed. This number is equivalent to the record's relative location in the file; hence, the 83rd record would be record number 83. The entry is right-justified hexadecimal. Therefore, word 7 will be all zeros for all record numbers less than 65,536. The direct access routine will convert the record number supplied to the actual disk address.
9	DC /0000	Return code. This word must be reserved by the user. After each LIBF to any of the three entry points in the direct access routine it should be checked for the return code.[1]
10	DC /0000	Record address. This word must be reserved by the user. It will contain the address of the record being processed.

[1] Return codes for direct access are as follows:

Hexadecimal Number	Meaning
5555	File open
8000	Record number not in file
8001	Record size not within limits
8002	Records per sector not maximum
8003	Record number not positive
8004	Write before read
8005	File accessed when not open
8006	Buffer not on even-word boundary
0FFF	File closed

All 8XXX return codes except 8000, 8003 and 8004 are terminal errors. The file must be reopened to allow the program to retry the operations. Processing will again start at the first record.

Figure 12. Disk File Information Table for Direct Access

<u>ISAM File Label</u>. The first sector of any ISAM file contains the file label. This label contains information required by the ISAM routines for all future processing of the file. The file label is built by the ISAM load function, updated by ISAM add, and used by ISAM random and sequential. All label operations are performed automatically by the ISAM routines. The user need perform no label operation other than reserving one sector for the label when the file is initially defined.

The format of the ISAM label is shown in Figure 13.

Word Number	Label Entry Description
1	Key length
2	Record length
3	Number of index entries per sector
4	Index entry length
5	Number of records per sector
6	Record number of last prime data record
7	Index entry number of last entry in file
8	Sector address of last prime data record
9	Sector address of last index entry
10	Sector address of next overflow record
11	Record number of next overflow record

Figure 13. Format of an ISAM Label

<u>ISAM File Index</u>. The ability to read or write records anywhere in a file is provided by the file index. An entry in this index contains a cylinder address and the highest key that is associated with that cylinder. The ISAM routines locate a given record by searching the index for the key and then searching the specified cylinder for the desired record, again searching by key. To increase the efficiency of the ISAM routines, one sector of the index is retained in core storage for each file.

The key may be a part number or an employee name or any other identifying information that is contained in any record of the file. The key entries in the index are the numbers of the highest key on each cylinder in ascending collating sequence. The end-of-record key is the key with the highest possible value, i.e., all bits are ones.

A portion of an index or index table is shown below. Note that each entry contains two sets of the same information. The second set is overlayed to show overflow data when the affected cylinder overflows.

Key 15	First cylinder address	Key 15	First cylinder address	Zeros	Key 30	Second cylinder address	Key 31	Overflow sector address	Record number

normal entry — overflow entry

Key 45	Third cylinder address	Key 45	Third cylinder address	Zeros	all 1 bits	nth cylinder address	all 1 bits	nth cylinder address	Zeros

normal entry — last entry in index

Prime Data Area. This area contains the data records placed in the file by the ISAM load routine. The records must all be the same length (maximum 318 words). ISAM adds a two-word control field to each record. This control field, called the sequence-link control field, is used in the overflow area as a chaining indicator. It is used in the prime data area to indicate whether or not a cylinder has overflowed.

Data record	1 word	1 word
Key 75	Zeros	Zeros

Sequence-link control field.

Data record on a prime data cylinder.

Data record	1 word	1 word
Key 520	Zeros	X'FFFF'

Sequential-link control field.

Last data record on prime data cylinder that has overflowed.

Overflow Area. When a new record is added to an indexed sequential file, it is placed according to key sequence. If records were to remain in precise physical order, the insertion of each new record would require all records with higher keys to be shifted up. However, because ISAM files have an overflow area, a new record can be entered into its proper position on a cylinder and only cause records with higher keys on that cylinder to be shifted. The record that is forced off the end of the cylinder by the addition of the new record is written in the overflow area.

The index entry of any cylinder that has overflowed points to the overflow sector address and record number of the overflowed record in the overflow area. If two or more records in key order are added, the overflowed records are chained together in the overflow area through the entries in their sequence-link control field. The entry in the first record points to the second, the second to the third, etc. The last overflow record in the chain has a sequence-link control field of all zeros.

The number of cylinders to be allotted to the overflow area must be determined by the programmer when the file is initially defined. Records are placed in the overflow area in the order they have overflowed, not in key sequence.

To illustrate the overflow area, assume that on cylinder six of a defined file the last three entries have keys 150, 152 and 154. Key 154 would identify cylinder six in the index. Now we add a record with key 153, a record on another cylinder and a record with key 151. The overflow area would appear as shown below. Key 152 would identify cylinder six in the index. The overflow entry for cylinder six in the index would point to the overflow area.

Overflow area.

Key 154	Zeros	Zeros	Zeros	Zeros	Key 153	Overflow sector address	Rec. 0001

First record overflowed. The sequence-link control field is zeros indicating the end of a chain.

Record overflowed from another cylinder

Last record overflowed. The sequence-link control field points to the next key in sequence. In this case it is key 154 in the overflow area.

Creating and Using ISAM Files

An indexed sequential file is built using the ISAM load routine, is expanded using either the ISAM sequential or ISAM random routine.

Space for the file is initially established on the disk by using a DUP STOREDATA function. STOREDATA sets aside a specified number of sectors for that file and enters the file name in LET or FLET. This file name must be used in all future references to this file.

Determining ISAM File Size

The number of sectors required for an ISAM file is computed by the following formula (the remainder in all cases should be disregarded):

Prime data sectors + Index sectors + Overflow sectors + 1 (File label)

where:

Prime data sectors =

$$\frac{\text{Approximate number of records in file + number of records per sector - 1}}{\text{Number of records per sector}}$$

$$\text{Number of records per sector} = \frac{320}{\text{Record size + 2}}$$

The maximum record size is 318 words. Records cannot cross sector boundaries.

Index sectors =

$$\frac{\text{Number of prime data cylinders + number of index entries per sector - 1}}{\text{Number of index entries per sector}}$$

Number of prime data cylinders =

$$\frac{\text{number of prime data sectors + 7}}{8}$$

Number of index entries per sector=

$$\frac{320}{\text{Index entry size}}$$

Index entry size = 2 (key length in words) + 3

Key length is a maximum of 25 words (50 characters). If the length of the key in characters is odd, add one when calculating the number of words, i.e., 49 characters require 25 words.

Overflow sectors = The number of sectors the user wishes to allot to record overflow before the file must be rebuilt. The overflow area is automatically assigned to start at the sector following the last sector of prime data. This assignment is done by the ISAM load (close) routine.

When computing file size, always add one sector for the file label.

If desired, an Assembler language program can be used to perform the above calculations. The programmer need only know the index entry size (calculation shown above), the length of a record in words, the approximate number of records in the file and an estimate of the number of sectors of overflow area needed.

Key Length in Characters	Number of Entries on One Sector	Number of File Sectors Accomodated in One Index Sector
1-2	64	512
3-4	45	360
5-6	35	280
7-8	29	232
9-10	24	192
11-12	21	168
13-14	18	144
15-16	16	128
17-18	15	120
19-20	13	104
21-22	12	96
23-24	11	88
25-28	10	80
29-30	9	72
31-34	8	64
35-38	7	56
39-44	6	48
45-50	6	48

Figure 13.1 ISAM Cylinder Index Chart

Indexed Sequential Files	
Ranges of Record Lengths (in characters)	Records per Sector
1-2	106
3-4	80
5-7	64
7-8	53
9-10	45
11-12	40
13-14	35
15-16	32
17-18	29
19-20	26
21-22	24
23-24	22
25-26	21
27-28	20
29-30	18
31-32	17
33-36	16
37-38	15
39-40	14
41-44	13
45-48	12
49-54	11
55-60	10
61-66	9
67-76	8
77-86	7
87-102	6
103-124	5
125-156	4
157-208	3
209-316	2
317-636	1
637-640	Invalid

Figure 13.2 Space Utilization for Various Size Records for Indexed Sequential Files.

A program to calculate all values computed above is shown in Appendix J of the <u>IBM 1130 Disk Monitor System, Version 2, Programmer's and Operator's Guide</u>.

ISAM Load Routine

This routine loads presorted records, one after another, into the prime data area of the file. As each prime data cylinder is filled the load routine creates an entry in the file index. After all records are loaded in the prime data area the load routine creates the end of file record and the last index entry. The key for end of file and last index entry are all one bits.

The sequence of events on an ISAM load is open the file, perform the function and close the file. To accomplish these objectives the ISAM load routine has three entry points.

ISLDO - open the file
ISLD - write a record
ISLDC - close the file

The ISAM load routine is a part of the System Library. It is called by a LIBF. One parameter must be passed to the routine on each call and that parameter is the address of the Disk File Information (DFI) table. This parameter must immediately follow the LIBF statement.

The coding required to build a data file using the ISAM load routine is as follows:

```
START
         :
                   (USER CODE)
      LIBF   ISLDO      OPEN ISAM LOAD FILE
      DC     DFIAD      DFI ADDRESS (REQUIRED)
      LD     DFIAD+9    LOAD RETURN CODE
      BN     ERROR      GO TO ERROR ROUTINE IF NEG
         :
      LIBF   ISLD       WRITE RECORD
      DC     DFIAD      DFI ADDRESS (REQUIRED)
      LD     DFIAD+9    LOAD RETURN CODE
      BN     ERROR      GO TO ERROR ROUTINE IF NEG
         :
      LIBF   ISLDC      CLOSE ISAM LOAD FILE
      DC     DFIAD      DFI ADDRESS (REQUIRED)
      LD     DFIAD+9    LOAD RETURN CODE
      BN     ERROR      GO TO ERROR ROUTINE IF NEG
         :
*  DFI TABLE FOR ISAM LOAD ROUTINE
DFIAD DSA    FILEA      USER FILE
         :
ERROR EQU    *          ERROR ROUTINE
         :
      END    START
```

Disk File Information (DFI) Table. A file to be loaded by the ISAM load routine must be described using a DFI table which is 21 words long. (These words are numbered 0-20.) The DFI table has nineteen entries, eleven of which must be filled in by the user. The remaining eight entries must be initialized to zero by the user and are filled in by the program during execution.

Figure 14 shows the DFI table for the ISAM load routine.

Operation of the ISAM Load Routine. When the routine is entered at the open entry point ISLDO, it checks the validity of the DFI table entries, sets pointers and switches to be used internally by the routine and sets the return code in the DFI table to the code for file open.

The routine is then entered at ISLD to load a record to the file.

When the routine is entered at ISLDC, it writes the last record in the prime data area, an end-of-file record, the last index entry, and sets the return code to file closed. The end of file record contains all one bits.

The ISAM load routine returns to the statement immediately following the parameter that follows the LIBF to the routine for any of the three entry points.

Word	Entry	Meaning
0,1,2	DSA	The first entry in a DFI table is always a DSA statement. The DSA statement allows the programmer to refer symbolically to a disk stored data file without knowing its actual location. The label is defined as the current value of the Location Assignment Counter when the DSA statement is encountered. The operand is the name of the data file. For more information on DSA see IBM 1130/1800 Assembler Language.
3	DC /00XX	XX equals the key length in characters. Maximum is /0032. (50 characters)
4	DC /0XXX	XXX equals the length of the record in words. The maximum entry is /0140 (one 320-word record). This includes the two words required for the sequence-link control field.
5	DC LABEL1	The address of the index buffer. This address must be on an even-word boundary. The length of the index buffer is calculated by multiplying the number of index entries per sector by the index entry length and adding 2. The maximum length of this buffer is 322 words.
6	DC LABEL2	The address of the data buffer. This address must be on an even-word boundary. The length of the data buffer is calculated by multiplying the number of records per sector (word 14 in this table) by the record length (word 4 in this table) and adding 2. The maximum length of the data buffer is 322 words.
7	DC /XXXX	Routine type code. For ISAM load, XXXX = 1111.
8	DC /XXXX	XXXX equals the number of sectors required for the index. See "Determining ISAM File Size" in this section for the methods used to calculate this value.
9	DC /0000	Return code. This word must be reserved by the user. After each LIBF to any of the three entry points in the ISAM load routine it should be checked for the return code.[1]
10	DC /0000	Address of record being processed. This word must be reserved by the user.

[1] Return codes for ISAM load are as follows

Hexadecimal Number	Meaning
5555	File is open
8020	Not a load function
8021	Record size or number of records per sector incorrect
8022	Key length greater than maximum
8023	Index entry length not same as length computed from key length
8024	Number of index entries per sector incorrect
8025	Prime data area is full
8026	Index area is full
8027	File is not open
8028	Index buffer not on even-word boundary
8029	Data buffer not on even-word boundary
802A	Input record out of sequence
0FFF	File is closed

All 8XXX return codes except 802A are terminal errors. The file must be reopened to allow the program to retry the operation. Processing will again start at the first record.

Figure 14. Disk File Information Table for ISAM Load (Part 1 of 2)

Word	Entry	Meaning
11	DC /0000	Address of the index entry. This word must be reserved by the user.
12	DC /XXXX	XXXX equals the number of index entries per sector. See "Determining ISAM File Size" in this section for the methods used to calculate this value. This value must be the maximum number of index entries that will fit on a sector.
13	DC /XXXX	XXXX equals the index entry length in words. See "Determining ISAM File Size" in this section for the methods used to calculate this value.
14	DC /XXXX	XXXX equals the number of records per sector. See "Determining ISAM File Size" in this section for the methods used to calculate this value. The entry in this word must indicate the maximum number of records that will fit on a sector.
15	DC /0000	Prime data record number. This word must be reserved by the user.
16	DC /0000	Index entry number. This word must be reserved by the user.
17	DC LABEL3	Address of key hold area. This area is used to hold the key of the previous record so the records can be sequence checked. After the close routine has been executed this word will contain the sector address of the last prime data sector. The key hold area must be as many words long as there are characters in the record key.
18	DC /0000	Sector address of last index sector. This word must be reserved by the user.
19	DC /0000	Sector address of next overflow sector. This word must be reserved by the user.
20	DC /0000	Record number of next overflow record. This word must be reserved by the user.

Figure 14. Disk File Information Table for ISAM Load (Part 2 of 2)

ISAM Add Routine

This routine allows the user to add records to an existing file. The new records are placed in proper order by key sequence in the prime data area. The records forced off the prime data cylinders by the new records are placed in an overflow area. If the record to be added logically falls between the last record presently on the cylinder and the last record originally on the cylinder, it is written directly into the overflow area. If the record being added has a higher key than any record on the file, it is inserted before the end of file record. The add routine will operate most efficiently if the records being added are presorted by key sequence.

It is extremely important that an Add file be closed. This is to insure the file is properly updated for future processing. The add file should be closed before termination of the job as a result of either normal or abnormal EOJ. If the job is abnormally terminated because of a CPU failure or a DASD error (indicated by error code /5004 with DISKZ) when an ADD is being performed, it is possible that a duplicate record may have been generated on the file. If this occurs, the user should check his file and if such a duplicate record exists, it should be deleted.

The sequence of events on an ISAM add is open the file, perform the function and close the file. To accomplish these objectives the ISAM add routine has three entry points:

ISADO - open the file
ISAD - write a record
ISADC - close the file

The ISAM add routine is a part of the System Library. It is called by a LIBF. One parameter must be passed to the routine on each call and that parameter is the address of the Disk File Information (DFI) table. This parameter must immediately follow the LIBF statement.

The coding required to add records to an ISAM file is as follows.

```
START
      :           (USER CODE)
      LIBF        ISADO         OPEN ISAM ADD FILE
      DC          DFIAD         DFI ADDRESS (REQUIRED)
      LD          DFIAD+19      LOAD RETURN CODE
      BN          ERROR         GO TO ERROR ROUTINE IF NEG
      :
      LIBF        ISAD          WRITE RECORD
      DC          DFIAD         DFI ADDRESS (REQUIRED)
      LD          DFIAD+19      LOAD RETURN CODE
      BN          ERROR         GO TO ERROR ROUTINE IF NEG
      :
      LIBF        ISADC         CLOSE ISAM ADD FILE
      DC          DFIAD         DFI ADDRESS (REQUIRED)
      LD          DFIAD+19      LOAD RETURN CODE
      BN          ERROR         GO TO ERROR ROUTINE IF NEG
      :
* DFI TABLE FOR ISAM ADD ROUTINE
DFIAD DSA         FILEA         USER FILE
      :
ERROR EQU         *             ERROR ROUTINE
      :
      END         START
```

Disk File Information (DFI) Table. The ISAM add routine requires a DFI table describing the file. The DFI table (which is 21 words long, numbered 0-20) has nineteen entries, six of which must be filled in by the user. The remaining thirteen entries must be initialized to zero by the user and are filled in by the program during execution.

Figure 15 shows the DFI table for the ISAM add routine.

Operation of the ISAM Add Routine. When the routine is entered at the open entry point ISADO, it checks the validity of the DFI table entries, sets pointers and switches to be used internally by the routine and sets the return code in the DFI table to the code for file open.

The routine is then entered at ISAD to add a record to the file.

When the routine is entered at ISADC, the label is updated and the return code is set to file closed.

The ISAM add routine returns to the statement immediately following the parameter that follows the LIBF to the routine for any of the three entry points.

ISAM Sequential

The ISAM sequential routine is used to retrieve and update records on an ISAM file. Processing may start at the first record or at any record within the file.

The programmer can update each record immediately after it is processed by writing it back to the same location from which it was retrieved. This update is accomplished by specifying /0010 in word 7 of the DFI table when the file is opened and modifying word 19 of the DFI to /0001 before issuing the LIBF ISEQ. Word 19 must be restored to /0000 prior to reading the next record. An update is not required if the records are not changed.

The sequence of events for an ISAM sequential operation is open the file, set a low key limit if required, perform the function and close the file. To accomplish these objectives the ISAM sequential routine has four entry points:

- ISEQO - open the file
- ISETL - set low key limit (start processing at this record)
- ISEQ - process a record
- ISEQC - close the file

The ISAM sequential routine is a part of the System Library. It is called by a LIBF. One parameter must be passed to the routine on each call and that parameter is the address of the Disk File Information (DFI) table. This parameter must immediately follow the LIBF statement.

The coding required to retrieve and update records on an ISAM file starting with the first record is as follows:

```
START
      :           (USER CODE)
      LIBF        ISEQO         OPEN ISAM SEQUENTIAL
      DC          DFIAD         DFI ADDRESS (REQUIRED)
      LD          DFIAD+19      LOAD RETURN CODE
      BN          ERROR         GO TO ERROR ROUTINE IF NEG
      :
      LIBF        ISEQ          READ OR WRITE RECORD
      DC          DFIAD         DFI ADDRESS (REQUIRED)
      LD          DFIAD+19      LOAD RETURN CODE
      BN          ERROR         GO TO ERROR ROUTINE IF NEG
      :
      LIBF        ISEQC         CLOSE ISAM SEQUENTIAL
      DC          DFIAD         DFI ADDRESS (REQUIRED)
      LD          DFIAD+19      LOAD RETURN CODE
      BN          ERROR         GO TO ERROR ROUTINE IF NEG
      :
* DFI TABLE FOR ISAM SEQUENTIAL
DFIAD DSA         FILEA         USER FILE
      :
ERROR EQU         *             ERROR ROUTINE
      :
      END         START
```

Word	Entry	Meaning
0,1,2	DSA	The first entry in a DFI table is always a DSA statement. The DSA statement allows the programmer to refer symbolically to a disk stored data file without knowing its actual location. The label is defined as the current value of the Location Assignment Counter when the DSA statement is encountered. The operand is the name of the data file. Further information on DSA may be found in IBM 1130/1800 Assembler Language.
3	DC /00XX	XX equals the key length in characters. Maximum is /0032 (50 characters).
4	DC /0XXX	XXX equals the length of the record in words. The maximum entry is /0140 (one 320-word record).
5	DC LABEL1	The address of the index buffer. This address must be on an even word boundary. The length of the index buffer is calculated by multiplying the number of index entries per sector by the index entry length and adding 2. The maximum length of this buffer is 322 words.
6	DC LABEL2	The address of the record being added to the file.
7	DC /XXXX	Routine type code. For ISAM add, XXXX = 0000.
8	DC /0000	Index entry number in process. This word must be reserved by the user.
9	DC /0000	Return code. This word must be reserved by the user. After each LIBF to any of the three entry points in the ISAM add routine it should be checked for the return code.[1]
10	DC /0000	Prime data record number in process. This word must be reserved by the user.

[1] Return codes for ISAM Add are as follows.

Hexadecimal

Number	Meaning
5555	File is open
8030	Not an add function
8031	File is not open
8032	Key length in DFI table not same as key length in label
8033	Record length in DFI table not same as record length in label
8034	Key is presently on file
8035	Overflow area is full
8036	Index buffer not on even-word boundary
OFFF	File is closed

All 8XXX return codes except 8034 are terminal errors. The file must be reopened to allow the program to retry the operation. Processing will again start at the first record.

Figure 15. Disk File Information Table for ISAM Add (Part 1 of 2)

Word	Entry	Meaning
11	DC /0000	Address of the index entry. This word must be reserved by the user.
12	DC /0000	Number of index entries per sector. This word must be reserved by the user.
13	DC /0000	Index entry length in words. This word must be reserved by the user.
14	DC /0000	Number of records per sector. This word must be reserved by the user.
15	DC /0000	Record number of last prime data record processed. This word must be reserved by the user.
16	DC /0000	Number of last index entry for file. This word must be reserved by the user.
17	DC /0000	Sector address of last prime data sector. This word must be reserved by the user.
18	DC /0000	Sector address of last index sector. This word must be reserved by the user.
19	DC /0000	Sector address of next overflow sector. This word must be reserved by the user.
20	DC /0000	Record number of next overflow record. This word must be reserved by the user.

Figure 15. Disk File Information Table for ISAM Add (Part 2 of 2)

The coding required to retrieve and update records on an ISAM file starting at a record other than the first record on the file is as follows. (Note that the record key must be placed in the key hold area in a special format: one character per word, occupying the rightmost eight bits of the word. The coding included below illustrates one way that this can be done. It is required only if the key characters are left-justified.)

```
Label  Operation  F T  Operands & Remarks
START
         :                (USER CODE)
       LIBF            ISEQO        OPEN ISAM SEQUENTIAL
       DC              DFIAD        DFI ADDRESS (REQUIRED)
       LD              DFIAD+9      LOAD RETURN CODE
       BN              ERROR        GO TO ERROR ROUTINE IF NEG
         :
* READ IN LOW LIMIT ADDRESS. THE FOLLOWING EXAMPLE
* SHOWS ONE METHOD OF CONVERTING THE KEY TO THE
* FORM REQUIRED BY ISETL.
         :
       LD              DFIAD+3      KEY LENGTH IN CHARACTERS
       STO        L    1            LOAD INDEX REGISTER 1
       LD              DFIAD+8      RECORD KEY ADDRESS
       STO        L    2            LOAD INDEX REGISTER 2
       SLT             32           ZERO REGISTERS
LOOP   LD           2  0            LOAD WORD OF KEY
       SRA             8            SHIFT CHARACTER TO RH WORD
       STO          2  0            RESTORE WORD OF KEY
       MDX          2  1            INCREMENT KEY POINTER
       MDX          1  -1           DECREMENT CHARACTER COUNT
       MDX             LOOP         IF NON-ZERO, CONTINUE
         :
* END OF EXAMPLE. THE FOLLOWING CODING IS REQUIRED.
       LIBF            ISETL        SET LOW KEY LIMIT
       DC              DFIAD        DFI ADDRESS (REQUIRED)
```

Disk File Information (DFI) Table. The ISAM sequential routine requires a DFI table describing the file. The DFI table (which is 21 words long, numbered 0-20) has nineteen entries, eight of which must be filled in by the user. The remaining eleven entries must be initialized to zero by the user and are filled in by the program during execution.

Figure 16 shows the DFI table for the ISAM sequential routine.

```
Label  Operation  F T  Operands & Remarks
21  25 27    30  32 33 35   40   45   50   55   60   65   70
       LD              DFIAD+9      LOAD RETURN CODE
       BN              ERROR        GO TO ERROR ROUTINE IF NEG
         :
       LIBF            ISEQ         READ OR WRITE RECORD
       DC              DFIAD        DFI ADDRESS (REQUIRED)
       LD              DFIAD+9      LOAD RETURN CODE
       BN              ERROR        GO TO ERROR ROUTINE IF NEG
         :
       LIBF            ISEQC        CLOSE ISAM SEQUENTIAL
       DC              DFIAD        DFI ADDRESS (REQUIRED)
       LD              DFIAD+9      LOAD RETURN CODE
       BN              ERROR        GO TO ERROR ROUTINE IF NEG
         :
* DFI TABLE FOR ISAM SEQUENTIAL
DFIAD  DSA             FILEA        USER FILE
         :
ERROR  EQU             *            ERROR ROUTINE
         :
       END             START
```

Word	Entry	Meaning
0,1,2	DSA	The first entry in a DFI table is always a DSA statement. The DSA statement allows the programmer to refer symbolically to a disk stored data file without knowing its actual location. The label is defined as the current value of the Location Assignment Counter when the DSA statement is encountered. The operand is the name of the data file. Further information on DSA may be found in IBM 1130/1800 Assembler Language. Note that the first word of the DSA instruction is loaded with the last prime data sector address when the file is opened.
3	DC /00XX	XX equals the key length in characters. Maximum is /0032. (50 characters). The key length must be the same as the key length in the file label.
4	DC /0XXX	XXX equals the length of the record in words. The maximum entry is /0140 (one 320-word record). The record length must be the same as the record length in the file label.
5	DC LABEL1	The address of the index buffer. This address must be on an even-word boundary. The length of the index buffer is calculated by multiplying the number of index entries per sector by the index entry length and adding 2. The maximum length of this buffer is 322 words.
6	DC LABEL2	The address of the data buffer. This address must be on an even-word boundary. The length of the data buffer is calculated by multiplying the number of records per sector by the record length and adding two. The maximum length of the data buffer is 322 words.
7	DC /XXXX	Routine type code. For ISAM sequential retrieve, XXXX = 0001. For ISAM sequential update, XXXX = 0010.
8	DC /XXXX	Address of key hold area if processing starts at a point other than the first record in the file. If the entire file is being processed, this word must be /0000.
9	DC /0000	Return code. This word must be reserved by the user. After each LIBF to any of the four entry points in the ISAM sequential routine it should be checked for the return code.[1]
10	DC /0000	Address of record in process. This word must be reserved by the user.

[1] Return codes for ISAM sequential are as follows:

Hexadecimal Number	Meaning
5555	File is open
8040	Not a sequential retrieve or update function
8041	Index buffer not on even-word boundary
8042	Data buffer not on even-word boundary
8043	Key length in DFI table not same as key length in label
8044	Record length in DFI table not same as record length in label
8045	File is not open
8046	Write before read on update
FFFF	End of file
0FFF	File is closed

All 8XXX return codes except 8046 are terminal errors. The file must be reopened to allow the program to retry the operation. Processing will again start at the first record.

FFFF is a terminal error in the sense that it allows no further processing of the file. It does not, however, prevent the file from being closed in the normal manner.

Figure 16. Disk File Information Table for ISAM Sequential (Part 1 of 2)

Word	Entry	Meaning
11	DC /0000	Address of the index entry used to locate the record. This word must be reserved by the user.
12	DC /0000	Number of index entries per sector. This word must be reserved by the user.
13	DC /0000	Index entry length in words. This word must be reserved by the user.
14	DC /0000	Number of records per sector. This word must be reserved by the user.
15	DC /0000	Update-write indicator. This word must be reserved by the user.
16	DC /0000	Number of index entry in process. This word must be reserved by the user.
17	DC /0000	ISETL switch to indicate low-limit record found. This word must be reserved by the user.
18	DC /0000	Internal switch used to indicate that last record in overflow area has been found. This word must be reserved by the user.
19	DC /XXXX	Read/Write indicator. If routine type code (word 7 of this table) was a retrieve, this entry should be set to /0000. If word 7 indicates an update file, this entry should be /0000 for the retrieve and /0001 for the update. This word should be reset to /0000 before the next retrieve.
20	DC/0000	Prime data record number in process. This word must be reserved by the user.

Figure 16. Disk File Information for ISAM Sequential (Part 2 of 2)

Operation of the ISAM Sequential Routine. When the routine is entered at the open entry point ISEQO, it checks the validity of the DFI table entries, sets pointers and switches to be used internally by the routine and sets the return code in the DFI table to the code for file open.

If processing is not to start at the first record in the file, the routine is entered at ISETL to locate the starting record.

The routine is then entered at ISEQ to perform the processing functions.

When the routine is entered at ISEQC, the last record is processed and the return code is set to file closed.

The ISAM sequential routine returns to the statement immediately following the parameter that follows the LIBF to the routine for any of the four entry points.

ISAM Random

The ISAM random routine is used to retrieve and update records randomly on an ISAM file. The programmer first places the key field of the desired record in a user-defined area. ISAM random then searches the index to locate the cylinder containing the desired record and then searches that cylinder for the record. The sector containing the record is then read and that record is made available for processing.

The programmer can update each record immediately after it is processed by writing it back to the same location from which it was retrieved. This update is accomplished by specifying /1000 in the seventh word of the DFI table when the file is opened and modifying the nineteenth word of the DFI to /0001 before issuing the LIBF ISRD. The nineteenth word must be restored to /0000 prior to reading the next record. An update is not required if the records are not changed.

The sequence of events for an ISAM random operation is open the file, perform the function and close the file. To accomplish these objectives the ISAM random routine has three entry points.

ISRDO - open the file
ISRD - process a record
ISRDC - close the file

The ISAM random routine is a part of the System Library. It is called by a LIBF. One parameter must be passed to the routine on each call and that parameter is the address of the Disk File Information (DFI) table. This parameter must immediately follow the LIBF statement.

The coding required to retrieve and update records on an ISAM file using the random routine is as follows:

```
Label   Operation  F T  Operands & Remarks
21   25 27     30 32 33 35
START
          :              (USER CODE)
        LIBF             ISRDO         OPEN ISAM RANDOM
        DC               DFIAD         DFI ADDRESS (REQUIRED)
        LD               DFIAD+9       LOAD RETURN CODE
        BN               ERROR         GO TO ERROR ROUTINE IF NEG
          :
        LIBF             ISRD          READ OR WRITE RECORD
        DC               DFIAD         DFI ADDRESS (REQUIRED)
        LD               DFIAD+9       LOAD RETURN CODE
        BN               ERROR         GO TO ERROR ROUTINE IF NEG
          :
        LIBF             ISRDC         CLOSE ISAM RANDOM
        DC               DFIAD         DFI ADDRESS (REQUIRED)
        LD               DFIAD+9       LOAD RETURN CODE
        BN               ERROR         GO TO ERROR ROUTINE IF NEG
          :
* DFI   TABLE FOR ISAM RANDOM ROUTINE
DFIAD   DSA              FILEA         USER FILE
          :
ERROR   EQU              *             ERROR ROUTINE
          :
        END              START
```

Disk File Information (DFI) Table. The ISAM random routine requires a DFI table describing the file. The DFI table (which is 20 words long, numbered 0-19) has eighteen entries, eight of which must be filled in by the user. The remaining ten entries must be initialized to zero by the user and are filled in by the program during execution.

Figure 17 shows the DFI table for the ISAM random routine.

Operation of the ISAM Random Routine. When the routine is entered at the open entry point ISRDO, it checks the validity of the DFI table entries, sets pointers and switches to be used internally by the routine and sets the return code in the DFI table to the code for file open.

The file is then entered at ISRD to process a record.

When the routine is entered at ISRDC, the return code is set to file closed.

The ISAM random routine returns to the statement immediately following the parameter that follows the LIBF to the routine for any of the three entry points.

RPG OBJECT TIME SUBROUTINES

Included in the DM2 System Library is a group of subroutines that performs functions for the RPG object program. These subroutines are intended for system use only. Brief descriptions of the subroutines and their entry points are listed below.

RPG Decimal Arithmetic

Add, Subtract, and Numeric Compare. This subroutine performs the addition, subtraction and numeric comparison functions requested in the RPG calculation specification.

The entry points are:

RGADD - decimal addition routine

RGSUB - decimal subtraction routine

RGNCP - decimal numeric compare

Multiply. This subroutine multiplies two decimal fields defined in an RPG program.

The entry point is:

RGMLT - decimal multiply

Divide. The RPG object program calls this subroutine to divide one decimal field by another and store the quotient in a third field.

The entry point is:

RGDIV - decimal divide

Move Remainder. This subroutine is called by the RPG object program immediately following a divide operation. It places the remainder in a specified field.

The entry point is:

RGMVR - move remainder

Word	Entry	Meaning
0,1,2	DSA	The first entry in a DFI table is always a DSA statement. The DSA statement allows the programmer to refer symbolically to a disk stored data file without knowing its actual location. The label is defined as the current value of the Location Assignment Counter when the DSA statement is encountered. The operand is the name of the data file. Further information on DSA may be found in IBM 1130/1800 Assembler Language.
3	DC /00XX	XX equals the key length in characters. Maximum is /0032. (50 characters). The key length must be the same as the key length in the file being accessed.
4	DC /0XXX	XXX equals the length of the record in words. The maximum entry is /0140 (one 320-word record). The record length must be the same as the record length on the file being accessed.
5	DC LABEL1	The address of the index buffer. This address must be on an even-word boundary. The length of the index buffer is calculated by multiplying the number of index entries per sector by the index entry length and adding 2. The maximum length of this buffer is 322 words.
6	DC LABEL2	The address of the data buffer. This address must be on an even-word boundary. The length of the data buffer is calculated by multiplying the number of records per sector by the record length and adding two. The maximum length of the data buffer is 322 words.
7	DC /XXXX	Routine type code. For ISAM random retrieve, XXXX = 0100. For ISAM random update, XXXX = 1000.
8	DC LABEL3	Address of the key hold area containing the key of the record to be processed. The key must be in a special format: one character per word, occupying the rightmost eight bits of the word. See the coding for ISAM sequential that includes a LIBF to ISETL for an example of how the key can be placed in this format.
9	DC /0000	Return code. This entry must be reserved by the user. After each LIBF to any of the three entry points in the ISAM random routine it should be checked for the return code.
10	DC /0000	Address of record in process. This word must be reserved by the user.

[1] Return codes for ISAM random are as follows:

Hexadecimal Number	Meaning
5555	File is open
8050	Not a random retrieve or update function
8051	Index buffer not on even-word boundary
8052	Data buffer not on even-word boundary
8053	Key length in DFI table not same as key length in label
8054	Record length in DFI table not same as record length in label
8055	File is not open
8056	Write before read on update
8057	Record not on file
0FFF	File is closed

All 8XXX return codes except 8056 and 8057 are terminal errors. The file must be reopened to allow the program to retry the operation. Processing will again start at the first record.

Figure 17. Disk File Information Table for ISAM Random (Part 1 of 2)

Word	Entry	Meaning
11	DC /0000	Address of the index entry used to locate the record. This word must be reserved by the user.
12	DC /0000	Number of index entries per sector. This word must be reserved by the user.
13	DC /0000	Index entry length in words. This word must be reserved by the user.
14	DC /0000	Number of records per sector. This word must be reserved by the user.
15	DC /0000	Prime data record number. This word must be reserved by the user.
16	DC /0000	Number of index entry in process. This word must be reserved by the user.
17	DC /0000	First-time switch. This switch is set off after one record has been processed.
18	DC /0000	Internal switch used to indicate the record found is in the overflow area. This word must be reserved by the user.
19	DC /XXXX	Read/Write indicator. If routine type code (word 7 of this table) was a retrieve, this word should be set to /0000. If word 7 indicates an update file, this word should be /0000 for the retrieve and /0001 for the update. This word should be reset to /0000 before the next retrieve.

Figure 17. Disk File Information Table for ISAM Random (Part 2 of 2)

Binary/Decimal Conversion. This subroutine converts a three-word binary number to a fourteen-digit decimal number and vice-versa.

The entry points are:

RGBTD - binary to decimal conversion

RGDTB - decimal to binary conversion

RPG Sterling and Edit

Sterling Input Conversion. This subroutine converts a field in the British sterling format of pounds, shillings, pence and decimal pence to a decimal format of pence and decimal pence.

The entry point is:

RGSTI - sterling input conversion

Sterling Output Conversion. This subroutine performs the reverse function of RGSTI.

The entry point is:

RGSTO - sterling output conversion

Edit. This subroutine edits a numeric field using a user-specified edit word or edit code and places the edited value in an output area.

The entry point is:

RGEDT - edit

RPG Move

The five subroutines that comprise this group are responsible for the movement of data and fields requested by the object program.

The entry points and functions of these subroutines are:

- RGMV1, RGMV5 - move data from I/O buffer to assigned core field
- RGMV2 - move data from assigned core field to I/O buffer
- RGMV3 - perform the RPG calc operation MOVE
- RGMV4 - perform the RPG calc operation MOVEL

RPG Compare

This subroutine is used to compare alphameric fields.

The entry point is:

RGCMP - alphameric compare

RPG Indicators

Test. The condition of indicators specified in columns 9-17 of an RPG calculation specification are tested. If the conditions are met, the calc operation is performed. If the conditions are not met the operation is skipped.

The entry point is:

RGSI1 - test indicators

Set Resulting Indicators On Conditionally. This subroutine sets on resulting indicators as required based on the results of an arithmetic operation, a compare operation, or a table lookup. The resulting indicators are specified in columns 54-59 of the calculation specification.

The entry point is:

RGSI2 - set resulting indicators conditionally

Set Resulting Indicators On or Off. This subroutine will set or reset from one to three resulting indicators.

The entry points are:

RGSI3 - set resulting indicators on unconditionally

RGSI4 - clear resulting indicators off unconditionally

Zero or Blank Test. This subroutine tests for a zero or blank and returns an indication to the requesting program.

The entry point is:

RGSI5 - test a field for zero or blank

RPG Miscellaneous

Test Zone. Tests the zone of the leftmost position of an RPG alpha field and returns an indication to the requesting program.

The entry point is:

RGTSZ - perform TESTZ operation

Convert Record ID. Converts the record ID number supplied on a Record Address File (RAF) to a two-word binary number.

The entry point is:

RGCVB - convert record ID number to binary

Object-Time Error. Load accumulator with error number supplied by user and wait at $PRET for operator action. This subroutine then interprets operator action and proceeds accordingly.

The entry point is:

RGERR - RPG object program error interface

Blank After. This subroutine performs the RPG blank-after function if specified on the RPG output specification.

The entry point is:

RGBLK - zero or blank a field

Subroutines Used by FORTRAN (C/PT System)

Many of the functions and capabilities available within the general I/O and conversion subroutines described in this manual are beyond specification by the FORTRAN language. For example, the feed function of the 1442 cannot be specified in FORTRAN. Therefore, a set of limited-function I/O and conversion subroutines is included in the subroutine library for use by FORTRAN-compiled programs. Any subroutines written in Assembler language that execute I/O operations, and that are intended to be used in conjunction with FORTRAN-compiled programs must employ these special I/O subroutines for any I/O device specified in a mainline *IOCS record or for any device on the same interrupt level.

These subroutines are intended to operate in an error-free environment and thus provide no preoperative parameter checking.

The subroutine library contains the following special routines:

CARDZ	-	1442 I/O Subroutine
TYPEZ	-	Keyboard/Console Printer I/O Subroutine
WRTYZ	-	Console Printer Subroutine
PRNTZ	-	1132 Printer Subroutine
PAPTZ	-	1134/1055 Paper Tape I/O Subroutine
PLOTX	-	1627 Plotter Subroutine (see PLOTX)
HOLEZ	-	IBM Card Code/EBCDIC Conversion Subroutine
EBCTB	-	EBCDIC/Console Printer Code Table
HOLTB	-	IBM Card Code Table
GETAD	-	Subroutine Used to Locate Start Address of EBCTB/HOLTB

GENERAL SPECIFICATIONS

Except for PLOTX, the FORTRAN I/O device subroutines operate in a nonoverlapped mode. Thus, the device subroutines do not return control to the calling program until the operation is completed. These subroutines are all LIBF's without parameters.

The input/output buffer for the subroutines is a 121-word buffer starting at location /003C. The maximum amount of data transferable is listed in the description of each subroutine. Output data must be stored in unpacked (one character per word) EBCDIC format, /00XX. Data entered from an input device is converted to unpacked (one character per word) EBCDIC format, /00XX.

The EBCDIC character set recognized by the subroutine comprises digits 0-9, alphabetic characters A-Z, blank, and special characters $-+.&=(),'/*<%#@. Any other character is recognized as a blank by all subroutines except HOLEZ. HOLEZ recognizes an invalid character as an asterisk.

The Accumulator, Extension, and Index Registers 1 and 2 are used by the FORTRAN device subroutines and must be saved, if required, before entry into any given FORTRAN subroutine.

The Accumulator must be set to zero for input operations. For output operations, the Accumulator must be set /0002, except for PRNTZ and WRTYZ, in which output is the only valid operation. Index Registers 1 and 2 are set to the number of characters transmitted, except for PRNTZ (1132 Printer) in which Index Register 2 contains the number of characters printed plus an additional character for forms control.

ERROR HANDLING

Device errors, e.g., not-ready and read check, cause a WAIT in the subroutine itself. After the appropriate corrective action is taken by the operator, PROGRAM START is pressed to execute or reinitiate the operation.

DESCRIPTIONS OF I/O SUBROUTINES

The subroutines described in the sections that follow do not provide a check to determine validity of parameters (contents of Accumulator and Index Register 2). Invalid parameters cause indeterminate operation of the subroutines.

TYPEZ - KEYBOARD/CONSOLE PRINTER I/O SUBROUTINE

Buffer Size. Maximum of 80 words input, 120 words output.

Keyboard Input. The subroutine returns the carrier, reads up to 80 characters from the Keyboard, and stores them in the I/O buffer in EBCDIC format. Upon recognition of the end-of-field character or reception of the 80th character, the subroutine returns control to the user (the remainder of the buffer is unchanged). Upon recognition of the erase field character or the backspace character, the carrier is returned and the subroutine is reinitialized for the reentry of the entire message. Characters are printed by the Console Printer during Keyboard input.

Console Printer Output. The subroutine returns the carrier and prints the number of characters indicated by Index Register 2 from the I/O buffer.

Subroutines Required. The following subroutines are required with TYPEZ:

HOLEZ, GETAD, EBCTB, HOLTB

WRTYZ - CONSOLE PRINTER OUTPUT SUBROUTINE

Buffer Size. Maximum of 120 words.

Operation. This subroutine returns the carrier and prints the number of characters indicated by Index Register 2 from the I/O buffer.

Subroutines Required. The following subroutines are required with WRTYZ:

GETAD, EBCTB

CARDZ - 1442 CARD READ PUNCH I/O SUBROUTINE

Buffer Size. Maximum of 80 words.

Card Input. This subroutine reads 80 columns from a card and stores the information in the I/O buffer in EBCDIC format.

Card Output. This subroutine punches the number of characters indicated by Index Register 2 from the I/O buffer. Punching is done in IBM card code format.

Subroutines Required. The following subroutines are required with CARDZ:

HOLEZ, GETAD, EBCTB, HOLTB

PAPTZ - 1134/1055 PAPER TAPE READER PUNCH I/O SUBROUTINE

Buffer Size. Maximum of 80 characters.

1134 Paper Tape Input. This subroutine reads paper tape punched in PTTC/8 format. Paper tape is read until 80 characters have been stored or until a new-line character is read. If 80 characters have been stored and a new-line character has not been read, one more character, assumed to be a new-line character, is read from tape. (Delete and case-shift characters cause nothing to be stored.) If the first character read is not a case-shift character, it is assumed to be a lower case character. The input is converted to EBCDIC format.

1055 Paper Tape Output. The contents of the I/O buffer is converted from EBCDIC to PTTC/8, and the number of characters indicated by Index Register 2 is punched, in addition to the required case-shift characters.

PRNTZ - 1132 PRINTER OUTPUT SUBROUTINE

Buffer Size. Maximum of 121 characters.

Index Register 2. The value stored in Index Register 2 must be the number of characters to be printed plus an additional character for carriage control. Up to 120 characters can be printed in any one operation. The first character to be printed is stored in location /003D.

The carriage of the 1132 printer is controlled prior to the printing of a line. The following is a list of the carriage control characters and their related functions:

/00F1 Skip to channel 1 prior to printing
/00F0 Double space prior to printing
/004E No skip or space prior to printing
Any other character - Single space prior to printing.

Channel 12 Control. If a punch in channel 12 is encountered while a line is being printed, a skip-to-channel-1 is taken prior to the printing of the next line.

Subroutines Used by FORTRAN (DM2 System)

Many of the I/O and conversion subroutines cannot be specified in FORTRAN. Therefore, the System Library includes a set of limited-function I/O and conversion subroutines for FORTRAN programs. Any Assembler language I/O subroutines used by FORTRAN programs must employ these special subroutines for any I/O device specified in a mainline *IOCS control record.

Of all the FORTRAN device subroutines, only DISKZ, PRNTZ, PRNZ, and PLOTX return control to the caller after initiating an operation (PLOTX is described with the basic ISSs).

These subroutines are intended for use in an error-free environment and thus provide no preoperative parameter checking.

The System Library contains the following ISS and conversion subroutines for FORTRAN programs:

CARDZ -	1442 I/O Subroutine
PNCHZ -	1442 Output Subroutine
READZ -	2501 Input Subroutine
TYPEZ -	Keyboard/Console Printer I/O Subroutine
WRTYZ -	Console Printer Subroutine
PRNTZ -	1132 Printer Subroutine
PRNZ -	1403 Printer Subroutine
PAPTZ -	1134/1055 Paper Tape I/O Subroutine
PLOTX -	1627 Plotter Subroutine
DISKZ -	Disk I/O Subroutine
HOLEZ -	IBM Card Code/EBCDIC Conversion Subroutine
EBCTB -	EBCDIC/Console Printer Code Table
HOLTB -	IBM Card Code Table
GETAD -	Subroutine to Locate Start Address of EBCTB/HOLTB

GENERAL SPECIFICATIONS (EXCEPT DISKZ)

The "Z" device subroutines are ISS subroutines. These subroutines are all LIBF's without parameters. They use a 121-word input/output buffer, contained in the nondisk FORTRAN I/O subroutine SFIO. The maximum amount of data transferable is listed in the description of each subroutine. Output data must be stored in unpacked right-justified (one character per word) EBCDIC format. Input data is converted to unpacked EBCDIC format.

The EBCDIC character set recognized by the subroutines comprises digits 0-9, alphabetic characters A-Z, blank, and special characters $-+.&=(),'/*<%#@. Any other character is recognized as a blank by all subroutines except HOLEZ. HOLEZ recognizes an invalid character as an asterisk.

If a "Z" subroutine is used by an Assembler language I/O subroutine, the user should be aware of the significant information carried by the different registers. The Accumulator, Extension, and Index Registers 1 and 2 are used by the FORTRAN device subroutines and must be saved, if required, before entry into the subroutines. The Accumulator must be set to zero for input operations.

For output operations, the Accumulator must be set to /0002, except for PRNZ, PRNTZ, PNCHZ, and WRTYZ, in which output is the only valid operation. Index Register 2 must be set to the number of characters to be transferred, except for PRNZ and PRNTZ. For these two subroutines, Index Register 2 must contain the number of characters to be printed plus an additional character for carriage control. Index Register 1 must contain the starting address of the input buffer.

ERROR HANDLING

Device errors, e.g., not ready and read check, result in a branch to $PST1, $PST2, $PST3, and $PST4 depending on the level to which the device is assigned. After the appropriate corrective action is taken by the operator, PROGRAM START is pressed to execute or reinitiate the operation.

If a monitor control record is encountered by CARDZ, READZ, or PAPTZ, the subroutine initiates a CALL EXIT. The control record itself will not be processed.

DESCRIPTIONS OF I/O SUBROUTINES

The subroutines described in the sections that follow do not provide a check to determine validity of parameters (contents of Accumulator and Index Register 2). Invalid parameters cause indeterminate operation of the subroutines.

TYPEZ - KEYBOARD/CONSOLE PRINTER I/O SUBROUTINE

Buffer Size. Maximum of 80 words input, 120 words output.

Keyboard Input. The subroutine returns the carrier and reads up to 80 characters from the Keyboard and stores them in the I/O buffer in EBCDIC format. Upon recognition of the end-of-field character or reception of the 80th character, the subroutine returns control to the user (the remainder of the buffer is unchanged). Upon recognition of the erase field character or the backspace character, the carrier is returned and the subroutine is reinitialized for the reentry of the entire message. Characters are printed by the Console Printer during Keyboard input.

Console Printer Output. The subroutine returns the carrier and prints the number of characters indicated by Index Register 2 from the I/O buffer.

Subroutines Required. The following subroutines are required with TYPEZ:

HOLEZ, GETAD, EBCTB, HOLTB

WRTYZ - CONSOLE PRINTER OUTPUT SUBROUTINE

Buffer Size. Maximum of 120 words.

Operation. This subroutine returns the carrier and prints the number of characters indicated by Index Register 2 from the I/O buffer.

Subroutines Required. The following subroutines are required with WRTYZ:

GETAD, EBCTB

CARDZ - 1442 CARD READ PUNCH I/O SUBROUTINE

Buffer Size. Maximum of 80 words.

Card Input. This subroutine reads 80 columns from a card and stores the information in the I/O buffer in EBCDIC format.

Card Output. This subroutine punches the number of characters indicated by Index Register 2 from the I/O buffer. Punching is done in IBM Card Code.

Subroutines Required. The following subroutines are required with CARDZ:

HOLEZ, GETAD, EBCTB, HOLTB

PAPTZ - 1134/1055 PAPER TAPE READER PUNCH I/O SUBROUTINE

Buffer Size. Maximum of 120 characters.

1134 Paper Tape Input. This subroutine reads paper tape punched in PTTC/8 format. The subroutine reads paper tape until 120 characters have been stored or until a new-line character is read. If 120 characters have been stored and a new-line character has not been read, one more character, assumed to be a new-line character, is read from tape. (Delete and case-shift characters cause nothing to be stored.) If the first character read is not a case-shift character, it is assumed to be a lower case character. Subsequent reads assume the same case as the last character read until the case is changed by another case-shift character. The input is converted to EBCDIC format.

1055 Paper Tape Output. The contents of the I/O buffer is converted from EBCDIC to PTTC/8, and the number of characters indicated by Index Register 2 is punched, in addition to the required case-shift characters.

PRNTZ - 1132 PRINTER OUTPUT SUBROUTINE

Buffer Size. Maximum of 121 characters.

Index Register 2. The value stored in Index Register 2 must be the number of characters to be printed, plus an additional character for carriage control. Up to 120 characters can be printed in any one operation. If PRNTZ is user-called by a LIBF PRNTZ, only an even number of characters are printed. To print an odd number of characters add one additional blank.

The carriage of the 1132 Printer is controlled prior to the printing of a line. The following is a list of the carriage control characters and their related functions:

/00F1 Skip to channel 1 prior to printing
/00F0 Double space prior to printing
/004E No skip or space prior to printing
Any other character - Single space prior to printing.

Channel 12 Control. If a punch in channel 12 is encountered while a line is being printed, a skip-to-channel-1 is taken prior to the printing of the next line provided the next function is not /004E (no skip or space prior to printing).

PNCHZ - 1442 OUTPUT SUBROUTINE

Buffer Size. Maximum of 80 words.

Card Output. This subroutine punches from the I/O buffer the number of characters indicated in the location preceding the buffer. Punching is done in IBM Card Code.

Subroutines Required. The following subroutines are required with PNCHZ:

HOLEZ, GETAD, EBCTB, HOLTB

READZ - 2501 INPUT SUBROUTINE

Buffer Size. Maximum of 80 words.

Card Input. This subroutine reads 80 columns from a card and stores the information in the I/O buffer in EBCDIC format.

Subroutines Required. The following subroutines are required with READZ:

HOLEZ, GETAD, EBCTB, HOLTB

PRNZ - 1403 PRINTER SUBROUTINE

Buffer Size. Must be 121 words.

Index Register 2. The first character in the I/O buffer is the carriage control character, followed by up to 120 characters to be printed. If less than 120 characters are to be printed, the remainder of the buffer must be cleared to blanks before PRNZ is called. A value of 1 in Index Register 2 indicates that the I/O buffer contains only a carriage control character. A value of greater than 1 in Index Register 2 indicates that a line is to be printed.

The carriage is controlled prior to the printing of a line; no "after-print" carriage control is performed. The following is a list of the carriage control characters and their related functions:

/00F1 Skip to channel 1 prior to printing
/00F0 Double space prior to printing
/004E No skip or space prior to printing
Any other character - Single space prior to printing.

Channel 12 Control. If a punch in channel 12 is encountered while a line is being printed, a skip to channel 1 is executed prior to printing the next line provided the next function is not /004E (no skip or space prior to printing).

Data Code Conversion Subroutines

The basic unit of information within the 1130 computing system is the 16-bit binary word. This information can be interpreted in a variety of ways, depending on the circumstances. For example, in internal computer operations, words may be interpreted as instructions, as addresses, as binary integers, or as real (floating point) numbers (see "Arithmetic and Functional Subroutines").

A variety of data codes exists for the following reasons:

1. The programmer needs a compact notation to represent externally the bit configuration of each computer word. This representation is provided in the hexadecimal notation.

2. A code is required for representing alphameric (mixed alphabetic and numeric) data within the computer. This code is provided by the Extended Binary Coded Decimal Interchange Code (EBCDIC).

3. The design and operation of the input/output devices is such that many of them impose a unique correspondence between character representations in the external medium and the associated bit configurations within the computer. Subroutines are needed to convert input data from these devices to a form on which the computer can operate and to prepare computed results for output on the devices.

This and following sections of the manual describe the data codes used and the subroutines provided for converting data representations among these codes.

A detailed description of the binary, hexadecimal, and decimal number systems is contained in the publication, IBM Number Systems, FC20-1618.

Descriptions of Data Codes

In addition to the internal 16-bit binary representation, the conversion subroutines handle the following codes:

- Hexadecimal Notation.
- IBM Card Code.
- Perforated Tape and Transmission Code (PTTC/8).
- Console Printer (1053) Code.
- 1403 Printer Code (DM2 System only).
- Extended Binary Coded Decimal Interchange Code (EBCDIC).

A list of these codes is contained in Appendix D.

HEXADECIMAL NOTATION

Although binary numbers facilitate the operations of computers, they are awkward for the programmer to handle. A long string of 1's and 0's cannot be effectively transmitted from one individual to another. For this reason, the hexadecimal number system is often used as a shorthand method of communicating binary numbers. Because of the simple relationship of hexadecimal to binary, numbers can easily be converted from one system to another.

In hexadecimal notation a single digit is used to represent a 4-bit binary value as shown in Figure 18. Thus, a 16-bit word in the 1130 System can be expressed as four hexadecimal digits. For example, the binary value

1101001110111011

can be separated into four sections as follows:

Binary	1101	0011	1011	1011
Hexadecimal	D	3	B	B

Another advantage of hexadecimal notation is that fewer positions are required for output data printed, punched in cards, or punched in paper tape. In the example above, only four card columns are required to represent a 16-bit binary word.

BINARY	DECIMAL	HEXADECIMAL
0000	0	0
0001	1	1
0010	2	2
0011	3	3
0100	4	4
0101	5	5
0110	6	6
0111	7	7
1000	8	8
1001	9	9
1010	10	A
1011	11	B
1100	12	C
1101	13	D
1110	14	E
1111	15	F

Figure 18. Hexadecimal Notation

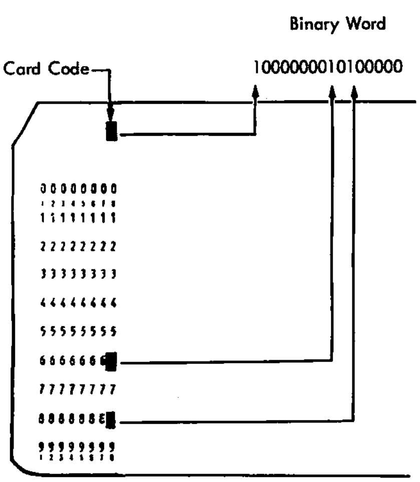
IBM CARD CODE

IBM Card Code can be used as an input/output code with the 1442 Card Read Punch, 1442 Card Punch, and 2501 Card Reader, and as an input code on the Keyboard.

This code defines a character by a combination of punches in a card column. Card code data is taken from or placed into the leftmost twelve bits of a computer word as shown below:

Card Row	12	11	0	1	2	3	4	5	6	7	8	9	-	-	-	-
Computer Word	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

For example, a plus sign, which has a card code of 12, 6, 8, is placed into core storage in the binary configuration illustrated in the following diagram:



PERFORATED TAPE AND TRANSMISSION CODE (PTTC/8)

The PTTC/8 code is an 8-bit code used with IBM 1134/1055 Paper Tape units. This code represents a character by a stop position, a check position, and six positions representing the 6-bit code, BA8421. PTTC/8 characters can be packed two per computer word as shown below:

	1st								2nd							
PTTC/8 Characters	S	B	A	C	8	4	2	1	S	B	A	C	8	4	2	1
Computer Word	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

The graphic character is defined by a combination of binary code and case; a control character is defined by a binary code and has the same meaning in upper or lower case. This implies that upper and lower case characters must appear in a PTTC/8 message wherever necessary to establish or change the case.

The binary and PTTC/8 codes for 1/ (lower case) and =? (upper case) are shown in Figure 19.

The delete and stop characters have a special meaning (in check mode only) when encountered by the paper tape subroutines.

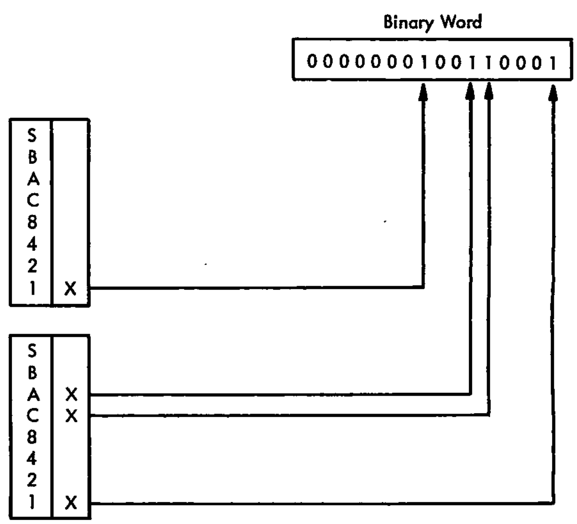


Figure 19. PTTC/8 Code for the Characters 1/ (if lower case) or the Characters =? (if upper case)

CONSOLE PRINTER CODE

The Console Printer uses an 8-bit code that can be packed two characters per 16-bit word.

The following control characters have special meanings when used with the Console Printer.

Character Control Operation

Character	Control Operation
HT	Tabulate
RES	Shift to black ribbon
NL	Carrier return to new line
BS	Backspace
LF	Line feed without carrier return
RS	Shift to red ribbon

EXTENDED BINARY CODED DECIMAL INTERCHANGE CODE (EBCDIC)

EBCDIC is the standard code for internal representation of alphameric and special characters and for the 1132 Printer. This code uses eight binary bits for each character, thus making it possible to store either one or two characters in a 16-bit word. Combinations of the eight bits allow 256 possible codes. (At present, not all of these combinations represent characters.) The complete EBCDIC code is listed in Appendix D.

For reasons of efficiency, most of the conversion subroutines do not recognize all 256 codes. The asterisked codes in Appendix D constitute the subset recognized by most of the conversion subroutines.

1403 PRINTER CODE

The 1403 Printer uses a 6-bit binary code with one parity bit. Data format is two 7-bit characters per word, as follows:

Bit	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Value	*	P	32	16	8	4	2	1	*	P	32	16	8	4	2	1
	1st data character								2nd data character							

* = Not Used
P = Parity Bit

Parity bits are not assigned by the hardware. The conversion subroutine must assign the parity bits and arrange the characters in the form in which they are to be printed.

Conversion Subroutines

These subroutines convert data to and from 16-bit binary words and I/O device codes.

BINDC Binary value to IBM Card Code decimal value.

DCBIN IBM Card Code decimal value to binary value.

BINHX Binary value to IBM Card Code hexadecimal value.

HXBIN IBM Card Code hexadecimal value to binary value.

HOLEB IBM Card Code subset to EBCDIC subset; EBCDIC subset to IBM Card Code subset.

SPEED IBM Card Code characters to EBCDIC; EBCDIC to IBM Card Code characters.

PAPEB PTTC/8 subset to EBCDIC subset; EBCDIC subset to PTTC/8 subset.

PAPHL PTTC/8 subset to IBM Card Code subset; IBM Card Code subset to PTTC/8 subset.

PAPPR PTTC/8 subset to Console Printer or 1403 Printer code.

HOLPR IBM Card Code subset to Console Printer or 1403 Printer code.

EBPRT EBCDIC subset to Console Printer or 1403 Printer code.

The following conversion tables are used by some of the conversion subroutines.

PRTY Console Printer and 1403 Printer code.

EBPA EBCDIC and PTTC/8 subsets.

HOLL IBM Card Code subset.

The following conversion subroutines are used by the DM2 system only.

BIDEC 32-bit binary value to IBM Card Code decimal value.

DECBI IBM Card Code decimal value to 32-bit binary value.

ZIPCO Supplement to all standard conversions except those involving PTTC/8.

The first four listed subroutines and the DM2 subroutines BIDEC and DECBI change numeric data from its input form to a binary form, or from a binary form to an appropriate output data code. The last eight (including ZIPCO) convert entire messages, one character at a time, from one input/output code to another. The types of conversions accomplished by these subroutines are illustrated in Figure 20.

Except where specified, these subroutines do not alter the Accumulator, Extension, Carry and Overflow indicators, or any index register.

CONVERTED FROM	CONVERTED TO									
	Binary	IBM Card Code (256)	IBM Card Code (Subset)	PTTC/8 (Subset)	EBCDIC (256)	EBCDIC (Subset) 1132 Printer	Console Printer	Hex Equivalent (Card Code)	Decimal Equivalent (Card Code)	1403 Printer Code
Binary								BINHX	BINDC BIDEC	
IBM Card Code (256)					SPEED ZIPCO*		ZIPCO*			ZIPCO*
IBM Card Code (Subset)				PAPHL		HOLEB	HOLPR			HOLPR
PTTC/8 (Subset)			PAPHL			PAPEB	PAPPR			PAPPR
EBCDIC (256)		SPEED					ZIPCO*			ZIPCO*
EBCDIC (Subset) 1132 Printer			HOLEB	PAPEB			EBPRT			EBPRT
Hex Equivalent (Card Code)	HXBIN			PAPHL		HOLEB	HOLPR			HOLPR
Decimal Equivalent (Card Code)	DCBIN DECBI			PAPHL		HOLEB	HOLPR			HOLPR
1403 Printer Code		ZIPCO*			ZIPCO*		ZIPCO*			
Console Printer Code		ZIPCO*			ZIPCO*					ZIPCO*

* In conjunction with appropriate conversion table.

Figure 20. Types of Conversion

Note 1. All mention of 1403 Printer Code applies to the DM2 system only.

Note 2. The conversion subroutines and conversion tables for the Communications Adapter are described in the publication IBM 1130 Synchronous Communications Adapter Subroutines. The subroutines are EBC48, HOL48, and HXCV. The adapter subroutine conversion table is STRTB.

Error Checking

All code conversion subroutines (except SPEED and ZIPCO) accept only the codes marked with an asterisk in Appendix D. An input character that does not conform to a specified code is an error.

BINHX and BINDC subroutines do not detect errors. HXBIN and DCBIN terminate conversion at the point of error detection; they do not replace the character in error. The contents of the Accumulator are meaningless when conversion is terminated because of an error.

The remainder of the conversion subroutines replace the character in error with a space character, stored in the output area in output code. Conversion is not terminated when an error is detected.

When a conversion subroutine detects an error it turns the Carry indicator off and turns the Overflow indicator on before returning control to the user. Otherwise, the settings of the Carry and Overflow indicators are not changed by the conversion subroutines.

BINDC

This subroutine converts a 16-bit binary value to its decimal equivalent in five IBM Card Code numeric characters and one sign character. The five characters and the sign are placed in six computer words as illustrated below.

I/O Locations	Conversion Data	Bits in Core Storage 0 ⟶ 15
Accumulator	+01538	0000 0110 0000 0010
OUTPT	+	1000 0000 1010 0000
OUTPT + 1	0	0010 0000 0000 0000
OUTPT + 2	1	0001 0000 0000 0000
OUTPT + 3	5	0000 0001 0000 0000
OUTPT + 4	3	0000 0100 0000 0000
OUTPT + 5	8	0000 0000 0010 0000

Calling Sequence

Label (21–25)	Operation (27–30)	F (32)	T (33)	Operands & Remarks (35–50)
	LIBF			BINDC
	DC			OUTPT
	•			•
OUTPT	BSS			6

Input

Input is a 16-bit binary value in the Accumulator.

Output

Output is an IBM Card Code sign character (plus or minus) in location OUTPT, and five IBM Card Code numeric characters in OUTPT+1 through OUTPT+5.

Errors Detected

The BINDC subroutine does not detect errors.

DCBIN

This subroutine converts a decimal value in five IBM Card Code numeric characters and a sign character to a 16-bit binary word. The conversion is the opposite of the BINDC subroutine conversion.

Calling Sequence

Label (21–25)	Operation (27–30)	F (32)	T (33)	Operands & Remarks (35–50)
	LIBF			DCBIN
	DC			INPUT
	•			•
INPUT	BSS			6

Input

Input is an IBM Card Code sign character in location INPUT and five IBM Card Code decimal characters in INPUT+1 through INPUT+5.

Output

Output is a 16-bit binary value displayed in the Accumulator.

Errors Detected

Any sign other than an IBM Card Code plus, ampersand, space, or minus, or any decimal digits other than a space or 0 through 9 is an error. Any converted value greater than +32767 or less than -32768 is an error.

BINHX

This subroutine converts a 16-bit binary word into hexadecimal notation in four IBM Card Code characters as illustrated below.

I/O Locations	Conversion Data	Bits in Core Storage 0 ⟶ 15
Accumulator	A59E	1010 0101 1001 1110
OUTPT	A	1001 0000 0000 0000
OUTPT + 1	5	0000 0001 0000 0000
OUTPT + 2	9	0000 0000 0001 0000
OUTPT + 3	E	1000 0001 0000 0000

Calling Sequence

Label	Operation	F	T	Operands & Remarks
	LIBF			BINHX
	DC			OUTPT
	•			•
OUTPT	BSS			4

Input

Input is a 16-bit binary word in the Accumulator.

Output

Output is four IBM Card Code hexadecimal digits in location OUTPT through OUTPT+3.

Errors Detected

The BINHX subroutine does not detect errors.

HXBIN

This subroutine converts four IBM Card Code hexadecimal characters into one 16-bit binary word. The conversion is the opposite of the BINHX subroutine conversion illustrated above.

Calling Sequence

Label	Operation	F	T	Operands & Remarks
	LIBF			HXBIN
	DC			INPUT
	•			•
INPUT	BSS			4

Input

Input is four IBM Card Code hexadecimal digits in INPUT through INPUT+3.

Output

Output is a 16-bit binary word in the Accumulator.

Errors Detected

Any input character other than an IBM Card Code 0 through 9 or A through F is an error.

HOLEB

This subroutine converts IBM Card Code subset to the EBCDIC subset or converts the EBCDIC subset to IBM Card Code subset. Code conversion is illustrated below.

I/O Locations	Conversion Data	Bits in Core Storage 0 ⟷ 15
INPUT	JS	1101 0001 1110 0010
OUTPT	J	0101 0000 0000 0000
OUTPT + 1	S	0010 1000 0000 0000

Calling Sequence

Label	Operation	F	T	Operands & Remarks
	LIBF			HOLEB CALL SUBSET CONVERSION
	DC			/000e CONTROL PARAMETER
	DC			INPUT INPUT AREA ADDRESS
	DC			OUTPUT OUTPUT AREA ADDRESS
	DC			f CHARACTER COUNT
	•			
	•			
	•			
INPUT	BSS			g INPUT AREA
	•			
	•			
	•			
OUTPT	BSS			h OUTPUT AREA

where

e indicates the direction of conversion,

f is the number of characters to be converted, g is the length of the input area. g must be equal to or greater than f if e is 0. If e is 1, g must be equal to f/2, or (f+1)/2 if f is odd.

h is the length of the output area. If e is 0, h must be equal to or greater than f/2, or (f+1)/2, if f is odd. If e is 1, h must be equal to or greater than f.

Control Parameter

The control parameter consists of four hexadecimal digits. Digits 1-3 are not used. The fourth digit specifies the direction of conversion:

0 - IBM Card Code to EBCDIC
1 - EBCDIC to IBM Card Code

Input

Input is either IBM Card Code or EBCDIC characters, (as specified by the control parameter) starting in location INPUT. EBCDIC characters must be packed two characters per binary word. IBM Card Code characters are stored one character to each binary word.

Output

Output is either IBM Card Code or EBCDIC characters starting in location OUTPT. Characters are packed as described above.

If the direction of the conversion is IBM Card Code input to EBCDIC output, the input area can overlap the output area if the address INPUT is equal to or greater than the address OUTPT. If the direction of the conversion is EBCDIC input to IBM Card Code output, the input area can overlap the output area if the address INPUT+n/2 is equal to or greater than the address OUTPT+n, where n is the character count specified. The subroutine starts processing at location INPUT.

Character Count

This number specifies the number of characters to be converted; it is not equal to the number of binary words used for the EBCDIC characters because those characters are packed two per binary word. If an odd count is specified for EBCDIC output, bits 8 through 15 of the last word in the output area are not altered.

Errors Detected

Any input character not asterisked in Appendix D is an error.

SPEED

This subroutine converts IBM Card Code to EBCDIC or EBCDIC to IBM Card Code. SPEED accepts all 256 characters defined in Appendix D.

If the input is IBM Card Code, the conversion time is much faster than that of HOLEB because a different conversion method is used when all 256 EBCDIC characters are accepted. If the SPEED subroutine is called before a card reading operation is completed, the SPEED subroutine synchronizes with a CARD subroutine read operation by checking bit 15 of the word to be processed before converting the word. If bit 15 is a one, the SPEED subroutine waits in a loop until the CARD0 or CARD1 subroutine sets the bit to a zero.

Note: SPEED should not be used with READ0 or READ1 since the 2501 subroutines do not prestore 1 bits in each word of the I/O area. Use HOLEB or ZIPCO for 2501 operations.

Calling Sequence

Label	Operation	F	T	Operands & Remarks
	LIBF			SPEED CALL EBCDIC CONVERSION
	DC			/00de CONTROL PARAMETER
	DC			INPUT INPUT AREA ADDRESS
	DC			OUTPUT OUTPUT AREA ADDRESS
	DC			f CHARACTER COUNT
	.			
	.			
	.			
INPUT	BSS			g INPUT AREA
	.			
	.			
	.			
OUTPT	BSS			h OUTPUT AREA

where

d indicates whether the EBCDIC characters are packed or unpacked,

e indicates the direction of conversion, f indicates the character count,

g is the length of the input area,

h is the length of the output area,

g and h are defined as follows:

IBM Card Code to packed EBCDIC

$g \geq f$
$h \geq f/2$, or $(f+1)/2$, if f is odd.

IBM Card Code to unpacked EBCDIC

$g \geq f$
$h \geq f$

Packed EBCDIC to IBM Card Code

$g \geq f/2$, or $(f+1)/2$, if f is odd.
$h \geq f$

Unpacked EBCDIC to IBM Card Code

$g \geq f$
$h \geq f$

Control Parameter

This parameter consists of four hexadecimal digits. Digits 1 and 2 must be zero. The third digit indicates whether the EBCDIC code is packed or unpacked.

0 - Packed, two EBCDIC characters per binary word

1 - Unpacked, one EBCDIC character per binary word (left-justified)

The fourth digit indicates the direction of conversion:

0 - IBM Card Code to EBCDIC
1 - EBCDIC to IBM Card Code

Input

Input is either IBM Card Code or EBCDIC characters (as specified by the control parameter) starting in location INPUT. EBCDIC characters can be packed or unpacked. IBM Card Code characters are stored one character to each binary word.

Output

Output is EBCDIC or IBM Card Code characters starting in location OUTPT. EBCDIC characters can be packed or unpacked; IBM Card Code characters are not packed.

The input area should not overlap the output area because of restart problems that can result from card feed errors.

Character Count

This parameter specifies the number of EBCDIC or IBM Card Code characters to be converted. If the character count is odd and the output code is packed EBCDIC, bits 8 through 15 of the last word are unaltered.

Errors Detected

Any input character code not listed in Appendix D is an error. All IBM Card Code punch combinations, except multiple punches in rows 1-7, are legal.

PAPEB

This subroutine converts PTTC/8 subset to EBCDIC subset or EBCDIC subset to PTTC/8 subset. PAPEB conversion of EBCDIC to PTTC/8 with the initialize case option selected is illustrated below.

I/O Locations	Conversion Data	Bits in Core Storage 0 → 15			
INPUT	JS	1101	0001	1110	0010
OUTPT +0	UC J	0000	1110	0101	0001
+1	S DEL	0011	0010	0111	1111

Calling Sequence

Label	Operation	F	T	Operands & Remarks
	LIBF			PAPEB CALL PTTC/8 CONVERSION
	DC			/00de CONTROL PARAMETER
	DC			INPUT INPUT AREA ADDRESS
	DC			OUTPUT OUTPUT AREA ADDRESS
	DC			f CHARACTER COUNT
	.			
	.			
	.			
INPUT	BSS			g INPUT AREA
	.			
	.			
	.			
OUTPT	BSS			h OUTPUT AREA

where

d is the case initialization digit,

e indicates the direction of conversion,

f indicates the character count,

g is the length of the input area. g must be equal to or greater than f/2 or (f+1)/2, if f is odd.

h is the length of the output area. h must be equal to or greater than f/2 or (f+1)/2, if f is odd.

Control Parameter

This parameter consists of four hexadecimal digits. Digits 1 and 2 are not used. The third digit indicates whether or not the case is to be initialized before conversion begins:

0 - Initialize case
1 - Do not alter case

The fourth digit indicates the direction of conversion:

0 - PTTC/8 to EBCDIC
1 - EBCDIC to PTTC/8

Input

Input (either PTTC/8 or EBCDIC characters, as specified by the control parameter) starts in location INPUT. Characters are packed two per 16-bit computer word in both codes.

Output

Output is either EBCDIC or PTTC/8 characters starting in OUTPT. Characters in either code are in packed format. The subroutine starts processing at location INPUT.

If the output is in EBCDIC, overlap of the input and output areas is possible if the address INPUT is equal to or greater than the address OUTPT.

If the output is in PTTC/8, overlap of the input and output areas is not recommended because the number of output characters might be greater than the number of input characters.

Character Count

This parameter specifies the number of PTTC/8 or EBCDIC characters in the input area. The count must include case-shift characters even though they will not appear in the output. Because the input is packed, the character count will not be equal to the number of binary words in the input area. If an odd number of output characters is produced, bits 8-15 of the last word used in the output area are set to a space character if the output is EBCDIC, or to a delete character if the output is PTTC/8.

There is no danger of overflowing the output area if the number of words in a PTTC/8 output area is equal to the number of characters in the input area.

Errors Detected

Any input character that is not marked with an asterisk in Appendix D is an error.

Subroutine Operation

If the input is in PTTC/8 code, all control characters (except case-shift (LC or UC) characters) are converted to output. Case-shift characters only define the case mode of the graphic characters that follow.

If the initialize option is selected, the case is set to lower. All characters are interpreted as lower case characters until an upper case shift (UC) character is encountered. If the do-not-alter option is selected, the case remains set according to the last case-shift character encountered in the previous LIBF message.

If the input is in EBCDIC, all data and control characters are converted to output. The user should not specify case shifting in his input message; this is handled automatically by the PAPEB subroutine.

Case-shift characters are inserted in a PTTC/8 output message where needed to define certain graphic characters that have the same binary value and are differentiated only by a case-mode character. For example, the binary value 0101 1011 (5B), is interpreted as a $ in lower case and an ! in upper case (see Appendix D).

If the initialize option is selected, the case-shift character needed to interpret the first graphic character is inserted in the output message and the case mode is initialized for that mode. If the do-not-alter option is selected, the case mode remains set according to the last case-shift character required in the previous LIBF message, i.e., no case shift is forced.

If a case-shift character appears in the input message, it is output but does not affect the case mode. If it is an upper case shift (UC) and the next input character requires an upper case shift, the subroutine still inserts an upper case shift into the message, i.e., two UC characters will appear in the output message.

The conversion is halted when the character count is decremented to zero or when a new-line (NL) control character is read.

PAPHL

This subroutine converts PTTC/8 subset to IBM Card Code subset or IBM Card Code subset to PTTC/8 subset. The relationship of the two codes for converting PTTC/8 to IBM Card Code is illustrated below:

I/O Locations	Conversion Data	Bits in Core Storage 0 ◄——► 15			
INPUT	UC J	0000	1110	0101	0001
	S T	0011	0010	0010	0011
OUTPT	J	0101	0000	0000	0000
OUTPT +1	S	0010	1000	0000	0000
OUTPT +2	T	0010	0100	0000	0000

Calling sequence

Label	Operation	F	T	Operands & Remarks
	LIBF			PAPHL CALL IBMCC CONVERSION
	DC			/00de CONTROL PARAMETER
	DC			INPUT INPUT AREA ADDRESS
	DC			OUTPUT OUTPUT AREA ADDRESS
	DC			f CHARACTER COUNT
	.			
	.			
	.			
INPUT	BSS			g INPUT AREA
	.			
	.			
	.			
OUTPT	BSS			h OUTPUT AREA

where

d is the case initialization digit,

e indicates the direction of conversion,

f indicates the character count,

g is the length of the input area. g must be equal to or greater than f if e is 0. If e is 1, g must be equal to f/2, or (f+1)/2 if f is odd.

h is the length of the output area. If e is 0, h must be equal to or greater than f/2, or (f+1)/2, if f is odd. If e is 1, h must be equal to or greater than f.

Control Parameter

This parameter consists of four hexadecimal digits. Digits 1 and 2 are not used. The third digit indicates whether or not the case is to be initialized before conversion begins:

0 - Initialize case
1 - Do not alter case

The fourth digit indicates the type of conversion:

0 - PTTC/8 to IBM Card Code
1 - IBM Card Code to PTTC/8

Input

Input is either PTTC/8 or IBM Card Code characters (as specified by the control parameter) starting in location INPUT. PTTC/8 characters are packed two per binary word; IBM Card Code characters are not packed.

Output

Output is either IBM Card Code or PTTC/8 code characters starting in location OUTPT. PTTC/8 codes are packed two per binary word; IBM Card Code characters are not packed.

If the conversion is IBM Card Code input to PTTC/8 output, the input area may overlap the output area if the address INPUT is equal to or greater than the address OUTPT. Case-shift characters are inserted in the output message where needed to define certain graphic characters (see "PAPEB").

If the conversion is PTTC/8 input to IBM Card Code output, the input area may overlap the output area if the address INPUT+n/2 is equal to or greater than the address OUTPT+n, where n is the character count. The subroutine starts processing at location INPUT.

Character Count

This parameter specifies the number of PTTC/8 or EBCDIC characters in the input area. The count must include case-shift characters, even though they will not appear in the output. Because the input may be packed, the character count may not be equal to the number of binary words in the input area.

There is no danger of overflowing the output area if the number of words in the output area is equal to the number of characters in the input area.

Errors Detected

Any input character not marked by an asterisk in Appendix D is an error.

Subroutine Operation

Case- and shift-character handling is described under "PAPEB".

If an odd number of PTTC/8 output characters is produced, bits 8-15 of the last used word in the output area are set to a delete character.

The conversion is halted when the character count is decremented to zero or when a new-line (NL) control character is read.

PAPPR

This subroutine converts PTTC/8 subset to either Console Printer or 1403 Printer code. The conversion to 1403 Printer code is illustrated below:

I/O Locations	Conversion Data		Bits in Core Storage 0 → 15
INPUT	UC	J	0000 1110 0101 0001
INPUT+1	LC	$	0110 1110 0101 1011
OUTPT	J	$	0101 1000 0110 0010

Calling Sequence

Label (21–25)	Operation (27–30)	F (32)	T (33)	Operands & Remarks (35–)	
	LIBF			PAPPR	CALL PTTC/8 CONVERSION
	DC			/ØØde	CONTROL PARAMETER
	DC			INPUT	INPUT AREA ADDRESS
	DC			OUTPT	OUTPUT AREA ADDRESS
	DC			f	CHARACTER COUNT
	.				
	.				
	.				
INPUT	BSS			g	INPUT AREA
	.				
	.				
	.				
OUTPT	BSS			h	OUTPUT AREA

where

d is the case initialization digit,

e is the output printer code digit,

f is the number of characters in the input area to be converted,

g is the length of the input area. g must be equal to or greater than f/2 if the character count is even, (f+1)/2 if the character count is odd.

h is the length of the output area. h must be equal to or greater than f/2, minus the number of paper tape control characters in the input area, plus 1 if the result is odd.

Control Parameter

This parameter consists of four hexadecimal digits. Digits 1 and 2 are not used. The third digit indicates whether or not the case is to be initialized before conversion begins:

0 - Initialize case
1 - Do not alter case

The fourth digit determines the output printer code.

0 - Console Printer code
1 - 1403 Printer code

Input

Input consists of PTTC/8 characters starting in location INPUT. PTTC/8 characters are packed two per binary word. All control characters except case-shift (LC or UC) characters are converted to output. Case-shift characters are used only to define the case mode of the graphic characters that follow.

Output

Output consists of either Console Printer or 1403 Printer characters starting in location OUTPT. This code is packed two characters per binary word. If overlap of the input and output areas is desired, the address INPUT must be equal to or greater than the address OUTPT. This is necessary because the subroutine starts processing at location INPUT.

Character Count

This parameter specifies the number of PTTC/8 characters in the input area. The count must include case-shift characters, even though they do not appear in the output. Because the input is packed, the character count is not equal to the number of binary words in the input area.

If an odd number of output characters is produced, bits 8-15 of the last used word in the output area are set to a space character.

The conversion is halted when the character count is decremented to zero or when a new-line (NL) control character is read.

Errors Detected

Any input character not marked by an asterisk in Appendix D is an error.

HOLPR

This subroutine converts IBM Card Code subset to either Console Printer or 1403 Printer code. The conversion to 1403 Printer code is illustrated below.

I/O Locations	Conversion Data	Bits in Core Storage 0 ⟶ 15
INPUT	J	0101 0000 0000 0000
INPUT+1	,	0010 0100 0010 0000
OUTPT	J,	0101 1000 0001 0110

Calling Sequence

```
        LIBF    HOLPR     CALL CARD CODE CONVERSION
        DC      /000e     CONTROL PARAMETER
        DC      INPUT     INPUT AREA ADDRESS
        DC      OUTPT     OUTPUT AREA ADDRESS
        DC      f         CHARACTER COUNT
        .
        .
        .
INPUT   BSS     g         INPUT AREA
        .
        .
        .
OUTPT   BSS     h         OUTPUT AREA
```

where

e is the output printer code digit,

f is the number of characters in the input area to be converted,

g is the length of the input area. g must be equal to or greater than f.

h is the length of the output area. h must be equal to or greater than f/2.

Control Parameter

This parameter consists of four hexadecimal digits. Digits 1-3 are not used. The fourth digit determines the output printer code.

0 - Console Printer code
1 - 1403 Printer code

Input

Input consists of IBM Card Code characters, starting in location INPUT. The characters are not packed.

Output

Output consists of either Console Printer or 1403 Printer characters, starting in location OUTPT. The code is packed two characters per binary word.

The input area may overlap the output area if the address INPUT is equal to or greater than the address OUTPT. The subroutine starts processing at location INPUT.

Character Count

This number specifies the number of IBM Card Code characters to be converted and is equal to the number of words in the input area. If an odd count is specified, bits 8-15 of the last word used in the output area are not altered.

Errors Detected

Any input character not marked with an asterisk in Appendix D is an error.

EBPRT

This subroutine converts EBCDIC subset to either Console Printer or 1403 Printer Code. The conversion to 1403 Printer code is shown below.

I/O Locations	Conversion Data	Core Storage Bits 0 ◄── ──► 15
INPUT	LE	1101 0011 1100 0101
INPUT + 1	ES	1100 0101 1110 0010
OUTPUT	LE	0001 1010 0110 1000
OUTPT + 1	ES	0110 1000 0000 1101

Calling Sequence

```
Label   Operation  F T  Operands & Remarks
        LIBF            EBPRT         CALL EBCDIC CONVERSION
        DC              /ØØØe         CONTROL PARAMETER
        DC              INPUT         INPUT AREA ADDRESS
        DC              OUTPT         OUTPUT AREA ADDRESS
        DC              f             CHARACTER COUNT
        .
        .
        .
INPUT   BSS             g             INPUT AREA
        .
        .
        .
OUTPT   BSS             h             OUTPUT AREA
```

where

e is the output printer code digit,

f is the number of characters in the input area to be converted,

g is the length of the input area. g must be equal to or greater than f/2.

h is the length of the output area. h must be equal to or greater than f/2.

Control Parameter

This parameter consists of four hexadecimal digits. Digits 1-3 are not used. The fourth digit determines the output printer code.

0 - Console Printer code
1 - 1403 Printer code

Input

Input consists of EBCDIC characters starting in location INPUT. EBCDIC characters are packed two per word.

Output

Output consists of either Console Printer or 1403 Printer code starting in location OUTPT. The code is packed two characters per binary word.

The address INPUT must be equal to or greater than the address OUTPT if overlap of the input and output areas is desired. The subroutine starts processing at location INPUT.

Character Count

This parameter specifies the number of EBCDIC characters to be converted. This count is not equal to the number of words in the input area. If an odd count is specified, bits 8-15 of the last word used in the output area are not altered; however, these bits may cause print checks if they comprise an illegal character.

Errors Detected

Any input character not marked with an asterisk in Appendix D is an error.

BIDEC

This subroutine converts a 32-bit binary value to its decimal equivalent in ten IBM Card Code numeric characters and one sign character. The conversion is illustrated below:

I/O Locations	Conversion Data	Core Storage Bits 0 ⟶ 15
Accumulator	+0016777218	0000 0001 0000 0000
Extension		0000 0000 0000 0010

I/O Locations	Conversion Data	Core Storage Bits 0 ⟶ 15
OUTPT	+	1000 0000 1010 0000
OUTPT + 1	0	0010 0000 0000 0000
OUTPT + 2	0	0010 0000 0000 0000
OUTPT + 3	1	0001 0000 0000 0000
OUTPT + 4	6	0000 0000 1000 0000
OUTPT + 5	7	0000 0000 0100 0000
OUTPT + 6	7	0000 0000 0100 0000
OUTPT + 7	7	0000 0000 0100 0000
OUTPT + 8	2	0000 1000 0000 0000
OUTPT + 9	1	0001 0000 0000 0000
OUTPT + 10	8	0000 0000 0010 0000

Calling Sequence

Label	Operation	F	T	Operands & Remarks
	LIBF			BIDEC CALL BINARY CONVERSION
	DC			OUTPUT OUTPUT AREA ADDRESS
	.			
	.			
	.			
OUTPT	BSS			11 OUTPUT AREA

Input

Input is a 32-bit binary value in the Accumulator and Extension.

Output

Output is an IBM Card Code sign character (+ or -) in location OUTPT, and ten IBM Card Code numeric characters in OUTPT+1 through OUTPT+10.

Errors Detected

The BIDEC subroutine does not detect errors.

DECBI

This subroutine converts a decimal value consisting of ten IBM Card Code numeric characters and a sign character to a 32-bit binary word. This subroutine is the opposite of the BIDEC subroutine (see above) except that fewer than ten characters may be specified.

Calling Sequence

Label	Operation	F	T	Operands & Remarks
	LIBF			DECBI CALL DECIMAL CONVERSION
	DC			INPUT INPUT AREA ADDRESS
	DC			WDCNT WORD COUNT ADDRESS
	•			
	•			
	•			
WDCNT	DC			a WORD COUNT
	•			
	•			
	•			
INPUT	BSS			b INPUT AREA

where

a is the number of characters to be converted not including the sign character,

b is the length of the input area. b must be equal to at least a plus 1.

Input

Input is an IBM Card Code sign character in location INPUT, the address (WDCNT) of the number of characters (1 to 10) to be converted, and specified number of characters in IBM Card Code in locations INPUT+1 through INPUT+N (where N = 1, 2,...10).

Output

Output is a 32-bit binary word, containing the converted value, in the Accumulator and Extension.

Errors Detected

Any of the following conditions causes the Overflow indicator to be turned on, the Carry indicator to be turned off, and an immediate exit to be made back to the caller:

1. Any sign other than a plus, minus, blank, or ampersand.

2. Any character other than a space or 0 through 9.

3. Any converted value greater than +2,147,483,647 or less than -2,147,483,648.

ZIPCO

This subroutine supplements all standard conversions except those involving PTTC/8 code. It offers the user the option of supplying his own conversion tables and codes. ZIPCO uses direct table access and is considerably faster than the other conversion subroutines.

Calling Sequence

Label	Operation	F	T	Operands & Remarks
	LIBF			ZIPCO CALL SPECIAL CONVERSION
	DC			/bcde CONTROL PARAMETER
	DC			INPUT INPUT AREA ADDRESS
	DC			OUTPT OUTPUT AREA ADDRESS
	DC			f CHARACTER COUNT
	CALL			i
	•			
	•			
	•			
INPUT	BSS			g INPUT AREA
	•			
	•			
	•			
OUTPT	BSS			h OUTPUT AREA

where

b is the input code digit,

c is the packed input digit,

d is the output code digit,

e is the packed output digit,

f is the number of characters to be converted,

g is the length of the input area,

h is the length of the output area,

j is the name of the conversion table to be used. This CALL is not executed; however, it is required following the character count parameter to cause the loading of the desired conversion table, provide the address of that table to ZIPCO, and provide information required by ZIPCO for the return to the calling program.

Control Parameter

This parameter consists of four hexadecimal digits as follows:

Digit 1	1 for 12-bit IBM Card Code input 0 for all other types of input
Digit 2	1 for unpacked input 0 for packed input
Digit 3	1 for 12-bit IBM Card Code output 0 for 8-bit IBM Card Code and all other types of output
Digit 4	1 for unpacked output 0 for packed output

Input

Input consists of packed or unpacked characters in the code specified by the conversion table and starting at location INPUT.

Output

Output consists of packed or unpacked characters in the code specified by the conversion table and starting at location OUTPT.

Character Count

This parameter specifies the number of input characters to be converted. If an odd count is specified with packed input, bits 8-15 of the last word used in the output area are not altered.

Table

The type of conversion is determined by the table called with ZIPCO. The user may call one of the IBM-supplied conversion tables or he may supply his own.

The following IBM-supplied System Library tables may be called with ZIPCO.

EBCCP - EBCDIC to Console Printer Code.
EBHOL - EBCDIC to IBM Card Code.
EBPT3 - EBCDIC to 1403 Printer code.
CPEBC - Console Printer code to EBCDIC.
CPHOL - Console Printer code to IBM Card Code.
CPPT3 - Console Printer code to 1403 Printer code.
HLEBC - IBM Card Code to EBCDIC.
HOLCP - IBM Card Code to Console Printer code.
HLPT3 - IBM Card Code to 1403 Printer code.
PT3EB - 1403 Printer code to EBCDIC.
PT3CP - 1403 Printer code to Console Printer Code.
PTHOL - 1403 Printer code to IBM Card Code.

Each conversion table consists of 256 characters-- 128 words with two 8-bit characters per word. The seven low-order bits of the character to be converted (input character) are used as an address. The address designates the position in the table of the corresponding conversion character. The high-order bit (bit 0) of the input character designates which half of the table word is to be used. When bit 0 is 1, the left half of the word is used. When bit 0 is 0, the right half of the word is used. All dummy entries of the IBM-supplied tables contain the code for a blank.

The following is an example of the conversion performed by ZIPCO. The tables show (1) the input EBCDIC values, (2) the table EBPT3 used for the conversion, and (3) the output characters in 1403 Printer code.

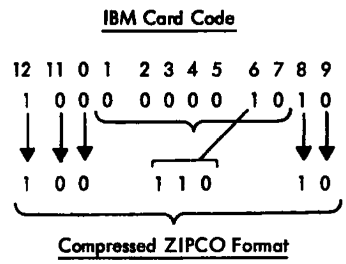
Input Location	Value
INPUT	1111 0010 0111 0010
INPUT+1	0000 0000 1000 0000
INPUT+2	0111 1111 1111 1111

Table Location	Value
EBPT3	0111 1111 0111 1111
EBPT3+1	0111 1111 0111 1111
.	.
.	.
.	.
EBPT3+114	0000 0001 0111 1111
.	.
.	.
.	.
EBPT3+127	0111 1111 0111 1111

Output Location	Value	1403 Print Character
OUTPT	0000 0001 0111 1111	2, b
OUTPT+1	0111 1111 0111 1111	b, b
OUTPT+2	0111 1111 0111 1111	b, b

When 12-bit IBM Card Code is specified as input (or output), ZIPCO performs a packing (or unpacking) of the character to 8-bits (or 12 bits). The 1-7 row punches on the card are expressed as a 3-bit hexadecimal number (there can never be more than one punch between the 1 and 7 row). In this format a 1 punch would be expressed as 001, a 7 punch as 111. The punches in the other card rows: 12, 11, 0, 8, and 9, are transferred directly.

For example, take the IBM Card Code character "+" which is a 12, 6, 8 punch.



1 0 0 1 1 0 1 0

Errors Detected

No errors are detected by ZIPCO.

Figure 20.1 is a sample of the System Library table EBPT3 (EBCDIC to 1403 Printer code) which may be called with ZIPCO.

```
EBCDIC TO 1403 CONV TABLE FOR ZIPCO                                  SOURCE

ADDR REL OBJECT  ST.NO.   LABEL OPCD FT OPERANDS

0000     050978F3  0020          ENT      EBPT3
0000 0  7F7F       0021   EBPT3  DC       /7F7F       NO GRAPHIC     NUL
0001 0  7F7F       0022          DC       /7F7F       NO GRAPHIC     NO GRAPHIC
0002 0  7F7F       0023          DC       /7F7F       NO GRAPHIC     NO GRAPHIC
0003 0  7F7F       0024          DC       /7F7F       NO GRAPHIC     NO GRAPHIC
0004 0  7F7F       0025          DC       /7F7F       NO GRAPHIC     PF
0005 0  7F7F       0026          DC       /7F7F       NO GRAPHIC     HT
0006 0  7F7F       0027          DC       /7F7F       NO GRAPHIC     LC
0007 0  7F7F       0028          DC       /7F7F       NO GRAPHIC     DEL
0008 0  7F7F       0029          DC       /7F7F       NO GRAPHIC     NO GRAPHIC
  :      :          :             :         :          :              :

0072 0  017F       0135          DC       /017F       2              NO GRAPHIC
0073 0  027F       0136          DC       /027F       3              NO GRAPHIC
0074 0  437F       0137          DC       /437F       4              NO GRAPHIC
0075 0  047F       0138          DC       /047F       5              NO GRAPHIC
0076 0  457F       0139          DC       /457F       6              NO GRAPHIC
0077 0  467F       0140          DC       /467F       7              NO GRAPHIC
0078 0  077F       0141          DC       /077F       8              NO GRAPHIC
0079 0  087F       0142          DC       /087F       9              '
007A 0  7F7F       0143          DC       /7F7F       NO GRAPHIC     NO GRAPHIC
007B 0  7F7F       0144          DC       /7F7F       NO GRAPHIC     NO GRAPHIC
007C 0  7F7F       0145          DC       /7F7F       NO GRAPHIC     NO GRAPHIC
007D 0  7F08       0146          DC       /7F08       NO GRAPHIC     '
007E 0  7F4A       0147          DC       /7F4A       NO GRAPHIC     #
007F 0  7F7F       0148          DC       /7F7F       NO GRAPHIC     NO GRAPHIC
0080               0149          END
```

Figure 20.1 System Library EBPT3

Arithmetic and Functional Subroutines

The IBM 1130 Subroutine System Library includes the arithmetic and functional subroutines that are the most frequently required because of their general applicability. There are 44 subroutines, some of which have several entry points.

Figure 21 lists the arithmetic and functional subroutines that are included in the Subroutine System Library

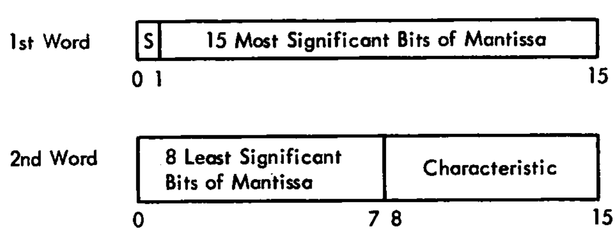
REAL DATA FORMATS

Many of the IBM 1130 arithmetic and functional subroutines offer two ranges of precision: standard and extended. The standard precision provides 23 significant bits, and the extended precision provides up to 31 significant bits. The magnitude of a real number must not be greater than 2^{127} or less than 2^{-128} (approximately 10^{38} and 10^{-39}).

To achieve correct results from a particular subroutine, the input arguments must be in the proper format.

Standard-Precision Format

Standard-precision real numbers are stored in core storage as shown below:

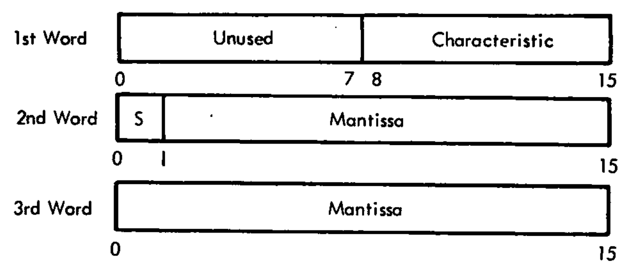


Numbers can consist of up to 23 significant bits (mantissa) with a binary exponent ranging from -128 to +127. Two adjacent storage locations are required for each number. The first (lowest) location must be even-numbered. The sign of the mantissa is in bit zero of the first word. The next 23 bits represent the mantissa (2's complement if the number is negative) and the remaining 8 bits represent the characteristic. The mantissa is normalized to fractional form, i.e., the implied binary point is between bits zero and one.

The characteristic is formed by adding +128 to the exponent. For example, an exponent of -32 is represented by a characteristic of 128-32, or 96. An exponent of +100 is represented by a characteristic of 100 + 128, or 228. Since 128_{10}=/80 the characteristic of a nonnegative exponent always has a 1-bit in position 1, while the characteristic of a negative exponent always produces a 0-bit in position 1. A normal zero consists of all zero bits in both the characteristic and the mantissa.

Extended-Precision Format

Extended-precision real numbers are stored in three adjacent core locations as shown below:



Numbers can consists of up to 31 significant bits with a binary exponent ranging from -128 to +127; however, normalization can, in some cases, cause the loss of 1 bit of significance.

Bits zero through seven of the first word are unused; bits eight through 15 of the first word represent the characteristic of the exponent (formed in the same manner as in the standard range format); bit zero of the second word contains the sign of the mantissa; and the remaining 31 bits represent the mantissa (2's complement if the number is negative).

Real Negative Number Representation

Real negative numbers differ from real positive numbers in only one respect; the mantissa is always the 2's complement of the equivalent positive value.

Example:

+.53125 is represented in core as 44000080

-.53125 is represented in core as BC000080

+4.0 is represented in core as 40000083

-4.0 is represented in core as C0000083

Note that a real negative number is never represented by a value of 800000xx, where xx is any characteristic between 00 and FF. The mantissa value of 800000 is its own 2's complement and therefore lies outside the definition of a real negative number, i.e., the 2's complement of its absolute value.

Fixed-Point Format

Fractional numbers, as applied to the fixed-point subroutines, XSQR, XMDS, XMD, and XDD, are defined as binary fractions with implied binary points of zero. That is, the binary point is positioned between the sign (bit 0) and the most significant bit (bit 1).

The user can consider the binary point to be in any position in his fixed-point numbers. To correctly interpret the results the following rules must be observed:

1. Only numbers with binary points in equivalent positions can be correctly added or subtracted.

2. The binary point location in the product of two numbers is the sum of the binary point locations of the multiplier and the multiplicand.

3. The binary point location in the quotient of two numbers is the difference between the binary point locations of the dividend and the divisor.

4. The binary point location in a number that is input to the fixed-point square root subroutine (XSQR) must be an even number from 0-14. The binary point location in the output root is half the binary point location of the input number.

REAL NUMBER PSEUDO ACCUMULATOR

IBM 1130 real number subroutines sometimes require an accumulator that can accommodate numbers in real number format. Since all of the 1130 registers are only 16 bits in length, a pseudo accumulator must be set up to contain two- or three-word real numbers. The pseudo accumulator (designated FAC for floating accumulator) is a three-word register occupying the three highest locations of the Transfer Vector (see IBM 1130/1800 Assembler Language). The user can refer to these words by using Index Register 3 plus a fixed displacement (XR3+125, 126, or 127). The format of the FAC is shown below.

Characteristic	Mantissa	Mantissa
XR3 + 125	XR3 + 126	XR3 + 127

FAC

The effective address of the mantissa is always even. The eight rightmost bits of the FAC are zero when using standard precision.

Note: Arithmetic and functional subroutines do not save and restore the contents of the 1130 Accumulator or the Extension. The calling program should provide for this if the contents are significant. When execution of the user's program begins, all three words of FAC contain zeros. Results of arithmetic and functional subroutines are truncated.

CALLING SEQUENCES

The arithmetic and functional subroutines are called via a CALL or LIBF statement (whichever is required) followed, in some cases, by a DC statement containing the actual or symbolic address of an argument. In the descriptions that follow, the notations (ARG) and (FAC) refer to the contents of the operand rather than its address. The name FAC refers to the real number pseudo accumulator. The extended-precision subroutine names are prefixed with the letter E (subroutines that handle both precisions have the same name and do not have a prefix).

SUBROUTINE	NAME	
Real (Floating Point)	Standard Precision	Extended Precision
Add/Subtract	*FADD/*FSUB	*EADD/*ESUB
Multiply	*FMPY	*EMPY
Divide	*FDIV	*EDIV
Load/Store FAC	*FLD/*FSTO	*ELD/*ESTO
Trigonometric Sine/Cosine	FSINE/FCOSN, FSIN/FCOS	ESINE/ECOSN, ESIN/ECOS
Trigonometric Arctangent	FATN, FATAN	EATN, EATAN
Square Root	FSQR, FSQRT	ESQR, ESQRT
Natural Logarithm	FLN, FALOG	ELN, EALOG
Exponential (e)	FXPN, FEXP	EXPN, EEXP
Hyperbolic Tangent	FTNH/FTANH	ETNH/ETANH
Real Base to an Integer Exponent	*FAXI	*EAXI
Real Base to a Real Exponent	*FAXB	*EAXB
Real to Integer	IFIX	IFIX
Integer to Real	FLOAT	FLOAT
Normalize	NORM	NORM
Real Binary to Decimal/Real Decimal to Binary	FBTD/FDTB	FBTD/FDTB
Real Arithmetic Range Check	FARC	FARC
Fixed-Point		
Integer Base to an Integer Exponent	*FIXI	*FIXI
Fixed-Point Square Root	XSQR	XSQR
Fixed-Point Fractional Multiply (short)	XMDS	
Fixed-Point Double Word Multiply	XMD	XMD
Fixed-Point Double Word Divide	XDD	XDD
Special Function		
Real Reverse Subtract	*FSBR	*ESBR
Real Reverse Divide	*FDVR	*EDVR
Real Reverse Sign	SNR	SNR
Real Absolute Value	FAVL, FABS	EAVL, EABS
Integer Absolute Value	IABS	IABS
Miscellaneous		
Get Parameters	FGETP	EGETP

Note: By adding an X to those names prefixed with an asterisk, the user can cause the contents of Index Register 1 to be added to the address of the argument specified in the subroutine calling sequence to form the effective argument address. For example, FADDX would be the modified form of FADD.

Figure 21. Arithmetic and Functional Subroutines

Note also that some of the functional subroutines can be called via two different calling sequences. One calling sequence assumes the argument is in FAC; the other specifies the location of the argument with a DC statement.

In addition, some subroutines can have indexed linkage to the argument. The calling sequence is the same except for the subroutine name which contains an X suffix. Also, some subroutines perform more than one type of arithmetic or function. For example, FSIN and FCOS are different entry points to the same subroutine. Each subroutine is listed in Figure 21 with the corresponding entry points.

Real Add

```
LIBF     FADD, FADDX, EADD or EADDX
DC       ARG
Input    Real augend in FAC
         Real addend in location ARG
Result   (FAC) + (ARG) replaces (FAC)
```

Real Subtract

```
LIBF     FSUB, FSUBX, ESUB or ESUBX
DC       ARG
```

Input	Real minuend in FAC
	Real subtrahend in location ARG
Result	(FAC) - (ARG) replaces (FAC)

Real Multiply

LIBF	FMPY, FMPYX, EMPY or EMPYX
DC	ARG
Input	Real multiplicand in FAC
	Real multiplier in location ARG
Result	(FAC) times (ARG) replaces (FAC)

Real Divide

LIBF	FDIV, FDIVX, EDIV or EDIVX
DC	ARG
Input	Real dividend in FAC
	Real divisor in location ARG
Result	(FAC) / (ARG) replaces (FAC)

Note: On a divide by zero, the divide check indicator is turned on, the dividend is not changed, and the dividend remains in FAC.

Load FAC

LIBF	FLD, FLDX, ELD or ELDX
DC	ARG
Input	Real number in location ARG
Result	(ARG) replaces (FAC)

Store FAC

LIBF	FSTO, FSTOX, ESTO or ESTOX
DC	ARG
Input	Real number in FAC
Result	(FAC) replaces (ARG)

Real Trigonometric Sine

CALL	FSINE or ESINE
Input	Real argument (in radians) in FAC
Result	Sine of (FAC) replaces (FAC)
	or
CALL	FSIN or ESIN
DC	ARG
Input	Real argument (in radians) in location ARG
Result	Sine of (ARG) replaces (FAC)

Real Trigonometric Cosine

CALL	FCOSN or ECOSN
Input	Real argument (in radians) in FAC
Result	Cosine of (FAC) replaces (FAC)
	or
CALL	FCOS or ECOS
DC	ARG
Input	Real argument (in radians) in location ARG
Result	Cosine of (ARG) replaces (FAC)

Real Trigonometric Arctangent

CALL	FATN or EATN
DC	ARG
Input	Real argument in FAC
Result	Arctangent of (FAC) replaces (FAC); the result lies within the range $\pm\frac{\pi}{2}$ radians (±90 degrees)
	or
CALL	FATAN or EATAN
DC	ARG
Input	Real argument in location ARG
Result	Arctangent of (ARG) replaces (FAC); the result lies within the range $\pm\frac{\pi}{2}$ radians (±90 degrees)

Real Square Root

CALL	FSQR or ESQR
Input	Real argument in FAC
Result	Square root of (FAC) replaces (FAC)
	or
CALL	FSQRT or ESQRT
DC	ARG
Input	Real argument in location ARG
Result	Square root of (ARG) replaces (FAC)

Real Natural Logarithm

CALL	FLN or ELN
Input	Real argument in FAC
Result	Log_e (FAC) replaces (FAC)
	or
CALL	FALOG or EALOG
DC	ARG
Input	Real argument in location ARG
Result	Log_n (ARG) replaces (FAC)

Real Exponential

CALL	FXPN or EXPN
Input	Real argument in FAC = n
Result	e^n replaces (FAC)
	or
CALL	FEXP or EEXP
DC	ARG
Input	Real argument in location ARG = n
Result	e^n replaces (FAC)

Real Hyperbolic Tangent

CALL	FTNH or ETNH
Input	Real argument in FAC
Result	TANH (FAC) replaces (FAC)
	or
CALL	FTANH or ETANH
DC	ARG

Input Real argument in location ARG
Result TANH (ARG) replaces (FAC)

Real Base to an Integer Exponent

LIBF FAXI, FAXIX, EAXI, or EAXIX
DC ARG
Input Real base in FAC
Integer exponent in location ARG
Result (FAC) raised to the exponent (ARG) replaces (FAC)

Real Base to a Real Exponent

CALL FAXB, FAXBX, EAXB or EAXBX
DC ARG
Input Real base in FAC
Real exponent in location ARG
Result (FAC) raised to the exponent (ARG) replaces (FAC)

Real to Integer

LIBF IFIX
Input Real number in FAC
Result Integer in the Accumulator

Integer to Real

LIBF FLOAT
Input Integer in the Accumulator
Result Real number in FAC

Normalize

LIBF NORM
Input Real unnormalized number in FAC
Result The mantissa portion of FAC is shifted until the most significant bit resides in bit position 1. The characteristic is changed to reflect the number of bit positions shifted.

Real Binary to Decimal

CALL FBTD
DC LDEC
Input Real number in FAC
Result A string of EBCDIC-coded data starting at location LDEC. Each EBCDIC character occupies the rightmost 8 bits of a word. The last character of the string is a blank.

The output format is exactly as follows:

sd.ddddddddEsddb

where:

s represents a sign (plus or minus)
d represents one of the decimal digits 0-9
b represents a blank

Real Decimal to Binary

CALL FDTB
DC LDEC
Input A string of EBCDIC coded data at location LDEC. Each EBCDIC character occupies the rightmost 8 bits of a word. The leftmost 8 bits must be zeros. The first character of the input must be the sign (plus or minus). Following the sign, one to nine decimal digits (0-9) may be specified. The decimal point may appear before, within, or after the decimal digits. Immediately after the last decimal digit (or decimal point), the exponent is specified as follows.

Esddb

where:

s represents the sign of the exponent (plus or minus)
d represents one of the decimal digits (0-9)
b represents a blank (the blank is required to indicate the end of the string)

No embedded blanks may appear in the input string as the first blank is interpreted as the end of the data.
Result Real number in FAC

Real Arithmetic Range Check

LIBF FARC
Result This subroutine checks for real number overflow or underflow, and sets programmed indicators for interrogation by a FORTRAN program.

Integer Base to an Integer Exponent

LIBF FIXI or FIXIX
DC ARG
Input Integer base in the Accumulator
Integer exponent in location ARG
Result (Accumulator) raised to the exponent contained in ARG replaces (Accumulator)

Fixed-Point Square Root

CALL XSQR
Input Fixed-point fractional argument (16 bits only) in the Accumulator.
Result Square root of (Accumulator) replaces (Accumulator). If the argument is negative the absolute value is used and the Overflow indicator is turned ON.

Fixed-Point Doubleword Multiply

LIBF	XMD
Input	Doubleword fractional multiplier in FAC (addressed by XR3 + 126) Doubleword fractional multiplicand in the Accumulator and Extension
Result	Doubleword fractional product in the Accumulator and Extension

Fixed-Point Fractional Multiply

LIBF	XMDS
Input	Doubleword fractional multiplier in the Accumulator and Extension Doubleword fractional multiplicand in FAC (addressed by XR3 + 126)
Result	Product in the Accumulator and Extension (XMDS is shorter and faster than XMD; however, the resulting precision is 24 bits).

Fixed-Point Doubleword Divide

LIBF	XDD
Input	Doubleword fractional dividend in FAC (addressed by XR3 + 126) Doubleword fractional divisor in Accumulator and Extension
Result	Doubleword fractional quotient in the Accumulator and Extension. The double dividend in FAC is destroyed by the execution of the subroutine.

Real Reverse Subtract

LIBF	FSBR, FSBRX, ESBR or ESBRX
DC	ARG
Input	Real minuend in location ARG Real subtrahend in FAC
Result	(ARG) - (FAC) replaces (FAC)

Real Reverse Divide

LIBF	FDVR, FDVRX, EDVR or EDVRX
DC	ARG
Input	Real dividend in location ARG Real divisor in FAC
Result	(ARG) / (FAC) replaces (FAC)

Note: On a divide by zero, the divide check indicator is turned on, the dividend is not changed, and the dividend remains in FAC.

Real Reverse Sign

LIBF	SNR
Input	Real number in FAC
Result	-(FAC) replaces (FAC)

Real Absolute Value

CALL	FAVL or EAVL
Input	Real number in FAC
Result	Absolute value of (FAC) replaces (FAC)

or

CALL	FABS or EABS
DC	ARG
Input	Real number in location ARG
Result	Absolute value of (ARG) replaces (FAC)

Integer Absolute Value

CALL	IABS
DC	ARG
Input	An integer in ARG
Result	Absolute value of (ARG) replaces (Accumulator)

Get Parameters (FGETP or EGETP)

Example:

```
MAIN    CALL    SUBR
        DC      ARG
NEXT    etc.
 .       .       .
 .       .       .
 .       .       .
SUBR    DC      0
        LIBF    FGETP or EGETP
SUBEX   DC      0
        etc.
 .       .       .
 .       .       .
 .       .       .
 .       .       .
        BSC I SUBEX
```

The FGETP subroutine performs two functions for a subroutine accessed by a CALL statement. It loads FAC with the contents of ARG; it sets SUBEX to return to NEXT in the calling program.

ARITHMETIC AND FUNCTIONAL SUBROUTINE ERROR INDICATORS

The highest three-word entry in the Transfer Vector is reserved for the real number pseudo accumulator (FAC). The next to highest three-word entry is reserved for the arithmetic and functional subroutine error indicators.

The first word (addressed XR3 + 122) of the second entry is used for real number arithmetic overflow and underflow indicators. The second word (XR3 + 123) is used for a divide check indicator, and the third word (XR3 + 124) is used for functional subroutine indicators. When execution begins, all three words contain zeros.

Word One

Each real number subroutine checks for exponent underflow and overflow. If either occurs, word one and FAC are set as follows.

1. if overflow has occurred (FAC = ± maximum), word one is set to 1.
2. if underflow has occurred (FAC = zero), word one is set to 3.

Word Two

The real number divide subroutines check for division by zero. If this occurs, word two is set to 1. The dividend is not changed and remains in FAC.

Word Three

The functional subroutines check for the following error conditions and set word three as described. All error conditions detected by the functional subroutines are indicated in word three.

Real Natural Logarithm. When the argument is zero, FAC is set to the largest negative value and a bit is moved into position 15 of word three with an OR instruction. When the argument is negative, the absolute value of the argument is used and a bit is moved into position 15 of word three with an OR instruction.

Real Trigonometric Sine and Cosine. When the absolute value of the argument is equal to or greater than 2^{24}, FAC is set to zero and a bit is moved into position 14 of word three with an OR instruction.

Real Square Root. When the argument is negative, the square root of the argument's absolute value is returned, and a bit is moved into position 13 of word three with an OR instruction.

Real to Integer. When the absolute value of the argument is greater than $2^{15}-1$, the largest possible signed result is placed in the accumulator and a bit is moved into position 12 of word three with an OR instruction.

Integer Base to an Integer Exponent. When the base is zero and the exponent is zero or negative, a zero result is returned and a bit is moved into position 11 of word three with an OR instruction.

Real Base to an Integer Exponent. When the base is zero and the exponent is zero or negative, a zero result is returned and a bit is moved into position 10 of word three with an OR instruction.

Real Base Raised to a Real Exponent. When the base is zero and the exponent is zero or negative, a zero result is returned and a bit is moved into position 9 of word three with an OR instruction. When the base is negative and the exponent is not zero, the absolute value of the base is used and a bit is moved into position 15 of word three with an OR instruction.

End of File (DM2 System Only). When the end-of-file record in the unformatted I/O area is read, a bit is moved into position 2 of word three with an OR instruction.

Functional Subroutine Accuracy

Given:

$e \equiv$ Maximum error
$f(x) \equiv$ True value of the function
$f^*(x) \equiv$ Value generated by subroutine
$(<+\infty) \equiv$ ≤Largest valid real number
$(>-\infty) \equiv$ ≥Most negative real number

EXTENDED PRECISION SUBROUTINES

The following statements of accuracy apply to extended precision subroutines.

ESIN

$$e \equiv \left| \frac{\sin(x) - \sin^*(x)}{x} \right| < 3.0 \times 10^{-9}$$

for the range

$$-1.0 \times 10^6 \leq x < 0$$

$$1.0 \times 10^6 \geq x > 0$$

for $x = 0$ $\sin(x) \equiv 0$

ECOS

$$e \equiv \left| \frac{\cos(x) - \cos^*(x)}{|x| + \frac{\pi}{2}} \right| < 3.0 \times 10^{-9}$$

for the range

$$-1.0 \times 10^6 \leq x \leq 1.0 \times 10^6$$

EATAN

$$e \equiv \left| \frac{\text{atn}(x) - \text{atn}^*(x)}{\text{atn}(x)} \right| < 2.0 \times 10^{-9}$$

for the range

$$-3.88336148 \times 10^{37} \leq x \leq 3.88336148 \times 10^{37}$$

EEXP

$$e \equiv \left| \frac{e^x - (e^x)^*}{e^x} \right| < \left\{ \begin{matrix} 2.0 \times 10^{-9} \; |x| \\ \text{or} \\ 2.0 \times 10^{-9} \end{matrix} \right\} \begin{matrix} \text{whichever} \\ \text{is} \\ \text{greater} \end{matrix}$$

for the range

$$-\ln(\infty) < x < \ln(\infty)$$

i.e., $0 < e^x < \infty$

ELN

$$e \equiv \left| \frac{\ln(x) - \ln^*(x)}{\ln(x)} \right| < 3.0 \times 10^{-9}$$

for the range

$$0 < x < \infty$$

ETANH

$$e \equiv \left|\tanh(x) - \tanh^*(x)\right| < 3.0 \times 10^{-9}$$

for the range

$$-\infty < x < \infty$$

ESQRT

$$e \equiv \left|\frac{\sqrt{x} - \sqrt{x}^*}{\sqrt{x}}\right| < 1.0 \times 10^{-9}$$

for the range

$$0 < x < \infty$$

STANDARD PRECISION SUBROUTINES

The following statements of accuracy apply to the standard precision subroutines.

FSIN

$$e \equiv \left|\frac{\sin(x) - \sin^*(x)}{x}\right| < 2.5 \times 10^{-7}$$

for the range

$$-1.0 \times 10^{6} \le x < 0$$

$$1.0 \times 10^{6} \ge x > 0$$

for $x = 0$ $\sin(x) \equiv 0$

FCOS

$$e \equiv \left|\frac{\cos(x) - \cos^*(x)}{|x| + \frac{\pi}{2}}\right| < 2.5 \times 10^{-7}$$

for the range

$$-1.0 \times 10^{6} \le x \le 1.0 \times 10^{6}$$

FATAN

$$e \equiv \left|\frac{\operatorname{atn}(x) - \operatorname{atn}^*(x)}{\operatorname{atn}(x)}\right| < 5.0 \times 10^{-7}$$

for the range

$$-3.883361 \times 10^{37} \le x \le 3.883361 \times 10^{37}$$

FEXP

$$e \equiv \left|\frac{e^x - (e^x)^*}{e^x}\right| < \left\{\begin{array}{c} 2.5 \times 10^{-7}\ |x| \\ \text{or} \\ 2.5 \times 10^{-7} \end{array}\right\} \begin{array}{c}\text{whichever} \\ \text{is} \\ \text{greater}\end{array}$$

for the range

$$-\ln(\infty) < x < \ln(\infty) \text{ i.e., } 0 < e^x < \infty$$

FLN

$$e \equiv \left|\frac{\ln(x) - \ln^*(x)}{\ln(x)}\right| < 4.0 \times 10^{-7}$$

for the range

$0 < x < 1$
$1 < x < \infty$
for $x = 1$ $\ln(x) \equiv 0$

FTANH

$$e \equiv \left|\tanh(x) - \tanh^*(x)\right| < 2.5 \times 10^{-7}$$

for the range

$$-\infty < x < +\infty$$

FSQRT

$$e \equiv \left| \frac{\sqrt{x} - \sqrt{x^*}}{\sqrt{x}} \right| < 2.5 \times 10^{-7}$$

for the range

$$0 < x < \infty$$

Elementary Function Algorithms

The choice of an approximating algorithm for a given function depends on such considerations as expected execution time, storage requirements, and accuracy. For a given accuracy, and within reasonable limits, storage requirements vary inversely as the execution time. Polynomial approximating is used to evaluate the elementary functions to effect the desired balance between storage requirements and efficiency.

SINE-COSINE

Polynomial Approximation

Given a real number, x, n, and y are defined such that

$$\frac{x}{2\pi} = n + y$$

where n is an integer and $0 \le y < 1$. Thus, $x = 2\pi n + 2\pi y$, and the identities are

$$\sin x = \sin 2\pi y \text{ and } \cos x = \cos 2\pi y.$$

The polynomial approximation, F(z), for the function $(\sin 2\pi z)/z$ is used where $-1/4 \le z \le 1/4$.

The properties of sines and cosines are used to compute these functions as follows:

$$\cos 2\pi y = F(z)$$

where

$z = 1/4 - y$ in the range $0 \le y \le 1/2$
$z = y - 3/4$ in the range $1/2 \le y < 1$

$$\sin 2\pi y = F(z)$$

where

$z = y$ in the range $0 \le y < 1/4$
$z = 1/2 - y$ in the range $1/4 \le y < 3/4$
$z = y - 1$ in the range $3/4 \le y < 1$

Extended Precision

$$F(z) = a_1 z + a_2 z^3 + a_3 z^5 + a_4 z^7 + a_5 z^9 + a_6 z^{11}$$

where

$a_1 = 6.2831853071$
$a_2 = -41.341702117$
$a_3 = 81.605226206$
$a_4 = -76.704281321$
$a_5 = 42.009805726$
$a_6 = -14.394135365$

Standard Precision

$$F(z) = a_1 z + a_2 z^3 + a_3 z^5 + a_4 z^7 + a_5 z^9$$

where

$a_1 = 6.2831853$
$a_2 = -41.341681$
$a_3 = 81.602481$
$a_4 = -76.581285$
$a_5 = 39.760722$

ARCTANGENT

Polynomial Approximation

The subroutine for arctangent is built around a polymonial, $F(x)$, that approximates Arctan (z) in the range $-.23 \le z \le .23$. The Arctan (z) for z outside this range is found by using the identities

$$\text{Arctan}(-z) = -\text{Arctan}(z)$$

and

$$\text{Arctan}(z) = a_k + \text{Arctan}\left[\frac{z - b_k}{zb_k + 1}\right]$$

where

$$a_k = \frac{k\pi}{7},\ b_k = \tan a_k$$

and k is determined so that

$$\tan\frac{(2k-1)\pi}{14} \le |z| < \tan\frac{(2k+1)\pi}{14} \quad k = 1,\ 2,\ 3.$$

Having determined the value of k appropriate to z, the transformation $x=(z-b_k)/(zb_k+1)$ puts x in the range $-\tan\pi/14 \le x < \tan\pi/14$. The polynomial $F(x)$ was chosen to be good over a range slightly larger (i.e., $.23 < \tan\pi/14$) so that the comparisons to determine the interval in which z lies need be only standard precision accuracy.

$$\text{Arctan}(z) = \begin{cases} a_k + F(x) & z \ge 0 \\ -a_k - F(x) & z < 0 \end{cases}$$

Extended Precision

$$F(x) = x\,(1.0 - a_1 x^2 + a_2 x^4 - a_3 x^6 + a_4 x^8)$$

where

$a_1 = .33333327142$
$a_2 = .19999056792$
$a_3 = .14235177463$
$a_4 = .09992331248$

Standard Precision

$$F(x) = x(1.0 - a_1 x^2 + a_2 x^4 - a_3 x^6)$$

where

$a_1 = .333329573$
$a_2 = .199641035$
$a_3 = .131779888$

SQUARE ROOT

Square Root (x)

Let $x = 2^{2b}F$ when $.25 \le F < 1$

then $\sqrt{X} = 2^b\sqrt{F}$

where $\sqrt{F} = P_i$ — i = number of approximation

$P_1 = AF + B$ — as a first approximation followed by 2 Newton iterations

where

$A = .875,\ B = .27863$ when $.25 \le F < .5$

or

$A = .578125,\ B = .421875$ when $.5 \le F < 1$

$$P_2 = \frac{\left(P_1 + \frac{F}{P_1}\right)}{2}$$

$$P_3 = \frac{\left(P_2 + \frac{F}{P_2}\right)}{2}$$

NATURAL LOGARITHM

Polynomial Approximation

Given a normalized real number

$$x = 2^k x f$$

where the range of f is $1/2 \le f < 1$, and j and g are found such that $x = 2^j g$ where $(\sqrt{2}/2 \le g < \sqrt{2})$. This is done by setting $j = k-1$, $g = 2f$ if $f < \sqrt{2}/2$ and $j = k$, $g = f$ otherwise.

Thus:

$$\ln(x) = j.\ln(2) + \ln(g).$$

The approximation for ln(g), $\sqrt{2}/2 \le g < \sqrt{2}$, is based on the series

$$\ln\frac{v+x}{v-x} = 2\left[(x/v) + (x^3/3v^3) + (x^5/5v^5) + \ldots\right]$$

which converges for $(-v < x < v)$.
With the transformation

$$x = v\frac{g-1}{g+1}, \quad v = (\sqrt{2} + 1)^2$$

so that $-1 \le x < 1$ for $\sqrt{2}/2 \le g < \sqrt{2}$.
Substituting

$$\ln(g) = 2\,(z + z^3/3 + z^5/5 + \ldots)$$

where $z = x/v = \frac{g-1}{g+1}$.

The approximation used is G(z) for ln(g)/z in the range $\sqrt{2}/2 \le g < \sqrt{2}$.

Then for both extended and standard precision,

$$z = \frac{g-1}{g+1}$$

$\sqrt{2}/2$ = .7071067811865
ln (2) = .6931471805599

Thus, the required calculation is

$$\ln(x) = j\,.\ln(2) + zG(z)$$

Extended Precision

$$G(z) = b_0 + b_2z^2 + b_4z^4 + b_6z^6 + b_8z^8$$

where

b_0 = 2.0
b_2 = .666666564181
b_4 = .400018840613
b_6 = .28453572660
b_8 = .125

Standard Precision

$$G(z) = b_0 + b_2z^2 + b_4z^4 + b_6z^6$$

where

b_0 = 2.0
b_2 = .66664413786
b_4 = .4019234697
b_6 = .25

EXPONENTIAL

Polynomial Approximation

To find e^x, the following identity is used.

To reduce the range, we let

$$x \log_2 e = n + d + z$$

where

n is the integral portion of the real number,

d is a discrete fraction (1/8, 3/8, 5/8, or 7/8) of the real number, and

z is the remainder which is in the range $-1/8 \le z \le 1/8$.

Thus,

$$e^x = 2^n \times 2^d \times 2^z$$

and it is necessary to only approximate 2^z for $-1/8 \leq z \leq 1/8$ by using the polynomial F(z).

Extended Precision

$$F(z) = a_0 + a_1 z + a_2 z^2 + a_3 z^3 + a_4 z^4 + a_5 z^5$$

where

a_0 = 1.0
a_1 = .69314718057
a_2 = .24022648580
a_3 = .055504105406
a_4 = .0096217398747
a_5 = .0013337729375

Standard Precision

$$F(z) = a_0 + a_1 z + a_2 z^2 + a_3 z^3 + a_4 z^4$$

where

a_0 = 1.0
a_1 = .693147079
a_2 = .240226486
a_3 = .0555301557
a_4 = .00962173985

HYPERBOLIC TANGENT

$$\text{Tanh}(x) = \frac{e^{2x}-1}{e^{2x}+1}$$

for

$x \geq 32$ Tanh (x) = 1
$x \leq -32$ Tanh (x) = -1

REAL BASE TO REAL EXPONENT

$$A = e^{\ln A}$$

therefore:

$$A^B = \left(e^{\ln A}\right)^B = e^{B \ln A}$$

Selective Dump Subroutines

The IBM 1130 Subroutine Library and the System Library include three dump subroutines: Dump Selected Data on the Console Printer, Dump Selected Data on the 1132 Printer, and Dump Status Area. These subroutines allow the user to dump selected portions of core storage during the execution of a user's program.

Dump Selected Data on Console Printer or 1132 Printer

Two subroutines are available to select an area of core storage and dump it on the Console Printer or the 1132 Printer. Each of these subroutines has two entry points, one for hexadecimal output and one for decimal output. The entry points for the various configurations are shown below:

DMTX0	Dump on Console Printer in hexadecimal format, using the WRTY0 subroutine
DMTD0	Dump on Console Printer in decimal format, using the WRTY0 subroutine
DMPX1	Dump on 1132 Printer in hexadecimal format, using the PRNT1 subroutine
DMPD1	Dump on 1132 Printer in decimal format, using the PRNT1 subroutine

Calling Sequence

The calling sequence for any of the above functions is as follows:

```
   CALL  ENTRY POINT
   DC    START
   DC    END
```

START and END represent the starting and ending addresses of the portion of core storage to be dumped. A starting address greater than the ending address results in the error message, ERROR IN ADDRESS, and a return to the calling program.

Format

Before the actual dump appears on the selected output device, the user is given one line of status information. This line indicates the status of the Overflow and Carry indicators (ON or OFF), the contents of the Accumulator and Extension, and the contents of the three index registers. The index register contents are given in both hexadecimal and decimal form, regardless of which type of output was requested. The format of the status information is shown below:

```
OFF      ON    HHHH (±DDDDD) HHHH (±DDDDD)
Overflow Carry Accumulator   Extension

HHHH (±DDDDD) HHHH (±DDDDD) HHHH (±DDDDD)
Index Reg 1   Index Reg 2   Index Reg 3
```

All other data is dumped eight words to a line; the address of the first word in each line is printed to the left of the line. Hexadecimal data is printed four characters per word; decimal data is printed five digits per word, preceded by a plus or minus sign.

Page numbers are not printed for either subroutine. However, the 1132 Printer subroutine does provide for automatic page overflow upon the sensing of a channel 12 punch in the carriage tape.

Dump Status Area

This subroutine provides a relatively easy and efficient means of dumping the first 80 words of core storage. These words contain status information relating to index registers, interrupt addresses, etc., which may be required frequently during the testing of a program. It may also be desirable to dump these words before loading because pressing PROGRAM LOAD destroys the data in the first 80 words of core storage.

The Dump Status Area subroutine is called via the following statement:

```
        CALL  DMP80
```

The Console Printer prints the first 80 words of core storage in hexadecimal form; the printing format provides spacing between words. After typing the last word, the subroutine returns control to the calling program.

The DM2 System Library contains a group of subroutines that perform various system utility functions. These subroutines, with the exception of SYSUP which can be called by the user, are intended for system use only. Under normal circumstances, they should not be deleted from the System Library.

The subroutines in the group are:

FLIPR - LOCAL/SOCAL overlay subroutine
RDREC - Read *ID record
CALPR - Call system print
FSLEN - Fetch phase IDs
FSYSU - Fetch system subroutine (FSYSU is an alternate entry point to FSLEN)
SYSUP - DCOM update

FLIPR (LOCAL/SOCAL OVERLAY)

The System Library contains a flipper subroutine (FLIPR) which is used to call LOCAL (load on call) and SOCAL (system load on call) subroutines into core storage. FLIPR is used with DISKZ, DISK1, or DISKN.

FLIPR passes the total word count to DISKZ, DISK1, or DISKN to fetch the LOCAL. When a LOCAL subroutine is called, control is passed to the flipper, which reads the LOCAL into core storage if it is not already in core and transfers control to it. All LOCALs in a given core load are executed from the same core storage locations; each LOCAL overlays the previous one. FLIPR fetches SOCALs in the same manner as LOCALs.

RDREC (READ *ID RECORD)

This subroutine is called by Disk Maintenance Programs to read the *ID (disk label) record. This subroutine is intended for system use only.

CALPR (CALL SYSTEM PRINT)

This subroutine calls FSLEN to bring the system print subroutine into core storage for the purpose of printing one or more lines on the principal printer. This subroutine is intended for system use only.

FSLEN (FETCH PHASE IDS AND FETCH SYSTEM SUBROUTINE)

This subroutine has two entry points. They are FSLEN and FSYSU.

- FSLEN (Fetch Phase IDs from SLET)

This entry point obtains the requested phase ID headers from SLET.

- FSYSU (Fetch System Subroutine)

Fetches the requested system subroutine into core storage.

This subroutine is intended for system use only.

SYSUP (DCOM UPDATE)

Whenever a core load requires changing disk cartridges during the job, SYSUP must be called to update DCOM on the master cartridge (logical drive 0) with the IDs and DCOM information from all satellite cartridges mounted on the system. The cartridges are specified in the list or array in the SYSUP calling sequence. The list or array must be exactly five words long or be ended by a zero (not both).

The Assembler language calling sequence for SYSUP is:

Label	Operation	F	T	Operands & Remarks
	CALL			SYSUP CALL DCOM UPDATE
	DC			LIST
	•			
	•			
	•			
LIST	DC			a
	DC			b
	DC			c
	DC			d
	DC			e

where

LIST is the address of the table of requested cartridge IDs, a is the ID of the master cartridge on the system,

b is the ID of the first satellite cartridge on the system,

c is the ID of the second satellite cartridge on the system,

d is the ID of the third satellite cartridge on the system,

e is the ID of the fourth satellite cartridge on the system.

If a is 0, the master cartridge remains unchanged.

The FORTRAN calling sequence for SYSUP is:

```
      CALL SYSUP(a)
```

where

a is the name of the last item in an array containing the IDs of the satellite cartridges on the system. The last entry in the array may be 0, in which case the master cartridge remains unchanged.

For example:

CALL SYSUP (K (5))

The array is stored in reverse order.

```
K(5)  DC
K(4)  DC
K(3)  DC
K(2)  DC
K(1)  DC
```

Thus K(5) is the entry for logical 0, the master cartridge.

SYSUP messages are listed in the publication <u>IBM 1130 Disk Monitor System, Version 2, Programmer's and Operator's Guide</u>. SYSUP execution is terminated if an error printout occurs.

The IBM 1130 DM2 System Library mainline programs provide the user with the ability to perform disk maintenance and paper tape utility functions by requesting execution of the appropriate program directly through the job stream.

The calling sequences for the System Library mainline programs are listed below. The operating procedures and error messages are contained in the IBM 1130 Disk Monitor System, Version 2, Programmer's and Operator's Guide.

Disk Maintenance Programs

The disk maintenance programs are mainline programs and subroutines that are a part of the System Library and that initialize and modify disk cartridge IDs, addresses, and tables required by the DM2 system. Normally, they should never be deleted from the System Library.

The disk maintenance programs are:

IDENT	-	Print Cartridge ID
DISC		Satellite Disk Initialization[1]
ID	-	Change Cartridge ID
COPY		Disk Copy
ADRWS	-	Write Sector Addresses in Working Storage
DFCNV	-	Disk Data File Conversion
DLCIB	-	Delete CIB
DSLET	-	Dump System Location Equivalence Table
MODIF	-	System Maintenance Program
MODSF	-	Library Maintenance Program

[1]All new cartridges are initialized using the standalone program DCIP (see IBM 1130 Disk Monitor System, Version 2, Programmer's and Operator's Guide).

IDENT (Print Cartridge ID)

This program prints the ID and physical drive number of each cartridge mounted on the system.

IDENT prints all cartridge IDs regardless of validity (JOB card processing only recognizes valid IDs).

The calling sequence for IDENT is:

```
// XEQ IDENT
```

DISC (Satellite Disk Initialization)

This program reinitializes up to four satellite cartridges -- all but the master cartridge. It writes the sector addresses, defective cylinder addresses, a cartridge ID, a LET, a DCOM, and a CIB on each cartridge being reinitialized.

DISC overrides all cartridge IDs specified on the JOB card except the master cartridge ID.

The calling sequence for DISC is:

```
// XEQ DISC
*IDFID1,TID1,FID2,TID2,...FIDn,TIDn
```

where

FID1 through FIDn are the IDs currently on the satellite cartridges to be reinitialized (identified by IDENT or a JOB record),

TID1 through TIDn are the IDs to be written on the satellite cartridges by this program. A valid cartridge ID is a number between /0001 and /7FFF.

ID (Change Cartridge ID)

This program changes the ID on up to four satellite cartridges.

```
// XEQ ID
*IDFID1,TID1,FID2,TID2,...FIDn,TIDn
```

where

FID1 through FIDn are the IDs currently on the satellite cartridges being changed (these IDs must be in the same logical order as the entries on the JOB card),

TID1 through TIDn are the new IDs to be written on the selected satellite cartridges.

COPY (Disk Copy)

This program copies the contents (except the defective cylinder table and the cartridge ID) of one cartridge onto another. The copy ID (word 5 of sector 0) is incremented by one prior to being written on the new cartridge.

The calling sequence for COPY is:

```
// XEQ COPY
*IDFID1,TID1,FID2,TID2,...FIDn,TIDn
```

where

FID1 through FIDn are the IDs of the cartridges to be copied.

TID1 through TIDn are the IDs of the cartridge onto which the copies are to be made.

If multiple copies are to be made from a single master, FID1 through FIDn will all contain the same ID.

ADRWS (Write Sector Addresses in Working Storage)

This program, linked to from DUP on detection of the DUP control record DWADR, writes sector addresses on all sectors of Working Storage on the disk cartridge specified by the DWADR control record (see DUP in the IBM 1130 Disk Monitor System, Version 2, Programmer's and Operator's Guide).

DFCNV (Disk Data File Conversion)

This program converts 1130 FORTRAN or Commercial Subroutine Package disk data files to disk files acceptable to 1130 RPG.

The calling sequence for DFCNV is:

```
// XEQ DFCNV      1
```

DLCIB (Delete Core Image Buffer)

This program deletes the CIB from a nonsystem cartridge. If a user area is defined, the user area is moved two cylinders closer to cylinder 0. The new addresses of disk areas moved as the result of the deletion of the CIB are reflected in DCOM on the master cartridge, on the nonsystem cartridge from which the CIB is deleted, and in COMMA.

The calling sequence for DLCIB is:

```
// XEQ DLCIB
*IDCART
```

where

CART is the ID of the non-system cartridge from which the CIB is to be deleted.

DSLET (Dump System Location Equivalence Table)

This program dumps the contents of SLET on the principal printer. Each entry printed consists of a symbolic name, a phase ID, a core address, a word count, and a disk sector address. A SLET dump is listed in the publication IBM 1130 Disk Monitor System, Version 2, Programmer's and Operator's Guide.

The calling sequence for DSLET is:

```
// XEQ DSLET
```

MODIF (System Maintenance Program)

Included in the DM2 System Library is a system maintenance program, MODIF, that provides the user with the ability to update the Monitor system on the master cartridge. This program makes changes to the version and modification level word in

DCOM, the Supervisor, DUP, FORTRAN Compiler, Assembler, and/or System Library. A card deck or paper tape containing corrections to update the Monitor system to the latest version and modification level is supplied by IBM. Every modification must be run to update the version and modification level, even if the affected program has been deleted from the system.

The calling sequence for MODIF is:

```
// XEQ MODIF
```

MODSF (Library Maintenance Program)

The purpose of MODSF is to update a library program written in the disk system format (DSF) and located in the User Area of disk storage. (To modify or replace a system program, see "MODIF (System Maintenance Program)" described earlier in this section.)

A program is updated by either replacing existing code, inserting additional code at the end of the program, or both. Existing coding is replaced as the program resides in the User Area. Several programs may be updated in a MODSF run, but only the last program in a MODSF run may have code added to it. When additional code is inserted, MODSF moves the program to Working Storage and inserts it there and ends its run by invoking DUP. To move the updated program back to the Users Areas, the user must provide the necessary *DELETE and *STORE records.

To update a program with MODSF, the user must prepare a patch control record, one or more patch data records, and a patch terminator record.

The calling sequence for MODSF is:

```
// XEQ MODSF
```

PAPER TAPE UTILITY (PTUTL)

This program accepts input from the keyboard or the 1134 paper tape reader and provides output on the console printer and/or the 1055 paper tape punch.

PTUTL allows changes and/or additions to FORTRAN and Assembler language source records as well as monitor control records.

The calling sequence for PTUTL is:

```
// XEQ PTUTL
```

Writing ISS and ILS (C/PT System)

The section on Writing ISSs and ILSs for the DM2 system will be found in the IBM 1130 Disk Monitor System, Version 2, Programmer's and Operator's Guide.

Interrupt Service Subroutines

The following rules must be adhered to when writing an ISS:

1. Precede the ISS statement with an LIBR statement if the subroutine is to be called by a LIBF rather than a CALL.

2. Precede the subroutine with an EPR (extended) or an SPR (standard) statement if precision specification is necessary.

3. Precede the subroutine with one ISS statement defining the entry point (one only), the ISS number, and the ILS subroutines required. The device interrupt level assignments and the ISS numbers used in the IBM-provided ISS and ILS subroutines are shown in Figure 22.

4. The entry points of an ISS are defined by the related ILS. This must be taken into consideration when a user-written ISS is used with an IBM-supplied ILS. The ILS executes a BSI to the ISS at the ISS entry point plus n (see Figure 22). The ISS must return to the ILS via a BSC instruction (not a BOSC).

5. When assembling the ISS on the monitor system an *LEVEL n control card must be included for each interrupt level associated with the device.

Interrupt Level Subroutines

An ILS is included in a program only if requested by a loaded ISS. The following are rules for writing an ILS:

1. Precede the subroutine with an ILS statement.

2. Precede all instructions by an ISS Branch Table and include one word per ILSW bit used. If the ILSW will not be scanned, (i.e., a single ISS subroutine to handle all interrupts on the level), then a one-word table is sufficient. The minimum table size is one word. Table words must be nonzero.

```
ILSW Bit 15 word  }
ILSW Bit 14 word  }
           .      }
           .      } ISS Branch Table
           .      }
ILSW Bit 0 word   }
```

The ISS Branch Table identifies both the ISS subroutine and the point within the ISS which should be entered for each bit used in the ILSW. The actual linkage is generated by the Relocating Loader or Core Image Converter. Basic to this generation is the ISS number implied by bits 8-15 of the branch table word and specified in the ISS statement. This number identifies a core location in which the loader or converter has stored the address of the called entry point in the ISS. This entry point address is incremented by the value in bits 0-7 of the branch table word, producing the branch linkage. The loader or converter replaces the ISS branch

ISS Number	Device	Device Interrupt Level Assignments	n
1	1442 Card Read Punch	0, 4	+4, +7
2	Keyboard/Console Printer	4	+4
3	1134/1055 Paper Tape Reader/Punch	4	+4
4	Single Disk Storage	2	+4
6	1132 Printer	1	+4
7	1627 Plotter	3	+4

Figure 22. C/PT System ISS/ILS Correspondence

table word with the generated branch linkage.

During execution, the ISS Branch Table contains core addresses. It may be used with an indirect BSI instruction to reach the ISS corresponding to that ILSW bit position. The ILSW bit that is ON can be determined by the execution of a SLCA instruction. At the completion of this instruction, the index register specified contains a relative value equivalent to the bit position in the ISS branch table. An indirect, indexed BSI may then be used to reach the appropriate ILS.

Each word in the ISS branch table has the following format:

Bits 0-7: Increment added to the entry point named in the ISS statement to obtain the interrupt entry point in the ISS for this ILSW bit. (In IBM-written ISS subroutines, this increment is +4 for the primary interrupt level and +7 for the secondary interrupt level.)

Bits 8-15: ISS number +51 for the ISS subroutine for this ILSW bit. This address should match word 13 of the compressed ISS header card.

3. The ILS entry point must immediately follow the ISS branch address table and must be a zero. The first zero word in the program is the end of the branch table and is also the entry point of the ILS. (The table must contain at least one entry.) The interrupt results in a BSI to the ILS entry point.
4. To clear the level, a user-written ILS, used with an IBM-supplied ISS, should exit via the return linkage with a BOSC instruction.

ILSs supplied by IBM in the Card/Paper Tape System, except ILS01, pass word 2 of the Sense Device IOCC to all ISSs. The ISSs in the Card/Paper Tape System require that this word be passed in the Accumulator. Observe this convention when writing ILSs, and when writing ISSs to be used with IBM-supplied ILSs.

```
                         ***   HDNG          ILS01                              ILS01000
                         ************************************************** ILS01001
                         * TITLE - ILS01                                    * ILS01002
                         * STATUS - CHANGE LEVEL 0                          * ILS01003
                         * FUNCTION/OPERATION - .ILS01. IS THE INTERRUPT    * ILS01004
                         *  LEVEL SUBROUTINE FOR LEVEL 1                    * ILS01005
                         * ENTRY POINTS - ILS01. ENTERED BY HARDWARE BSI    * ILS01006
                         *  VIA LOCATION 9                                  * ILS01007
                         * INPUT - NONE                                     * ILS01008
                         * OUTPUT - NONE                                    * ILS01009
                         * EXTERNAL ROUTINES - NONE                         * ILS01010
                         * EXITS - NORMAL - BOSC INDIRECT THROUGH .ILS01.   * ILS01011
                         *       -ERROR - NONE                              * ILS01012
                         * TABLES/WORK AREAS - NONE                         * ILS01013
                         * ATTRIBUTES - REUSABLE                            * ILS01014
                         * NOTES -                                          * ILS01015
                         *            ******      1130 ILS01                * ILS01016
                         *            *      THIS IS THE INTERRUPT LEVEL    * ILS01017
                         *            *      SUBROUTINE FOR LEVEL 1.        * ILS01018
                         *            *      THE 1132 PRINTER AND THE       * ILS01019
                         *            *      COMMUNICATIONS ADAPTER ARE ON  * ILS01020
                         *            *      LEVEL 1.                       * ILS01021
                         *            *      BIT 0 - 1132 PRINTER           * ILS01022
                         *            *      BIT 1 - COMMUNICATIONS ADAPTER* ILS01023
                         *            ******                                * ILS01024
                         ************************************************** ILS01025
                         *                                                    ILS01026
                               ILS  01                                        ILS01027
0000 0  0439             P2    DC       /0439                                 ILS01028
0001 0  043B             CAT2  DC       /043B                                 ILS01029
0002 0  0000             ILS01 DC       0          ENTERED BY HARDWARE BSI    ILS01030
                         *                              VIA LOCATION 0009     ILS01031
0003 0  D810                   STD      AQ         SAVE ACC AND EXTENSION     ILS01032
0004 0  2806                   STS      STAT            STATUS                ILS01033
0005 0  6908                   STX    1 XR1+1           INDEX 1               ILS01034
                         *                                                    ILS01035
0006 0  080F                   XIO      SENS-1     SENSE ILSW                 ILS01036
0007 01 4C280011               BSC  L   VIP,+Z     PROCESS 1132 INTERRUPT     ILS01037
0009 01 44800001               BSI  I   CAT2       PROCESS ADAPTER INTERRUPT  ILS01038
                         *                                                    ILS01039
000B 0  2000             STAT  LDS      0          RESTORE                    ILS01040
000C 0  C807                   LDD      AQ                                    ILS01041
000D 00 65000000         XR1   LDX  L1  *-*                                   ILS01042
                         *                                                    ILS01043
000F 01 4CC00002               BOSC I   ILS01      TURN OFF LEVEL AND EXIT    ILS01044
                         *                                                    ILS01045
0011 01 44800000         VIP   BSI  I   P2         PROCESS 1132 INTERRUPT     ILS01046
0013 0  70F7                   MDX      STAT       GO TO RESTORE AND EXIT     ILS01047
                         *                                                    ILS01048
0014    0002             AQ    BSS  E   2          FOR SAVING ACC AND EXT.    ILS01049
0016 0  0000                   DC       0                                     ILS01050
0017 0  0300             SENS  DC       /0300      IOCC TO SENSE ILSW         ILS01051
                         *                                                    ILS01052
0018                           END                                            ILS01062
```

```
                          ***   HDNG     LIBF CARD0                                CRD00001
                                LIBR                                               CRD00002
0000       03059130       1130  ISS   01 CARD0      0     4                        CRD00003
                          ************************************************** CRD00004
                          *     THIS 1130 SUBROUTINE OPERATES THE 1442 CARD * CRD00005
                          *     READER PUNCH. IT INITIATES REQUESTED OPERA- * CRD00006
                          *     TIONS, PROCESSES ANY COLUMN OR OPERATION    * CRD00007
                          *     COMPLETE INTERRUPTS, AND AUTOMATICALLY      * CRD00008
                          *     INITIATES ERROR RECOVERY PROCEDURES.        * CRD00009
                          *                                                 * CRD00010
                          *     IDENTIFYING FEATURE - NO ERROR PARAMETER    * CRD00011
                          ************************************************** CRD00012
                          *              LOADER DEFINED LOCATIONS           * CRD00013
                          ************************************************** CRD00014
0000 0 - 695E             CARD0 STX    1 CA30+1       LIBF ENTRANCE         (+0) CRD00015
0001 00 65800000          LINK  LDX   I1 0            LOADER STORES TV ADDR (+2) CRD00016
0003 0  7006                    MDX      CA10                                    CRD00017
0004 0  0000              INT1  DC       0            COLUMN INTERRUPT      (+4) CRD00018
0005 01 4C0000DA                BSC   L  NT14                                    CRD00019
0007 0  0000              INT2  DC       0            OP CMPLTE INTERRUPT   (+7) CRD00020
0008 01 4C00009F                BSC   L  NT10                                    CRD00021
                          ************************************************** CRD00022
                          *              LIBF PROCESSING                    * CRD00023
                          ************************************************** CRD00024
                          *     THIS PORTION STORES CALLING SEQUENCE INFO   * CRD00025
                          *     AND CHECKS THE DEVICE STATUS BEFORE ANY I/O * CRD00026
                          *     OPERATION IS INITIATED. A CALLING ERROR OR  * CRD00027
                          *     NOT READY 1442 CAUSES AN ERROR EXIT TO      * CRD00028
                          *     LOCATION 41. IF THE OPERATION WILL CAUSE    * CRD00029
                          *     INTERRUPTS, THE ROUTINE IS SET BUSY AND THE * CRD00030
                          *     IOCS COUNTER IS INCREMENTED TO INDICATE     * CRD00031
                          *     INTERRUPT(S) PENDING.                       * CRD00032
                          ************************************************** CRD00033
000A 0  D07B              CA10  STO      TEMP         SAVE STATUS                CRD00034
000B 0  2856                    STS      CA32                                    CRD00035
000C 0  6A54                    STX    2 CA31+1                                  CRD00036
000D 0  C100                    LD     1 0            X1= ADDR OF CALL+1         CRD00037
000E 0  180C                    SRA      12           IS FUNCTION TEST           CRD00038
000F 01 4C200015                BSC   L  CA14,Z         NO                       CRD00039
0011 0  C078                    LD       BUSY           YES, IS ROUTINE BUSY     CRD00040
0012 0  4818                    BSC      +-                                      CRD00041
0013 0  7101                    MDX    1 +1               NO, EXIT TO CALL+3     CRD00042
0014 0  7046                    MDX      CA28             YES, EXIT TO CALL+2    CRD00043
0015 0  9077              CA14  S        D0004        IS FUNCTION LEGAL          CRD00044
0016 01 4C300070                BSC   L  CA40,Z-        NO, ERROR                CRD00045
0018 0  807A                    A        H7003                                   CRD00046
0019 0  D00B                    STO      CA20                                    CRD00047
001A 0  806D                    A        CONST                                   CRD00048
001B 0  D007                    STO      CA18                                    CRD00049
001C 0  C06D              CA15  LD       BUSY         IS ROUTINE BUSY            CRD00050
001D 01 4C20001C                BSC   L  CA15,Z         YES, WAIT TIL NOT        CRD00051
001F 0  0868              CA17  XIO      SENSE-1      IS DEVICE READY            CRD00052
0020 01 4C040072                BSC   L  CA42,E         NO, ERROR                CRD00053
0022 0  C066                    LD       SENSE        SETUP CONTROL IOCC         CRD00054
0023 0  9075              CA18  S        SETUP                                   CRD00055
0024 0  D062                    STO      INIT                                    CRD00056
0025 0  7000              CA20  MDX      CA20+1       WHAT IS FUNCTION           CRD00057
0026 0  7003                    MDX      CA21           = GET                    CRD00058
0027 0  703D                    MDX      CA36           = PUT                    CRD00059
0028 0  701B                    MDX      CA25           = FEED                   CRD00060
0029 0  702B                    MDX      CA26           = STK                    CRD00061
002A 0  9072              CA21  S        SETUP+4      GET FUNCTION               CRD00062
002B 0  D059                    STO      COLM+1         SET UP READ I/O          CRD00063
002C 00 C5800001          CA21B LD    I1 1                                       CRD00064
002E 01 4C080070                BSC   L  CA40,+         = ERROR IF ZERO OR NEG   CRD00065
0030 0  D009                    STO      CA22+1                                  CRD00066
0031 0  805A                    A        D0001          SAVE WORD COUNT +1       CRD00067
0032 0  D061                    STO      COUNT            BECAUSE DECREMENT IS   CRD00068
0033 0  D063                    STO      RSTRT            BEFORE COLUMN READ     CRD00069
0034 0  905B                    S        D0081                                   CRD00070
0035 01 4C300070                BSC   L  CA40,Z-        = ERROR IF OVER +81      CRD00071
0037 0  C101                    LD     1 1                                       CRD00072
0038 0  D004                    STO      CA23+1                                  CRD00073
0039 00 66000000          CA22  LDX   L2 0                                       CRD00074
003B 0  C050                    LD       D0001                                   CRD00075
003C 00 D6000000          CA23  STO   L2 0              STORE +1 IN DATA AREA    CRD00076
003E 0  72FF                    MDX    2 -1               (= NOT READ INDIC FOR  CRD00077
003F 0  70FC                    MDX      CA23             SPEED CONVRT SBRT)     CRD00078
0040 0  C101              CA24  LD     1 1              SAVE DATA ADDRESS        CRD00079
0041 0  D042                    STO      COLM                                    CRD00080
0042 0  D055                    STO      RSTRT+1                                 CRD00081
0043 0  7101                    MDX    1 +1             SET X1 TO SKIP 2ND PARAM CRD00082
0044 0  0843              CA25  XIO      SENSE-1                                 CRD00083
0045 0  1003                    SLA      3              IS LAST CARD IND ON      CRD00084
0046 01 4C100050                BSC   L  CA25B,-          NO                     CRD00085
0048 0  C0DC                    LD       CA20           IS FUNCTION GET OR FEED  CRD00086
0049 01 4C040050                BSC   L  CA25B,E          NO                     CRD00087
004B 0  1008                    SLA      8              IS FUNCTION GET          CRD00088
```

```
004C 0  4808              BSC     +                                        CRD00089
004D 0  71FF              MDX   1 -1             YES. SET XR1 = LIBF+1     CRD00090
004E 0  083B              XIO     FEED-1       EJECT CARD                  CRD00091
004F 0  702C              MDX     CA43                                     CRD00092
0050 00 74010032  CA25B  MDX  L  50.+1        INCREMENT IOCS COUNTER       CRD00093
0052 0  1000              NOP                                              CRD00094
0053 0  C038              LD      D0001                                    CRD00095
0054 0  D035              STO     BUSY        SET ROUTINE BUSY             CRD00096
0055 0  C03F      CA26    LD      ERROR                                    CRD00097
0056 01 4C20005A          BSC  L  CA27.Z                                   CRD00098
0058 0  082D              XIO     INIT-1      INITIATE I/O                 CRD00099
0059 0  7001              MDX     CA28                                     CRD00100
005A 0  082F      CA27    XIO     FEED-1                                   CRD00101
005B 0  7101      CA28    MDX   1 +1                                       CRD00102
005C 0  C029              LD      TEMP                                     CRD00103
005D 0  6906      CA29    STX   1 CA34+1      SET EXIT TO SKIP 1ST PARAM CRD00104
005E 00 65000000  CA30    LDX  L1 0           RESTORE STATUS               CRD00105
0060 00 66000000  CA31    LDX  L2 0                                        CRD00106
0062 0  2000      CA32    LDS     0                                        CRD00107
0063 00 4C000000  CA34    BSC  L  0           EXIT                         CRD00108
0065 0  9038      CA36    S       SETUP+5                                  CRD00109
0066 0  D01E              STO     COLM+1        SETUP PUNCH I/O            CRD00110
0067 00 C5800001          LD   I1 1                                        CRD00111
0069 01 4C080070          BSC  L  CA40.+        = ERROR IF ZERO OR NEG     CRD00112
006B 0  D028              STO     COUNT                                    CRD00113
006C 0  D02A              STO     RSTRT         SAVE WORD COUNT            CRD00114
006D 0  9021              S       D0080         DO NOT PUNCH OVER 80 COL CRD00115
006E 0  4808              BSC     +                                        CRD00116
006F 0  70D0              MDX     CA24                                     CRD00117
0070 0  C021      CA40    LD      H1001       ERROR CODE - ILLEGAL CALL    CRD00118
0071 0  700B              MDX     CA44                                     CRD00119
0072 0  1801      CA42    SRA     1           IS DEVICE BUSY               CRD00120
0073 01 4C04001F          BSC  L  CA17.E        YES. WAIT TIL NOT          CRD00121
0075 0  1003              SLA     3           IS DSW ERROR INDIC ON        CRD00122
0076 01 4C10007C          BSC  L  CA43.-        NO                         CRD00123
0078 0  C0AC              LD      CA20          YES. IS FUNCT GET/FEED     CRD00124
0079 01 4C04007C          BSC  L  CA43.E          NO                       CRD00125
007B 0  D019              STO     ERROR           YES. INDIC SKIP 1ST CD CRD00126
007C 0  C014      CA43    LD      H1000       ERROR CODE - DVCE NOT RDY    CRD00127
007D 0  71FF      CA44    MDX   1 -1                                       CRD00128
007E 00 6D000028          STX  L1 40            STORE CALL ADDR IN 40      CRD00129
0080 0  6129              LDX   1 41            SET EXIT FOR 41            CRD00130
0081 0  70DB              MDX     CA29                                     CRD00131
                  ************************************************** CRD00132
                  *               CONSTANTS                        * CRD00133
                  ************************************************** CRD00134
0082    0000              BSS  E  0                                        CRD00135
0082 1  0082      ADDR    DC      CHAR-1      ADDR TO REPLACE O/P AREA     CRD00136
0083 0  0000      CHAR    DC      0           TEMPORARY REGISTER         O CRD00137
0084 0  0000      COLM    DC      0           IOCC FOR COLUMN I/O        E CRD00138
0085 0  0000              DC      0                                      O CRD00139
0086 0  0000      TEMP    DC      0           TEMPORARY STORAGE            CRD00140
0087 0  0400      INIT    DC      /0400       IOCC TO INITIATE I/O       O CRD00141
0088 0  2075      CONST   DC      SETUP-CA18-1+/2000                       CRD00142
0089 0  1700      SENSE   DC      /1700       SENSE DSW WITHOUT RESET    O CRD00143
008A 0  0000      BUSY    DC      0           ROUTINE BUSY INDICATOR       CRD00144
008B 0  1402      FEED    DC      /1402       IOCC TO FEED 1 CARD        O CRD00145
008C 0  0001      D0001   DC      +1                                       CRD00146
008D 0  0004      D0004   DC      +4                                       CRD00147
008E 0  0008      D0008   DC      +8                                       CRD00148
008F 0  0050      D0080   DC      +80                                      CRD00149
0090 0  0051      D0081   DC      +81                                      CRD00150
0091 0  1000      H1000   DC      /1000                                    CRD00151
0092 0  1001      H1001   DC      /1001                                    CRD00152
0093 0  7003      H7003   DC      /7003       INSTRUCTIONS = MDX X +3      CRD00153
0094 0  0000      COUNT   DC      0           NO. WORDS TO XFER            CRD00154
0095 0  0000      ERROR   DC      0           SKIP ONE CARD INDIC          CRD00155
0096 0  0000      INDIC   DC      0           FEED CHK (RD STATION) IND    CRD00156
0097 0  0000      RSTRT   DC      0           RESTART INFO - WORD COUNT    CRD00157
0098 0  0000              DC      0                          DATA ADDR     CRD00158
0099 0  02FC      SETUP   DC      /02FC       INITIATE IOCC SETUP - GET    CRD00159
009A 0  02FF              DC      /02FF                           - PUT    CRD00160
009B 0  02FE              DC      /02FE                           - FEED CRD00161
009C 0  0280              DC      /0280                           - STK    CRD00162
009D 0  0204              DC      /0204       COLUMN IOCC SETUP   - GET    CRD00163
009E 0  0301              DC      /0301                           - PUT    CRD00164
```

```
                        ************************************************** CRD00165
                        *               OP COMPLETE INTERRUPT PROCESSING   * CRD00166
                        ************************************************** CRD00167
                        *     THIS PORTION IS ENTERED FROM INTERR LEVEL    * CRD00168
                        *     SROUTINE 04. IF NO ERROR HAS BEEN DETECTED,  * CRD00169
                        *     THE ROUTINE IS SET NOT BUSY AND THE IOCS     * CRD00170
                        *     COUNTER IS DECREMENTED TO INDICATE           * CRD00171
                        *     INTERRUPT PROCESSING COMPLETED. OTHERWISE    * CRD00172
                        *     THE SUBROUTINE LOOPS UNTIL THE OPERATOR HAS  * CRD00173
                        *     INTERVENED AND THE 1442 BECOMES READY. AT    * CRD00174
                        *     WHICH TIME THE CARDS ARE POSITIONED AND THE  * CRD00175
                        *     I/O OPERATION IS RE-INITIATED.               * CRD00176
                        ************************************************** CRD00177
009F 0  80EC            NT10  A      D0001      OPER COMPLETE INTERRUPT      CRD00178
00A0 0  D0E2                  STO    CHAR                                    CRD00179
00A1 0  08E0                  XIO    CHAR-1       SENSE DSW WITH RESET       CRD00180
00A2 0  1003                  SLA    3            IS OPERATION OK            CRD00181
00A3 01 4C0200BA              BSC  L NT11,C         NO, ERROR                CRD00182
00A5 01 4C2800B4        NT10B BSC  L NT10X,Z+       NO, LAST CARD            CRD00183
00A7 0  C0ED                  LD     ERROR                                   CRD00184
00A8 0  1002                  SLA    2              YES, WAS THIS SKIP OP    CRD00185
00A9 0  1810                  SRA    16                                      CRD00186
00AA 0  D0EA                  STO    ERROR                                   CRD00187
00AB 01 4C0200C5              BSC  L NT12,C           YES, INITIATE FUNCT    CRD00188
00AD 00 74FF0032        NT10E MDX  L 50,-1            NO, TERMINATE FUNCT    CRD00189
00AF 0  1000                  NOP                     DECREMENT IOCS COUNT   CRD00190
00B0 0  1810                  SRA    16                                      CRD00191
00B1 0  D0D8                  STO    BUSY             CLEAR ROUTINE BUSY     CRD00192
00B2 01 4C800007              BSC  I INT2             EXIT                   CRD00193
00B4 0  C0CD            NT10X LD     ADDR                                    CRD00194
00B5 0  80D6                  A      D0001                                   CRD00195
00B6 0  F0CD                  EOR    COLM             IS FUNCTION PUT        CRD00196
00B7 0  4818                  BSC    +-                 NO                   CRD00197
00B8 0  08D1                  XIO    FEED-1             YES, EJECT LAST CD   CRD00198
00B9 0  70F3                  MDX    NT10E                                   CRD00199
00BA 0  1005            NT11  SLA    5            SAVE FD CHK (RD STA) IND   CRD00200
00BB 0  C0CB                  LD     INIT         IS FUNCT PUNCH             CRD00201
00BC 01 4C0400C5              BSC  L NT12,E         YES, DONT SKIP           CRD00202
00BE 0  1801                  SRA    1            IS FUNCT FEED              CRD00203
00BF 01 4C0400D5              BSC  L NT13B,E        YES                      CRD00204
00C1 0  C0D6                  LD     RSTRT+1      WAS ONE COL READ IN        CRD00205
00C2 0  F0C1                  EOR    COLM                                    CRD00206
00C3 01 4C1800D7              BSC  L NT13E,+-       NO, SKIP 1ST CARD        CRD00207
00C5 0  08BC            NT12  XIO    CHAR-1                                  CRD00208
00C6 01 4C0400C5              BSC  L NT12,E       WAIT TIL READER READY      CRD00209
00C8 0  C0CC                  LD     ERROR        IS CARD SKIP NECESSARY     CRD00210
00C9 01 4C1800CE              BSC  L NT13,+-        NO                       CRD00211
00CB 0  08BE                  XIO    FEED-1       SKIP 1ST CARD              CRD00212
00CC 01 4C800007              BSC  I INT2                                    CRD00213
00CE 0  C0C8            NT13  LD     RSTRT                                   CRD00214
00CF 0  D0C4                  STO    COUNT            SETUP FOR RETRY        CRD00215
00D0 0  C0C7                  LD     RSTRT+1                                 CRD00216
00D1 0  D0B2                  STO    COLM                                    CRD00217
00D2 0  08B3                  XIO    INIT-1       INITIATE I/O OPERATION     CRD00218
00D3 01 4C800007              BSC  I INT2         EXIT                       CRD00219
00D5 01 4C0200C5        NT13B BSC  L NT12,C         NO SKIP IF FD CHK (RD)   CRD00220
00D7 0  C0BB            NT13E LD     H7003                                   CRD00221
00D8 0  D0BC                  STO    ERROR          SET BIT 1 OF INDIC       CRD00222
00D9 0  70EB                  MDX    NT12                                    CRD00223
                        ************************************************** CRD00224
                        *               COLUMN INTERRUPT PROCESSING        * CRD00225
                        ************************************************** CRD00226
                        *     THIS PORTION IS ENTERED FROM INTERR LEVEL    * CRD00227
                        *     SUBROUTINE 00. AFTER THE REQUESTED NO. OF    * CRD00228
                        *     COLUMNS HAS BEEN READ, THE REMAINING COLUMN  * CRD00229
                        *     INTERRUPTS ARE MERELY TURNED OFF AS THEY     * CRD00230
                        *     OCCUR. WHEN THE LAST COLUMN REQUESTED IS     * CRD00231
                        *     PUNCHED. AN INDICATION IS GIVEN TO THE 1442  * CRD00232
                        *     TO INITIATE AN OP COMPLETE INTERRUPT.        * CRD00233
                        ************************************************** CRD00234
00DA 0  D0A8            NT14  STO    CHAR       COLUMN REQUEST INTERRUPT     CRD00235
00DB 0  08A6                  XIO    CHAR-1       SENSE DSW WITH RESET       CRD00236
00DC 01 74FF0094              MDX  L COUNT,-1     ANY MORE COLS TO PROCESS   CRD00237
00DE 0  700D                  MDX    NT18           YES                      CRD00238
00DF 01 4C1000E4              BSC  L NT16,-       IS THIS READ COL INTERR    CRD00239
00E1 C1 74010094              MDX  L COUNT,+1       YES, SET TO SKIP         CRD00240
00E3 0  700B                  MDX    NT22             NEXT COL               CRD00241
00E4 01 74010084        NT16  MDX  L COLM,+1        NO, STORE STOP PUNCH     CRD00242
00E6 01 C4800084              LD   I COLM             BIT (BIT 12) IN COL    CRD00243
00E8 0  E8A5                  OR     D0008            DATA                   CRD00244
00E9 0  D099                  STO    CHAR                                    CRD00245
00EA 0  C097                  LD     ADDR             PUNCH FROM TEMPORARY   CRD00246
00EB 0  D098                  STO    COLM               LOCATION             CRD00247
00EC 01 74010084        NT18  MDX  L COLM,+1      SET ADDR FOR NEXT COLUMN   CRD00248
00EE 0  0895            NT20  XIO    COLM         EXECUTE COLUMN I/O         CRD00249
00EF C1 4C800004        NT22  BSC  I INT1       EXIT                         CRD00250
00F2                          END                                            CRD00251
```

Appendix A. Listing of Subroutines

Figure 23 is a listing of the Card/Paper Tape System Subroutine Library. The Disk Monitor 2 System Library is listed in Figure 24.

Subroutine	Names	Subroutines Required
FORTRAN		
Called by CALL		
Loader Reinitialization (card only)	LOAD	None
Data Switch	DATSW	None
Sense Light On	SLITE, SLITT	None
Overflow Test	OVERF	None
Divide Check Test	DVCHK	None
Function Test	FCTST	None
Trace Start	TSTRT	TSET
Trace Stop	TSTOP	TSET
Integer Transfer of Sign	ISIGN	None
Real Transfer of Sign (E)	ESIGN	ESUB, ELD
Real Transfer of Sign (S)	FSIGN	FSUB, FLD
Called by LIBF (Card/Paper Tape)		
Real IF Trace (E)	VIF	TTEST, VWRT, VIOF, VCOMP
Real IF Trace (S)	WIF	FSTO, TTEST, WWRT, WIOF, WCOMP
Integer IF Trace (E)	VIIF	TTEST, VWRT, VIOF, VCOMP
Integer IF Trace (S)	WIIF	TTEST, WWRT, WIOI, WCOMP
Integer Arithmetic Trace (E)	VIAR, VIARX	TTEST, VWRT, VIOI, VCOMP
Integer Arithmetic Trace (S)	WIAR, WIARX	TTEST, WWRT, WIOI, WCOMP
Real Arithmetic Trace (E)	VARI, VARIX	ESTO, TTEST, VWRT, VIOF, VCOMP
Real Arithmetic Trace (S)	WARI, WARIX	FSTO, TTEST, WWRT, WIOF, WCOMP
Computed GO TO Trace (E)	VGOTO	TTEST, VWRT, VIOI, VCOMP
Computed GO TO Trace (S)	WGOTO	TTEST, WWRT, WIOI, WCOMP
Trace Test-Set Indicator	TTEST, TSET	None
Pause	PAUSE	None
Stop	STOP	None
Subscript Calculation	SUBSC	None
Store Argument Address	SUBIN	None
I/O Linkage (E)	VFIO, VRED, VWRT, VCOMP VIOAI, VIOAF, VIOFX, VIOIX, VIOF, VIOI	FLOAT, ELD/ESTO, IFIX
I/O Linkage (S)	WFIO, WRED, WWRT, WCOMP WIOAI, WIOAF, WIOFX, WIOIX, WIOF, WIOI	FLOAT, FLD/FSTO, IFIX
Card Input/Output	CARDZ	HOLEZ
Printer-Keyboard Output	WRTYZ	GETAD, EBCTB
Printer-Keyboard Input/Output	TYPEZ	GETAD, EBCTB, HOLEZ
1132 Printer Output	PRNTZ	None
Paper Tape Input/Output	PAPTZ	None
Card Code-EBCDIC Conversion	HOLEZ	GETAD, EBCTB, HOLTB
Console Printer Code Table	EBCTB	None
Card-Keyboard Code Table	HOLTB	None
Address Calculation	GETAD	None

Figure 23. C/PT System Subroutine Library (Part 1 of 3)

Subroutine	Names	Subroutines Required
ARITHMETIC AND FUNCTIONAL		
Called by CALL		
Real Hyperbolic Tangent (E)	ETNH, ETANH	EEXP, ELD/ESTO, EADD, EDIV, EGETP
Real Hyperbolic Tangent (S)	FTNH, FTANH	FEXP, FLD/FSTO, FADD, FDIV, FGETP
Real Base to Real Exponent (E)	EAXB, EAXBX	EEXP, ELN, EMPY
Real Base to Real Exponent (S)	FAXB, FAXBX	FEXP, FLN, FMPY
Real Natural Logarithm (E)	ELN, EALOG	XMD, EADD, EMPY, EDIV, NORM, EGETP
Real Natural Logarithm (S)	FLN, FALOG	FSTO, XMDS, FADD, FMPY, FDIV, NORM, FGETP
Real Exponential (E)	EXPN, EEXP	XMD, FARC, EGETP
Real Exponential (S)	FXPN, FEXP	XMDS, FARC, FGETP
Real Square Root (E)	ESQR, ESQRT	ELD/ESTO, EADD, EMPY, EDIV, EGETP
Real Square Root (S)	FSQR, FSQRT	FLD/FSTO, FADD, FMPY, FDIV, FGETP
Real Trigonometric Sine/Cosine (E)	ESIN, ESINE, ECOS, ECOSN	EADD, EMPY, NORM, XMD, EGETP
Real Trigonometric Sine/Cosine (S)	FSIN, FSINE, FCOS, FCOSN	FADD, FMPY, NORM, XMDS, FSTO, FGETP
Real Trigonometric Arctangent (E)	EATN, EATAN	EADD, EMPY, EDIV, XMD, EGETP, NORM
Real Trigonometric Arctangent (S)	FATN, FATAN	FADD, FMPY, FDIV, XMDS, FSTO, FGETP
Fixed-Point Square Root	XSQR	None
Real Absolute Value (E)	EAVL, EABS	EGETP
Real Absolute Value (S)	FAVL, FABS	FGETP
Integer Absolute Value	IABS	None
Real Binary to Decimal/Real Decimal to Binary	FBTD, FDTB	None
Called by LIBF		
Get Parameters (E)	EGETP	ELD
Get Parameters (S)	FGETP	FLD
Real Base to Integer Exponent (E)	EAXI, EAXIX	ELD/ESTO, EMPY, EDVR
Real Base to Integer Exponent (S)	FAXI, FAXIX	FLD/FSTO, FMPY, FDVR
Real Reverse Divide (E)	EDVR, EDVRX	ELD/ESTO, EDIV
Real Reverse Divide (S)	FDVR, FDVRX	FLD/FSTO, FDIV
Real Divide (E)	EDIV, EDIVX	XDD, FARC
Real Divide (S)	FDIV, FDIVX	FARC
Real Multiply (E)	EMPY, EMPYX	XMD, FARC
Real Multiply (S)	FMPY, FMPYX	XMDS, FARC
Real Reverse Subtract (E)	ESBR, ESBRX	EADD
Real Reverse Subtract (S)	FSBR, FSBRX	FADD
Real Add/Subtract (E)	EADD, EADDX, ESUB, ESUBX	FARC, NORM
Real Add/Subtract (S)	FADD, FADDX, FSUB, FSUBX	NORM, FARC
Load/Store FAC (E)	ELD, ELDX, ESTO, ESTOX	None
Load/Store FAC (S)	FLD, FLDX, FSTO, FSTOX	None
Fixed Point Double Word Divide	XDD	XMD
Fixed Point Double Word Multiply	XMD	None
Fixed Point Fractional Multiply (short)	XMDS	None
Real Reverse Sign	SNR	None
Integer to Real	FLOAT	NORM
Real to Integer	IFIX	None
Fixed Integer Base to an Integer Exponent	FIXI, FIXIX	None
Normalize	NORM	None
Real Arithmetic Range Check	FARC	None
DUMP		
Called by CALL		
Dump Status Area	DMP80	None
Selective Dump on Console Printer	DMTX0, DMTD0	WRTY0
Selective Dump on Printer	DMPX1, DMPD1	PRNT1
INTERRUPT LEVEL*		
Level 0		None
Level 1		None
Level 2		None
Level 3		None
Level 4		None
*These subroutines are not identified by name in the card and paper tape systems		
CONVERSION		
Called by LIBF		
Binary to Decimal	BINDC	None
Binary to Hexadecimal	BINHX	None
Decimal to Binary	DCBIN	None
EBCDIC to Console Printer Code	EBPRT	EBPA, PRTY
IBM Card Code to or From EBCDIC	HOLEB	EBPA, HOLL
IBM Card Code to Console Printer Code	HOLPR	HOLL, PRTY

Figure 23. C/PT System Subroutine Library (Part 2 of 3)

Subroutine	Names	Subroutines Required
Called by LIBF (Cont'd)		
Hexadecimal to Binary	HXBIN	None
EBCDIC to or from PTTC/8	PAPEB	EBPA
IBM Card Code to or from PTTC/8	PAPHL	EBPA, HOLL
PTTC/8 to Console Printer Code	PAPPR	None
IBM Card Code to or from EBCDIC	SPEED	None
EBCDIC and PTTC/8 Table	EBPA	None
IBM Card Code Table	HOLL	None
Console Printer Code Table	PRTY	None
DISK SUBROUTINE INITIALIZE		
Called by CALL		
Set Pack Initialization Subroutine	SPIR0, SPIR1, SPIRN	DISK0, DISK1, DISKN
INTERRUPT SERVICE		
Called by LIBF		
Card	CARD0, CARD1	ILS00, ILS04
Disk	DISK0, DISK1, DISKN	ILS02
Paper Tape	PAPT1, PAPTN	ILS04
Plotter	PLOT1	ILS03
1132 Printer	PRNT1	ILS01
Keyboard/Console Printer	TYPE0, WRTY0	HOLL, PRTY, ILS04
PLOTTER SUBROUTINES		
Standard Plot Calls		
Standard Precision Character	FCHAR	FSIN, FCOS, FPLOT, FCHRX, FLD, FSTOX, FSTO
Standard Precision Scale	SCALF	FRULE
Standard Precision Grid	FGRID	FPLOT, POINT, FADD, FLD, FSTO, SNR
Standard Precision Plot	FPLOT	FMOVE, YPLT, PLOT1
Extended Plot Calls		
Extended Precision Character	ECHAR	ESIN, ECOS, EPLOT, ECHRX, ELD, ESTO, ESTOX
Extended Precision Scale	SCALE	ERULE
Extended Precision Grid	EGRID	EPLOT, POINT, EADD, ELD, ESTO, SNR
Extended Precision Plot	EPLOT	EMOVE, XYPLT, PLOT1
Common Plot Call		
Point Characters	POINT	PLOT1
Standard Plot LIBFs		
Standard Precision Annotation	FCHRX, FCHR1, WCHR1	FLOAT, FMPY, IFIX, FADD, FLDX, FINC, XYPLT, PLOT1, FSTOX, FLD
Standard Precision Plot Scaler	FRULE, FMOVE, FINC	FLDX, FSUBX, FMPYX, FLD, FSTOX, FMPY, IFIX, FADD
Extended Plot LIBFs		
Extended Precision Annotation	ECHRX, ECHR1, VCHR1	FLOAT, EMPY, IFIX, EADD, ELDX, EINC, XYPLT, PLOT1, ESTOX, ELD
Extended Precision Plot Scaler	ERULE, EMOVE, EINC	ELDX, ESUBX, EMPYX, ELD, ESTOX, EMPY, IFIX, EADD, ESTO
Common Plot LIBFs		
Pen Mover	XYPLT	PLOT1
Interface	PLOT1	PLOTX
Interrupt Service	PLOTX	
Synchronous Communications Adaptor Subroutines		
Synchronous Communications Adaptor (SCA) STR Mode	SCAT1	IOLOG/CPLOG, ILS01
SCA (BSC, Point-to-Point Mode)	SCAT2	IOLOG/CPLOG, ILS01
SCA (BSC, Multi-Point Mode)	SCAT3	ILS01
1132-SCA Print with Overlap	PRNT2	ILS01
4 of 8 Code to EBCDIC, EBCDIC to 4 of 8 Code	EBC48	HXCV, STRTB
4 of 8 Code to IBM Card, IBM Card Code to 4 of 8 Code	HOL48	HXCV, HOLCA, STRTB
4 of 8 Code to Table of Displacements	HXCV	None
Table of IBM Card Codes	HOLCA	None
Table of 4 of 8 and EBCDIC Codes	STRTB	None

Figure 23. C/PT System Subroutine Library (Part 3 of 3)

System Library Programs	Names	Type and Subtype	Subroutines Required	ID Field (73-75)
MAINLINES				
<u>Disk Maintenance Programs</u>				
Disk Initialization	DISC	2 -	SYSUP, RDREC, DISKZ	U6C
Print Cartridge ID	IDENT	2 -	CALPR, DISKZ	U6F
Change Cartridge ID	ID	2 -	RDREC, CALPR DISKZ	U6G
Disk Copy	COPY	2 -	RDREC, DISKZ	U6B
Writer Sector Addresses in WS	ADRWS (cannot be called)	2 -	Linked from DUP DWADR	U6A
Delete CIB	DLCIB	2 -	RDREC, DISKZ	U6D
Dump System Location Equivalence Table	DSLET	2 -	FSLEN, DISKZ	U6E
Library Maintenance	MODSF	2 -	DISKZ	U6I
System Maintenance	MODIF	2 -	DISKZ	U6H
Disk Data File Conversion[1]	DFCNV	2 -	DISK1, ELD FLD, NORM	W1L
<u>Paper Tape Utility</u>				
Keyboard or 1134 Input/Console Printer or 1055 Output	PTUTL	2 -	PAPHL, PAPPR, PAPT1, TYPE0	U6J
SUBROUTINES				
<u>Utility Calls</u>				
Selective Dump on Console Printer	DMTD0, DMTX0	4,0	WRTY0	U5B
Selective Dump on 1132 Printer	DMPD1, DMPX1	4,0	PRNT1	U5C
Dump 80 Subroutine	DMP80	4,0	None	U5A
Update DCOM	SYSUP	4,0	FSLEN, FSYSU	U5E
Call System Print	CALPR	4,0	FSLEN	U7A
Read *ID Record	RDREC	4,0	FSLEN	U7C
Fetch Phase IDs or, Fetch System Subroutine	FSLEN, FSYSU	4,0	DISKZ	U7B
Dummy Log Subroutine for SCA Subroutines	IOLOG/CPLOG	4,0	None	
<u>Common FORTRAN Calls</u>				
Test Data Entry Switches	DATSW	4,8	None	T3A
Divide Check Test	DVCHK	4,8	None	T3B
Functional Error Test	FCTST	4,8	None	T3C
Overflow Test	OVERF	4,8	None	T3E
Selective Dump	PDUMP	4,0	SFIO, SIOAI, SIOAF, SWRT, SCOMP	T3F

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[1]Not distributed to papertape users.

Figure 24. 1130 Disk Monitor Version 2 System Library (Part 1 of 9)

System Library Programs	Names	Type and Subtype	Subroutines Required	ID Field (73-75)
Common FORTRAN Calls (continued)				
Sense Light Control and Test	SLITE, SLITT	4,8	None	T3G
FORTRAN Trace Stop	TSTOP	4,8	TSET	T3H
FORTRAN Trace Start	TSTRT	4,8	TSET	T3I
Integer Transfer of Sign	ISIGN	4,8	None	T3D
Extended Arith/Funct Calls				
Extended Precision Hyperbolic Tangent	ETANH, ETNH	4,8	EEXP, EADD, EDIV, EGETP, ELD/ESTO	S2I
Extended Precision A**B Function	EAXB, EAXBX	4,8	EEXP, ELN, EMPY	S2C
Extended Precision Natural Logarithm	ELN, EALOG	4,8	XMD, EADD, EMPY, EDIV, NORM, EGETP	S2E
Extended Precision Exponential	EEXP, EXPN	4,8	XMD, FARC, EGETP	S2D
Extended Precision Square Root	ESQR, ESQRT	4,8	EADD, EMPY, EDIV, EGETP, ELD/ESTO	S2H
Extended Precision Sine-Cosine	ESIN, ESINE, ECOS, ECOSN	4,8	EADD, EMPY, NORM, XMD, EGETP	S2G
Extended Precision Arctangent	EATN, EATAN	4,8	EADD, EMPY, EDIV, XMD, EGETP, NORM	S2B
Extended Precision Absolute Value Function	EABS, EAVL	4,8	EGETP	S2A
FORTRAN Sign Transfer Calls				
Extended Precision Transfer of Sign	ESIGN	4,8	ESUB, ELD	S2F
Standard Precision Transfer of Sign	FSIGN	4,8	FSUB, FLD	R2F
Standard Arith/Funct Calls				
Standard Precision Hyperbolic Tangent	FTANH, FTNH	4,8	FEXP, FADD, FDIV, FGETP, FLD/FSTO	R2I
Standard Precision A**B Function	FAXB, FAXBX	4,8	FEXP, FLN, FMPY	R2C
Standard Precision Natural Logarithm	FLN, FALOG	4,8	FSTO, XMDS FADD, FMPY, FDIV, NORM FGETP	R2E
Standard Precision Exponential	FEXP, FXPN	4,8	XMDS, FARC, FGETP	R2D
Standard Precision Square Root	FSQR, FSQRT	4,8	FADD, FMPY, FDIV, FGETP, FLD/FSTO	R2H
Standard Precision Sine-Cosine	FSIN, FSINE FCOS, FCOSN	4,8	FADD, FMPY, NORM, XMDS, FSTO, FGETP	R2G
Standard Precision Arctangent	FATN, FATAN	4,8	FADD, FMPY, FDIV, XMDS, FSTO, FGETP	R2B
Standard Precision Absolute Value Function	FABS, FAVL	4,8	FGETP	R2A

Figure 24. 1130 Disk Monitor Version 2 System Library (Part 2 of 9)

System Library Programs	Names	Type and Subtype	Subroutines Required	ID Field (73-75)
Common Arith/Funct Calls				
Fixed Point (Fractional) Square Root	XSQR	4,8	None	T1C
Integer Absolute Function	IABS	4,8	None	T1B
Floating Binary/EBC Decimal Conversions	FBTD (BIN. TO DEC.) FDTB (DEC. TO BIN.)	4,0	None	T1A
Flipper for LOCAL/SOCAL Subprograms	FLIPR	4,0	DISKZ, DISK1, or DISKN	U5D
FORTRAN Trace Subroutines				
Extended Floating Variable Trace	SEAR, SEARX	3,0	ESTO, TTEST, SWRT, SIOF, SCOMP	S2J
Fixed Variable Trace	SIAR, SIARX	3,0	TTEST, SWRT, SIOI, SCOMP	T6B
Standard Floating IF Trace	SFIF	3,0	FSTO, TTEST, SWRT, SIOF, SCOMP	R2K
Extended Floating IF Trace	SEIF	3,0	FSTO, TTEST, SWRT, SIOF, SCOMP	S2K
Fixed IF Trace	SIIF	3,0	TTEST, SWRT, SIOI, SCOMP	T6C
Standard Floating Variable Trace	SFAR, SFARX	3,0	FSTO, TTEST, SWRT, SIOF, SCOMP	R2J
GO TO Trace	SGOTO	3,0	TTEST, SWRT, SIOI, SCOMP	T6A
Nondisk FORTRAN Format I/O				
FORTRAN Format Subroutine	SFIO, SIOI, SIOAI, SIOF, SIOAF, SIOFX, SCOMP, SWRT, SRED, SIOIX	3,3	FLOAT, IFIX, ELD/ESTO or FLD/FSTO, PAUSE	T4C
FORTRAN Find Subroutine	SDFND	3,1	DISKZ, DISK1, or DISKN	T4B
Disk FORTRAN I/O	SDFIO, SDRED, SDWRT, SDCOM, SDAF, SDF, SDI, SDIX, SDFX, SDAI	3,1	DISKZ, DISK1, or DISKN, PAUSE	T4A
Unformatted FORTRAN Disk I/O	UFIO, URED, UWRT, UIOI, UIOF, UIOAI, UIOAF, UIOFX, UIOIX, UCOMP, BCKSP, EOF, REWND	3,1	DISKZ, DISK1, or DISKN, PAUSE	T4D

Figure 24. 1130 Disk Monitor Version 2 System Library (Part 3 of 9)

System Library Programs	Names	Type and Subtype	Subroutines Required	ID Field (73-75)
<u>FORTRAN Common LIBFs</u>				
FORTRAN Pause	PAUSE	3,0	None	T2A
FORTRAN Stop	STOP	3,2	None	T2B
FORTRAN Subscript Displacement Calculation	SUBSC	3,0	None	T2D
FORTRAN Subroutine Initialization	SUBIN	3,0	None	T2C
FORTRAN Trace Test and Set	TTEST, TSET	3,0	None	T2E
<u>FORTRAN I/O and Conversion Subroutines</u>				
FORTRAN 1442 Input/Output Subroutine	CARDZ	5,3	HOLEZ, GETAD, EBCTB, HOLTB, ILS00, ILS04	T5A
FORTRAN 1442 Output Subroutine	PNCHZ	5,3	HOLEZ, GETAD, EBCTB, HOLTB, ILS00, ILS04	T5G
FORTRAN 2501 Input Subroutine	READZ	5,3	HOLEZ, GETAD, EBCTB, HOLTB, ILS04	T5J
Disk I/O Routine (Part of Supervisor)	DISKZ	-	ILS02	---
FORTRAN Paper Tape Subroutine	PAPTZ	5,3	ILS04	T5F
FORTRAN 1132 Printer Subroutine	PRNTZ	5,3	ILS01	T5H
Call to PRNTZ to Call to PRNT2 Conversion	PRTZ2	5,3	PRNT2, ILS01	WIK
FORTRAN 1403 Printer Subroutine	PRNZ	5,3	ILS04	T5I
FORTRAN Keyboard-Typewriter Subroutine	TYPEZ	5,3	GETAD, EBCTB, HOLEZ, ILS04	T5K
FORTRAN Typewriter Subroutine	WRTYZ	5,3	GETAD, EBCTB, ILS04	T5L
FORTRAN 1627 Plotter Subroutine	PLOTX	5,0	ILS03	V1L
FORTRAN Hollerith to EBCDIC Conversion	HOLEZ	3,3	GETAD, EBCTB, HOLTB, PAUSE	T5D
FORTRAN Get Address Routine	GETAD	3,3	None	T5C
FORTRAN EBCDIC Table	EBCTB	3,3	None	T5B
FORTRAN Hollerith Table	HOLTB	3,3	None	T5E
FORTRAN Multiple Terminal Communications Adapter (MTCA) Call Interface	MTCAZ	4,0	MTCA0	W5C
<u>Extended Arith/Funct LIBFs</u>				
Extended Precision Get Parameter Subroutine	EGETP	3,2	ELD	S1E
Extended Precision A**I Function	EAXI, EAXIX	3,2	ELD/ESTO EMPY, EDVR	S1B
Extended Precision Divide Reverse	EDVR, EDVRX	3,2	ELD/ESTO, EDIV	S1D
Extended Precision Float Divide	EDIV, EDIVX	3,2	XDD, FARC	S1C
Extended Precision Float Multiply	EMPY, EMPYX	3,2	XMD, FARC	S1G
Extended Precision Subtract Reverse	ESBR, ESBRX	3,2	EADD	S1H
Extended Add-Subtract	EADD, ESUB, EADDX, ESUBX	3,2	FARC, NORM	S1A
Extended Load-Store	ELD, ELDX, ESTO, ESTOX	3,0	None	S1F

Figure 24. 1130 Disk Monitor Version 2 System Library (Part 4 of 9)

System Library Programs	Names	Type and Subtype	Subroutines Required	ID Field (73-75)
Standard Arith/Funct LIBFs				
Standard Precision Get Parameter Subroutine	FGETP	3,2	FLD	R1E
Standard Precision A**I Function	FAXI, FAXIX	3,2	FLD/FSTO, FMPY, FDVR	R1B
Standard Precision Divide Reverse	FDVR, FDVRX	3,2	FLD/FSTO, FDIV	R1D
Standard Precision Float Divide	FDIV, FDIVX	3,2	FARC	R1C
Standard Precision Float Multiply	FMPY, FMPYX	3,2	XMDS, FARC	R1G
Standard Precision Subtract Reverse	FSBR, FSBRX	3,2	FADD	R1H
Standard Add-Subtract	FADD, FSUB, FADDX, FSUBX	3,2	NORM, FARC	R1A
Standard Load-Store	FLD, FLDX, FSTO, FSTOX	3,0	None	R1F
Standard Precision Fractional Multiply	XMDS	3,2	None	S3I
Common Arith/Funct LIBFs				
Fixed (Fractional) Double Divide	XDD	3,2	XMD	S3G
Fixed Point (Fractional) Double Multiply	XMD	3,2	None	S3H
Sign Reversal Function	SNR	3,2	None	S3F
Integer to Floating Point Function	FLOAT	3,0	NORM	S3C
Floating Point to Integer Function	IFIX	3,0	None	S3D
I**J Integer Function	FIXI, FIXIX	3,2	None	S3B
Normalize Subroutine	NORM	3,0	None	S3E
Floating Accumulator Range Check Subroutine	FARC	3,2	None	S3A
Interrupt Service Subroutines				
1442 Card Read Punch Input/Output (No error Parameter)	CARD0	5,0	ILS00, ILS04	U2A
1442 Card Read Punch Input/Output (Error Parameter)	CARD1	5,0	ILS00, ILS04	U2B
2501 Card Read Input (No Error Parameter)	READ0	5,0	ILS04	U2L
2501 Card Read Input (Error Parameter)	READ1	5,0	ILS04	U2M
1442 Card Punch Output (No Error Parameter)	PNCH0	5,0	ILS00, ILS04	U2H
1442 Card Punch Output (Error Parameter)	PNCH1	5,0	ILS00, ILS04	U2I
Multiple Sector Disk Input/Output (Part of Supervisor)	DISK1	-	ILS02	---
High Speed Multiple Sector Disk Input/Output (Part of Supervisor)	DISKN	-	ILS02	---
Synchronous Communications Adapter (SCA) STR Mode	SCAT1	5,0	IOLOG/CPLOG, ILS01	W1F
SCA (BSC, Point-to-Point Mode)	SCAT2	5,0	IOLOG/CPLOG, ILS01	W1H
SCA (BSC, Multi-Point Mode	SCAT3	5,0	IOLOG/CPLOG, ILS01	W1I
Paper Tape Input/Output	PAPT1	5,0	ILS04	U2D
Simultaneous Paper Tape Input/Output	PAPTN	5,0	ILS04	U2E
Character/Word Count Paper Tape Input/Output	PAPTX	5,0	ILS04	U2F

Figure 24. 1130 Disk Monitor Version 2 System Library (Part 5 of 9)

System Library Programs	Names	Type and Subtype	Subroutines Required	ID Field (73-75)
Interrupt Service Subroutines (continued)				
Plotter Output Subroutine	PLOT1	5,0	ILS03	U2G
Plotter Output Subroutine	PLOTX	5,0	ILS03	V1L
1132 Printer Output Subroutine	PRNT1	5,0	ILS01	U2J
1132-SCA Print With Overlap	PRNT2	5,0	ILS01	W1E
1403 Printer Output Subroutine	PRNT3	5,0	ILS04	U2K
Keyboard/Console Printer Input/Output	TYPE0	5,0	HOLL, PRTY ILS04	U2N
Console Printer Output Subroutine	WRTY0	5,0	ILS04	U2O
1231 Optical Mark Page Reader Input Subroutine	OMPR1	5,0	ILS04	U2C
MTCA Base Section	MTCA0	5,0	ILS03, TSM41, TSTTY	W5B
MTCA 2741 Terminal Select	TSM41	4,0	None	W5D
MTCA Teletype Select	TSTTY	4,0	None	W5E
Conversion Subroutines				
Binary Word to 6 Decimal Characters (Card Code)	BINDC	3,0	None	U4B
Binary Word to 4 Hexadecimal Characters (Card Code)	BINHX	3,0	None	U4C
6 Decimal Characters (Card Code) to Binary Word	DCBIN	3,0	None	U4G
EBCDIC to Console Printer Output Code	EBPRT	3,0	EBPA, PRTY	U3A
Card Code to EBCDIC-EBCDIC to Card Code	HOLEB	3,0	EBPA, HOLL	U3B
Card Code to Console Printer Output Code	HOLPR	3,0	HOLL, PRTY	U3C
4 Hexadecimal Characters (Card Code) to Binary Word	HXBIN	3,0	None	U3D
PTTC/8 to EBCDIC-EBCDIC to PTTC/8	PAPEB	3,0	EBPA	U3E
PTTC/8 to Card Code-Card Code to PTTC/8	PAPHL	3,0	EBPA, HOLL	U3F
PTTC/8 to Console Printer Output Code	PAPPR	3,0	EBPA, PRTY	U3G
Card Code to EBCDIC-EBCDIC to Card Code	SPEED	3,0	None	U3H
4 of 8 Code to EBCDIC-EBCDIC to 4 of 8 Code	EBC48	3,0	HXCV, STRTB	W1A
4 of 8 Code to IBM Card Code-IBM Card Code to 4 of 8 Code	HOL48	3,0	HXCV, HOLCA, STRTB	W1B
4 of 8 Code to Table of Displacements	HXCV	3,0	None	W1D
32-Bit Binary Value to IBM Card Code Decimal Value	BIDEC	3,0	None	U4A
IBM Card Code Decimal Value to 32-Bit Binary Value	DECBI	3,0	None	U4H
Supplement to All Standard Conversions Except Those Involving PTTC/8	ZIPCO	3,0	Any ZIPCO Conversion Table	U3I
MTCA Code Conversion	FEB41, BEB41, F41EB, B41EB, QEB41, Q41EB	4,0	None	W5A
Conversion Tables				
EBCDIC and PTTC/8	EBPA	3,0	None	U4K
Card Code Table	HOLL	3,0	None	U4P
Console Printer Output Code Table	PRTY	3,0	None	U4Q
Table of IBM Card Codes	HOLCA	3,0	None	W1C
Table of 4 of 8 and EBCDIC Codes	STRTB	3,0	None	W1G

Figure 24. 1130 Disk Monitor Version 2 System Library (Part 6 of 9)

System Library Programs	Names	Type and Subtype	Subroutines Required	ID Field (73-75)
ZIPCO Conversion Tables				
EBCDIC to Console Printer Code	EBCCP	4,0	None	U4I
EBCDIC to IBM Card Code	EBHOL	4,0	None	U4J
EBCDIC to 1403 Printer Code	EBPT3	4,0	None	U4L
Console Printer Code to EBCDIC	CPEBC	4,0	None	U4D
Console Printer Code to IBM Card Code	CPHOL	4,0	None	U4E
Console Printer Code to 1403 Printer Code	CPPT3	4,0	None	U4F
IBM Card Code to EBCDIC	HLEBC	4,0	None	U4M
IBM Card Code to Console Printer Code	HOLCP	4,0	None	U4O
IBM Card Code to 1403 Printer Code	HLPT3	4,0	None	U4N
1403 Printer Code to EBCDIC	PT3EB	4,0	None	U4S
1403 Printer Code to Console Printer Code	PT3CP	4,0	None	U4R
1403 Printer Code to IBM Card Code	PTHOL	4,0	None	U4T
Log Subroutine				
Dummy Log Subroutine called by SCAT1, SCAT2, SCAT3	IOLOG, CPLOG	4,0	None	W1J
Interrupt Level Subroutines				
Interrupt Level Zero Subroutine	ILS00	7,0	None	U1A
Interrupt Level One Subroutine	ILS01	7,0	None	U1B
Interrupt Level Two Subroutine (Part of Supervisor)	ILS02	7,1	None	U1C
Interrupt Level Three Subroutine	ILS03	7,0	None	U1D
Interrupt Level Four Subroutine (Part of Supervisor)	ILS04	7,1	None	U1E
Special Interrupt Level Subroutines (Restores Index Register 3)				
Interrupt Level Zero Subroutine	ILSX0	7,0	None	U1F
Interrupt Level One Subroutine	ILSX1	7,0	None	U1G
Interrupt Level Two Subroutine	ILSX2	7,0	None	U1H
Interrupt Level Three Subroutine	ILSX3	7,0	None	U1I
Interrupt Level Four Subroutine	ILSX4	7,0	None	U1J
Standard Plot Calls				
Standard Precision Character	FCHAR	4,0	FSIN, FCOS, FPLOT, FCHRX, FLD, FSTOX, FSTO	V1F
Standard Precision Scale	SCALF	4,0	FRULE	V1O
Standard Precision Grid	FGRID	4,0	FPLOT, POINT, FADD, FLD, FSTO, SNR	V1H
Standard Precision Plot	FPLOT	4,0	FMOVE, XYPLT, PLOT1	V1I
Extended Precision Character	ECHAR	4,0	ESIN, ECOS, EPLOT, ECHRX, ELD, ESTO, ESTOX	V1A

Figure 24. 1130 Disk Monitor Version 2 System Library (Part 7 of 9)

System Library Programs	Names	Type and Subtype	Subroutines Required	ID Field (73-75)
Standard Plot Calls (continued)				
Extended Precision Scale	SCALE	4,0	ERULE	V1N
Extended Precision Grid	EGRID	4,0	EPLOT, POINT, EADD, ELD, ESTO, SNR	V1C
Extended Precision Plot	EPLOT	4,0	EMOVE, XYPLT, PLOT1	V1D
Common Plot Call				
Point Characters	POINT	4,0	PLOTI	V1M
Standard Plot LIBFs				
Standard Precision Annotation	FCHRX, FCHRI, WCHRI	3,0	FLOAT, FMPY IFIX, FADD, FLDX, FINC, XYPLT, PLOTI, FSTOX, FLD	V1G
Standard Precision Plot Scaler	FRULE, FMOVE, FINC	3,0	FLDX, FSUBX, FMPYX, FLD, FSTOX, FMPY, IFIX, FADD	V1J
Extended Plot LIBFs				
Extended Precision Annotation	ECHRX, ECHRI, VCHRI	3,0	FLOAT, EMPY, IFIX, EADD, ELDX, EINC, XYPLT, PLOTI, ESTOX, ELD	V1B
Extended Precision Plot Scaler	ERULE, EMOVE, EINC	3,0	ELDX, ESUBX, EMPYX, ELD, ESTOX, EMPY, IFIX, EADD, ESTO	V1E
Common Plot LIBFs				
Pen Mover	XYPLT	3,2	PLOTI	V1P
Interface	PLOTI	3,2	PLOTX	V1K
Interrupt Service	PLOTX	5,0	ILS03	V1L
Disk I/O				
Sequential Address	SEQOP, SEQIO, SEQCL	3,0	DISKZ	W2F
Direct Access	DAOPN, DAIO, DACLS	3,0	DISKZ	W3E
ISAM Load	ISLDO, ISLD, ISLDC	3,0	DISKZ	W3D
ISAM Add	ISADO, ISAD, ISADC	3,0	DISKZ	W3C
ISAM Sequential	ISEQO, ISETL, ISEQ, ISEQC	3,0	DISKZ	W3B
ISAM Random	ISRDO, ISRD, ISRDC	3,0	DISKZ	W3A

Figure 24. 1130 Disk Monitor Version 2 System Library (Part 8 of 9)

System Library Programs	Names	Type and Subtype	Subroutines Required	ID Field (73-75)
RPG Decimal Arithmetic				
Add, Subtract, and Numeric Compare[1]	RGADD, RGSUB, RGNCP	3,0	None	W2T
Multiply[1]	RGMLT	3,0	RGBTD, RGDTB	W2S
Divide[1]	RGDIV	3,0	None	W2R
Move Remainder[1]	RGMVR	3,0	RGETD	W2Q
Binary Conversion[1]	RGBTD, RGDTB	3,0	None	W2P
RPG Sterling and Edit				
Sterling Input Conversion[1]	RGSTI	3,0	RGBTD, RGDTB	W4B
Sterling Output Conversion[1]	RGSTO	3,0	RGETD, RGDTE	W4A
Edit[1]	RGEDT	3,0	RGMV2, RGSI5	W2O
RPG Move				
From I/O Buffer to Core[1]	RGMV1, RGMV5	3,0	None	W2N
From Core to I/O Buffer[1]	RGMV2	3,0	None	W2M
MOVE Operation[1]	RGMV3	3,0	None	W2L
MOVEL Operation[1]	RGMV4	3,0	None	W2K
RPG Compare				
Alphameric[1]	RGCMP	3,0	None	W2J
RPG Indicators				
Test[1]	RGSI1	3,0	None	W2I
Set Resulting On[1]	RGSI2	3,0	None	W2H
Set on, Set off[1]	RGSI3, RGSI4	3,0	None	W2G
Test for 0 or Blank[1]	RGSI5	3,0	None	W2F
RPG Miscellaneous				
Test Zone[1]	RGTSZ	4,0	None	W2D
Convert to Binary[1]	RGCVB	3,0	None	W2C
Object Time Error[1]	RGERR	4,0	None	W2B
Blank After[1]	RGBLK	3,0	None	W2A
Alternating Sequence[1]	ALTSE	--		

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[1]Not distributed to papertape users.

Figure 24. 1130 Disk Monitor Version 2 System Library (Part 9 of 9)

Appendix B. Errors Detected by the ISS Subroutines

ERROR	CONTENTS OF ACCUMULATOR: Binary	CONTENTS OF ACCUMULATOR: Hexadecimal	Contents of Extension (if any)
1442 Card Read Punch or 1442 Card Punch			
*Last card	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0	
*Feed check *Read check *Punch check	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1	0 0 0 1	
Device not ready Last card indicator on for Read	0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0	1 0 0 0	
Illegal device (not 0 version) Device not in system Illegal function Word count over +80 Word count zero or negative	0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 1	1 0 0 1	
Keyboard/Console Printer			
Device not ready	0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0	2 0 0 0	
Device not in system Illegal function Word count zero or negative	0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1	2 0 0 1	
Keyboard wants input (TYPEZ only)	0 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0	2 0 0 2	
1134/1055 Paper Tape Reader/Punch			
*Punch not ready	0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0	0 0 0 4	
*Reader not ready	0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1	0 0 0 5	
Device not ready	0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0	3 0 0 0	
Illegal device Illegal function Word count zero or negative Illegal check digit	0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 1	3 0 0 1	
2501 Card Reader			
*Last card	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0	
*Feed check *Read check	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1	0 0 0 1	
Device not ready	0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0	4 0 0 0	
Illegal function Word count over +80 Word count zero or negative	0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1	4 0 0 1	
Disk			
*Data error remaining after 16 attempts (DM2) or 10 attempts (C/PT) during read operation.	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1	0 0 0 1	Bits 0-3 logical drive number, bits 4-15 working sector address.
*Data error remaining after 16 attempts (DM2) or 10 attempts (C/PT) during write operation.	0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0	0 0 0 2	Bits 0-3 logical drive number, bits 4-15 working sector address.
*Seek failure remaining after 16 attempts (DM2) or 10 attempts (C/PT).	0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1	0 0 0 3	Bits 0-3 logical drive number, bits 4-15 working sector address.
*Attempt to read or write above sector address 1599 (disk overflow).	0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0	0 0 0 4	
Device not ready.	0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0	5 0 0 0	

ERROR	CONTENTS OF ACCUMULATOR		Contents of Extension (if any)
	Binary	Hexadecimal	
Disk (continued)			
Illegal device, invalid function, device not on system, attempt to write in file protected area, word count zero or negative or starting address over 1599 (DISK1 and DISKZ only).	0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 1	5 0 0 1	
Write select/Power unsafe.	0 1 0 1 0 0 0 0 0 0 0 0 0 0 1 0	5 0 0 2	
Data error during read/write operation or seek failure after 16 attempts (DM2) or 10 attempts (C/PT) or on an attempt to read or write above sector address 1599 (disk overflow). Error occurred during the processing of a Monitor call. (DISK1 and DISKZ only).	0 1 0 1 0 0 0 0 0 0 0 0 0 1 0 0	5 0 0 3	Bits 0–3 logical drive number, bits 4–15 working, sector address, except for disk overflow.
Data error remaining after 16 attempts (DISKZ only).	0 1 0 1 0 0 0 0 0 0 0 0 0 1 0 0	5 0 0 4	Bits 0–3 logical drive number, bits 4–15 working sector address + 1.
1132 Printer			
*Channel 9 detected	0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1	0 0 0 3	
*Channel 12 detected	0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0	0 0 0 4	
Device not ready or end of forms	0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0	6 0 0 0	
Illegal function Word count over +60 Word count zero or negative	0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1	6 0 0 1	
Plotter			
Plotter not ready	0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0	7 0 0 0	
Illegal function Word count zero or negative	0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 1	7 0 0 1	
1403 Printer			
*Ring check *Sync check *Parity check	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1	0 0 0 1	
*Channel 9 detected	0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1	0 0 0 3	
*Channel 12 detected	0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0	0 0 0 4	
Device not ready or end of forms	1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0	9 0 0 0	
Illegal function Word count over +60 Word count zero or negative	1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 1	9 0 0 1	
PRNZ only: Ring check Sync check Parity check	1 0 0 1 0 0 0 0 0 0 0 0 0 0 1 0	9 0 0 2	
Optical Mark Page Reader			
Master mark	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1	0 0 0 1	
Timing mark error Read error	0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0	0 0 0 2	
Hopper empty	0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1	0 0 0 3	
Document selected	0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0	0 0 0 4	
Device not ready	1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0	A 0 0 0	
Illegal function	1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1	A 0 0 1	
Feed check, last document processed	1 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0	A 0 0 2	
Feed check, last document not processed	1 0 1 0 0 0 0 0 0 0 0 0 0 0 1 1	A 0 0 3	

NOTE: The errors marked with an asterisk cause a branch to user error routine. These are postoperative errors and are detected during the processing of interrupts; as a consequence, the user error subroutine is an interrupt subroutine, executed at the priority level of the I/O device. All other errors cause a branch to location /0029 on the C/PT system or to one of the traps in the DM2 system, at $PRET, $PST1, $PST2, $PST3, or $PST4. If the error WAIT is in the preoperative Error Trap the address of the LIBF or the CALL is in location $PRET.

Appendix C. Subroutine Action on Return from a User's Error Subroutine

Error Code	Condition	Subroutine Action
1442 Card Read Punch or 1442 Card Punch		
0000	If function is PUNCH otherwise	Eject card and terminate Terminate immediately
0001[1]	If Accumulator is 0 otherwise	Terminate immediately C/PT System: Loop until 1442 is ready, then reinitiate operation DM2 System: WAIT at $PST4, clear 1442 with NPRO key, assure that 2nd card run out is in correct pre-punched form (1st card contains punch error), replace cards in 1442 hopper, press 1442 start key, and press PROGRAM START.
2501 Card Reader		
0000		Terminate
0001[1]	If Accumulator is 0 otherwise	Terminate immediately WAIT at $PST4 until 2501 is readied and PROGRAM START pressed
1134/1055 Paper Tape Reader/Punch		
0004, 0005	If Accumulator is 0 otherwise	Terminate immediately Check again for device ready
Disk		
0001, 0002, and 0003	If Accumulator is 0 otherwise	Terminate immediately Retry 10 times (C/PT system), or 16 times (DM2 system)
0004		Terminate and go to exit
1132 Printer		
0003, and 0004	If Accumulator is 0 otherwise	Terminate immediately Skip to channel 1 and then terminate
1403 Printer		
0001	If Accumulator is 0 otherwise	Terminate immediately Check for device ready and reinitiate the operation
0003, and 0004	If Accumulator is 0 otherwise	Terminate immediately Skip to channel 1 and then terminate
1231 OMPR		
0001	If Accumulator is 0 otherwise	Continue normal processing Use contents of Accumulator as new address of I/O area
0002[1]	If Accumulator is 0 otherwise	Terminate immediately Check device ready, then reinitiate operation
0003		Terminate
0004[1]	If Accumulator is 0 otherwise[2]	Terminate immediately Check device ready, then reinitiate operation

[1] Assumes operator intervention
[2] User must provide a WAIT in his error subroutine to allow him to remove the sheet from the select stacker, place the sheet back in the hopper, and make the 1231 ready.

Appendix D. Character Code Chart

Ref No.	EBCDIC Binary 0123	EBCDIC Binary 4567	EBCDIC Hex	IBM Card Code Rows 12	11	0	9	8	7-1	IBM Card Code Hex	Graphics and Control Names		1132 Printer EBCDIC Subset Hex	PTTC/8 Hex U-Upper Case L-Lower Case	Console Printer Hex	Notes	1403 Printer Hex
0	0000	0000	00	12		0	9	8	1	B030	NUL						
1		0001	01	12			9		1	9010							
2		0010	02	12			9		2	8810							
3		0011	03	12			9		3	8410							
4		0100	04	12			9		4	8210	PF	Punch Off					
5*		0101	05	12			9		5	8110	HT	Horiz. Tab		6D (U/L)	41	①	
6*		0110	06	12			9		6	8090	LC	Lower Case		6E (U/L)			
7*		0111	07	12			9		7	8050	DEL	Delete		7F (U/L)			
8		1000	08	12			9	8		8030							
9		1001	09	12			9	8	1	9030							
10		1010	0A	12			9	8	2	8830							
11		1011	0B	12			9	8	3	8430							
12		1100	0C	12			9	8	4	8230							
13		1101	0D	12			9	8	5	8130							
14		1110	0E	12			9	8	6	80B0							
15		1111	0F	12			9	8	7	8070							
16	0001	0000	10	12	11		9	8	1	D030							
17		0001	11		11		9		1	5010							
18		0010	12		11		9		2	4810							
19		0011	13		11		9		3	4410							
20*		0100	14		11		9		4	4210	RES	Restore		4C (U/L)	05	②	
21*		0101	15		11		9		5	4110	NL	New Line		DD (U/L)	81	③	
22*		0110	16		11		9		6	4090	BS	Backspace		5E (U/L)	11		
23		0111	17		11		9		7	4050	IDL	Idle					
24		1000	18		11		9	8		4030							
25		1001	19		11		9	8	1	5030							
26		1010	1A		11		9	8	2	4830							
27		1011	1B		11		9	8	3	4430							
28		1100	1C		11		9	8	4	4230							
29		1101	1D		11		9	8	5	4130							
30		1110	1E		11		9	8	6	40B0							
31		1111	1F		11		9	8	7	4070							
32	0010	0000	20		11	0	9	8	1	7030							
33		0001	21			0	9		1	3010							
34		0010	22			0	9		2	2810							
35		0011	23			0	9		3	2410							
36		0100	24			0	9		4	2210	BYP	Bypass					
37*		0101	25			0	9		5	2110	LF	Line Feed		3D (U/L)	03		
38*		0110	26			0	9		6	2090	EOB	End of Block		3E (U/L)			
39		0111	27			0	9		7	2050	PRE	Prefix					
40		1000	28			0	9	8		2030							
41		1001	29			0	9	8	1	3030							
42		1010	2A			0	9	8	2	2830							
43		1011	2B			0	9	8	3	2430							
44		1100	2C			0	9	8	4	2230							
45		1101	2D			0	9	8	5	2130							
46		1110	2E			0	9	8	6	20B0							
47		1111	2F			0	9	8	7	2070							
48	0011	0000	30	12	11	0	9	8	1	F030							
49		0001	31				9		1	1010							
50		0010	32				9		2	0810							
51		0011	33				9		3	0410							
52		0100	34				9		4	0210	PN	Punch On					
53*		0101	35				9		5	0110	RS	Reader Stop		0D (U/L)	09	④	
54*		0110	36				9		6	0090	UC	Upper Case		0E (U/L)			
55		0111	37				9		7	0050	EOT	End of Trans.					
56		1000	38				9	8		0030							
57		1001	39				9	8	1	1030							
58		1010	3A				9	8	2	0830							
59		1011	3B				9	8	3	0430							
60		1100	3C				9	8	4	0230							
61		1101	3D				9	8	5	0130							
62		1110	3E				9	8	6	00B0							
63		1111	3F				9	8	7	0070							

NOTES: Typewriter Output
① Tabulate
② Shift to black
③ Carrier Return
④ Shift to red

* Recognized by all Conversion subroutines
Codes that are not asterisked are recognized only by the SPEED subroutine

Ref No.	EBCDIC Binary 0123	EBCDIC Binary 4567	EBCDIC Hex	IBM Card Code Rows 12	11	0	9	8	7-1	IBM Card Code Hex	Graphics and Control Names	1132 Printer EBCDIC Subset Hex	PTTC/8 Hex U-Upper Case L-Lower Case	Console Printer Hex	1403 Printer Hex
64*	0100	0000	40	no punches						0000	blank	40**	10 (U/L)	21	7F
65		0001	41	12		0	9		1	B010					
66		0010	42	12		0	9		2	A810					
67		0011	43	12		0	9		3	A410					
68		0100	44	12		0	9		4	A210					
69		0101	45	12		0	9		5	A110					
70		0110	46	12		0	9		6	A090					
71		0111	47	12		0	9		7	A050					
72		1000	48	12		0	9	8		A030					
73		1001	49	12				8	1	9020					
74*		1010	4A	12				8	2	8820	¢		20 (U)	02	
75*		1011	4B	12				8	3	8420	. (period)	4B	6B (L)	00	6E
76*		1100	4C	12				8	4	8220	<		02 (U)	DE	
77*		1101	4D	12				8	5	8120	(	4D	19 (U)	FE	57
78*		1110	4E	12				8	6	80A0	+	4E	70 (U)	DA	6D
79*		1111	4F	12				8	7	8060	| (logical OR)		3B (U)	C6	
80*	0101	0000	50	12						8000	&	50	70 (L)	44	15
81		0001	51	12	11		9		1	D010					
82		0010	52	12	11		9		2	C810					
83		0011	53	12	11		9		3	C410					
84		0100	54	12	11		9		4	C210					
85		0101	55	12	11		9		5	C110					
86		0110	56	12	11		9		6	C090					
87		0111	57	12	11		9		7	C050					
88		1000	58	12	11		9	8		C030					
89		1001	59		11			8	1	5020					
90*		1010	5A		11			8	2	4820	!		5B (U)	42	
91*		1011	5B		11			8	3	4420	$	5B	5B (L)	40	62
92*		1100	5C		11			8	4	4220	*	5C	08 (U)	D6	23
93*		1101	5D		11			8	5	4120	)	5D	1A (U)	F6	2F
94*		1110	5E		11			8	6	40A0	;		13 (U)	D2	
95*		1111	5F		11			8	7	4060	¬ (logical NOT)		6B (U)	F2	
96*	0110	0000	60		11					4000	- (dash)	60	40 (L)	84	61
97*		0001	61			0			1	3000	/	61	31 (L)	BC	4C
98		0010	62		11	0	9		2	6810					
99		0011	63		11	0	9		3	6410					
100		0100	64		11	0	9		4	6210					
101		0101	65		11	0	9		5	6110					
102		0110	66		11	0	9		6	6090					
103		0111	67		11	0	9		7	6050					
104		1000	68		11	0	9	8		6030					
105		1001	69			0		8	1	3020					
106		1010	6A	12	11					C000					
107*		1011	6B			0		8	3	2420	, (comma)	6B	3B (L)	80	16
108*		1100	6C			0		8	4	2220	%		15 (U)	06	
109*		1101	6D			0		8	5	2120	_ (underscore)		40 (U)	BE	
110*		1110	6E			0		8	6	20A0	>		07 (U)	46	
111*		1111	6F			0		8	7	2060	?		31 (U)	86	
112	0111	0000	70	12	11	0				E000					
113		0001	71	12	11	0	9		1	F010					
114		0010	72	12	11	0	9		2	E810					
115		0011	73	12	11	0	9		3	E410					
116		0100	74	12	11	0	9		4	E210					
117		0101	75	12	11	0	9		5	E110					
118		0110	76	12	11	0	9		6	E090					
119		0111	77	12	11	0	9		7	E050					
120		1000	78	12	11	0	9	8		E030					
121		1001	79					8	1	1020					
122*		1010	7A					8	2	0820	:		04 (U)	82	
123*		1011	7B					8	3	0420	#		0B (L)	C0	
124*		1100	7C					8	4	0220	@		20 (L)	04	
125*		1101	7D					8	5	0120	' (apostrophe)	7D	16 (U)	E6	0B
126*		1110	7E					8	6	00A0	=	7E	01 (U)	C2	4A
127*		1111	7F					8	7	0060	"		0B (U)	E2	

** Any code other than those defined for the 1132 will be interpreted by the PRNT1 subroutine as a blank.

Ref No.	EBCDIC Binary 0123	EBCDIC Binary 4567	EBCDIC Hex	IBM Card Code Rows 12	11	0	9	8	7-1	IBM Card Code Hex	Graphics and Control Names	1132 Printer EBCDIC Subset Hex	PTTC/8 Hex U-Upper Case L-Lower Case	Console Printer Hex	1403 Printer Hex
128	1000	0000	80	12		0		8	1	B020					
129		0001	81	12		0			1	B000	a				
130		0010	82	12		0			2	A800	b				
131		0011	83	12		0			3	A400	c				
132		0100	84	12		0			4	A200	d				
133		0101	85	12		0			5	A100	e				
134		0110	86	12		0			6	A080	f				
135		0111	87	12		0			7	A040	g				
136		1000	88	12		0		8		A020	h				
137		1001	89	12		0	9			A010	i				
138		1010	8A	12		0		8	2	A820					
139		1011	8B	12		0		8	3	A420					
140		1100	8C	12		0		8	4	A220					
141		1101	8D	12		0		8	5	A120					
142		1110	8E	12		0		8	6	A0A0					
143		1111	8F	12		0		8	7	A060					
144	1001	0000	90	12	11			8	1	D020					
145		0001	91	12	11				1	D000	j				
146		0010	92	12	11				2	C800	k				
147		0011	93	12	11				3	C400	l				
148		0100	94	12	11				4	C200	m				
149		0101	95	12	11				5	C100	n				
150		0110	96	12	11				6	C080	o				
151		0111	97	12	11				7	C040	p				
152		1000	98	12	11			8		C020	q				
153		1001	99	12	11		9			C010	r				
154		1010	9A	12	11			8	2	C820					
155		1011	9B	12	11			8	3	C420					
156		1100	9C	12	11			8	4	C220					
157		1101	9D	12	11			8	5	C120					
158		1110	9E	12	11			8	6	C0A0					
159		1111	9F	12	11			8	7	C060					
160	1010	0000	A0		11	0		8	1	7020					
161		0001	A1		11	0			1	7000					
162		0010	A2		11	0			2	6800	s				
163		0011	A3		11	0			3	6400	t				
164		0100	A4		11	0			4	6200	u				
165		0101	A5		11	0			5	6100	v				
166		0110	A6		11	0			6	6080	w				
167		0111	A7		11	0			7	6040	x				
168		1000	A8		11	0		8		6020	y				
169		1001	A9		11	0	9			6010	z				
170		1010	AA		11	0		8	2	6820					
171		1011	AB		11	0		8	3	6420					
172		1100	AC		11	0		8	4	6220					
173		1101	AD		11	0		8	5	6120					
174		1110	AE		11	0		8	6	60A0					
175		1111	AF		11	0		8	7	6060					
176	1011	0000	B0	12	11	0		8	1	F020					
177		0001	B1	12	11	0			1	F000					
178		0010	B2	12	11	0			2	E800					
179		0011	B3	12	11	0			3	E400					
180		0100	B4	12	11	0			4	E200					
181		0101	B5	12	11	0			5	E100					
182		0110	B6	12	11	0			6	E080					
183		0111	B7	12	11	0			7	E040					
184		1000	B8	12	11	0		8		E020					
185		1001	B9	12	11	0	9			E010					
186		1010	BA	12	11	0		8	2	E820					
187		1011	BB	12	11	0		8	3	E420					
188		1100	BC	12	11	0		8	4	E220					
189		1101	BD	12	11	0		8	5	E120					
190		1110	BE	12	11	0		8	6	E0A0					
191		1111	BF	12	11	0		8	7	E060					

Ref No.	EBCDIC Binary 0123	EBCDIC Binary 4567	EBCDIC Hex	IBM Card Code Rows 12	11	0	9	8	7-1	IBM Card Code Hex	Graphics and Control Names	1132 Printer EBCDIC Subset Hex	PTTC/8 Hex U-Upper Case L-Lower Case	Console Printer Hex	1403 Printer Hex
192	1100	0000	C0	12		0				A000	(+ zero)				
193*		0001	C1	12					1	9000	A	C1	61 (U)	3C or 3E	64
194*		0010	C2	12					2	8800	B	C2	62 (U)	18 or 1A	25
195*		0011	C3	12					3	8400	C	C3	73 (U)	1C or 1E	26
196*		0100	C4	12					4	8200	D	C4	64 (U)	30 or 32	67
197*		0101	C5	12					5	8100	E	C5	75 (U)	34 or 36	68
198*		0110	C6	12					6	8080	F	C6	76 (U)	10 or 12	29
199*		0111	C7	12					7	8040	G	C7	67 (U)	14 or 16	2A
200*		1000	C8	12				8		8020	H	C8	68 (U)	24 or 26	6B
201*		1001	C9	12			9			8010	I	C9	79 (U)	20 or 22	2C
202		1010	CA	12		0	9	8	2	A830					
203		1011	CB	12		0	9	8	3	A430					
204		1100	CC	12		0	9	8	4	A230					
205		1101	CD	12		0	9	8	5	A130					
206		1110	CE	12		0	9	8	6	A0B0					
207		1111	CF	12		0	9	8	7	A070					
208	1101	0000	D0		11	0				6000	(- zero)				
209*		0001	D1		11				1	5000	J	D1	51 (U)	7C or 7 E	58
210*		0010	D2		11				2	4800	K	D2	52 (U)	58 or 5A	19
211*		0011	D3		11				3	4400	L	D3	43 (U)	5C or 5E	1A
212*		0100	D4		11				4	4200	M	D4	54 (U)	70 or 72	5B
213*		0101	D5		11				5	4100	N	D5	45 (U)	74 or 76	1C
214*		0110	D6		11				6	4080	O	D6	46 (U)	50 or 52	5D
215*		0111	D7		11				7	4040	P	D7	57 (U)	54 or 56	5E
216*		1000	D8		11			8		4020	Q	D8	58 (U)	64 or 66	1F
217*		1001	D9		11		9			4010	R	D9	49 (U)	60 or 62	20
218		1010	DA	12	11		9	8	2	C830					
219		1011	DB	12	11		9	8	3	C430					
220		1100	DC	12	11		9	8	4	C230					
221		1101	DD	12	11		9	8	5	C130					
222		1110	DE	12	11		9	8	6	C0B0					
223		1111	DF	12	11		9	8	7	C070					
224	1110	0000	E0			0		8	2	2820					
225		0001	E1		11	0	9		1	7010					
226*		0010	E2			0			2	2800	S	E2	32 (U)	98 or 9A	0D
227*		0011	E3			0			3	2400	T	E3	23 (U)	9C or 9E	0E
228*		0100	E4			0			4	2200	U	E4	34 (U)	B0 or B2	4F
229*		0101	E5			0			5	2100	V	E5	25 (U)	B4 or B6	10
230*		0110	E6			0			6	2080	W	E6	26 (U)	90 or 92	51
231*		0111	E7			0			7	2040	X	E7	37 (U)	94 or 96	52
232*		1000	E8			0		8		2020	Y	E8	38 (U)	A4 or A6	13
233*		1001	E9			0	9			2010	Z	E9	29 (U)	A0 or A2	54
234		1010	EA		11	0	9	8	2	6830					
235		1011	EB		11	0	9	8	3	6430					
236		1100	EC		11	0	9	8	4	6230					
237		1101	ED		11	0	9	8	5	6130					
238		1110	EE		11	0	9	8	6	60B0					
239		1111	EF		11	0	9	8	7	6070					
240*	1111	0000	F0			0				2000	0	F0	1A (L)	C4	49
241*		0001	F1						1	1000	1	F1	01 (L)	FC	40
242*		0010	F2						2	0800	2	F2	02 (L)	D8	01
243*		0011	F3						3	0400	3	F3	13 (L)	DC	02
244*		0100	F4						4	0200	4	F4	04 (L)	F0	43
245*		0101	F5						5	0100	5	F5	15 (L)	F4	04
246*		0110	F6						6	0080	6	F6	16 (L)	D0	45
247*		0111	F7						7	0040	7	F7	07 (L)	D4	46
248*		1000	F8					8		0020	8	F8	08 (L)	E4	07
249*		1001	F9				9			0010	9	F9	19 (L)	E0	08
250		1010	FA	12	11	0	9	8	2	E830					
251		1011	FB	12	11	0	9	8	3	E430					
252		1100	FC	12	11	0	9	8	4	E230					
253		1101	FD	12	11	0	9	8	5	E130					
254		1110	FE	12	11	0	9	8	6	E0B0					
255		1111	FF	12	11	0	9	8	7	E070					

Appendix E. Core Requirements of Subroutines

Communications Adapter subroutine core requirements are listed in the publication IBM 1130 Synchronous Communications Adapter Subroutines, GC26-3706. MTCA subroutine core requirements are listed in the publication IBM 1130 Computing System, Multiple Terminal Communications Adapter (MTCA), Input/Output Control System (IOCS) Subroutines, GC34-0015. 1627 Plotter subroutine core requirements are included in the publication IBM 1130/1800 Plotter Subroutines.

Standard		Extended	
FADD/FADDX FSUB/FSUBX	102	EADD/EADDX ESUB/ESUBX	98
FMPY/FMPYX	52	EMPY/EMPYX	46
FDIV/FDIVX	86	EDIV/EDIVX	78
FLD/FLDX FSTO/FSTOX	54	ELD/ELDX ESTO/ESTOX	46
FLOAT	10		10
IFIX	40		40
NORM	42		42
FSBR/FSBRX	24	ESBR/ESBRX	24
FDVR/FDVRX	28	EDVR/EDVRX	28
SNR	8		8
FABS/FAVL	12	EABS/EAVL	12
IABS	16		16
FGEPT	22	EGETP	22
FARC	34		34
XMDS	28		--
FIXI/FIXIX	68		68
XSQR	52		52
XMD	66		66
XDD	74		74
FSIN/FSINE FCOS/FCOSN	118	ESIN/ESINE ESCOS/ESCOSN	138
FATN/FATAN	130	EATN/EATAN	148
FSQR/FSQRT	70	ESQR/ESQRT	76
FLN/FALOG	136	ELN/EALOG	148
FEXP/FEXPN	118	EEXP/EXPN	140
FAXI/FAXIX	78	EAXI/EAXIX	82
FAXB/FAXBX	54	EAXB/EAXBX	54
FTNH/FTANH	54	ETNH/ETANH	46
FBTD (bin. to dec.) FDTB (dec. to bin.)	446		446
DMTD0/DMTX0	412		412
DMPD1/DMPX1	520		520
DMP80	102		102
DATSW	34		34
DVCHK	16		16
FCTST	30		30
LOAD	138		138
OVERF	18		18
SLITE, SLITT	70		70
TSTOP	6		6
TSTRT	6		6
ISIGN	24		24
FSIGN	34	ESIGN	34

Standard		Extended	
C/PT System		C/PT System	
WARI/WARIX	32	VARI/VARIX	32
WIAR/WIARX	36	VIAR/VIARX	36
WIF	26	VIF	26
WIIF	24	VIIF	24
WGOTO	22	VGOTO	22
WFIO/WIOI/WIOAI/ WIOF/WIOAF/ WIOFX/WCOMP/ WWRT/WRED/ WIOIX	854	VFIO/VIOI/VIOAI/ VIOF/VIOAF/ VIOFX/VCOMP/ VWRT/VRED/ VIOIX	864
DM2 System		DM2 System	
SDFIO/SDAF/SDAI/ SDCOM/SDF/SDFX/ SDI/SDIX/SDRED/ SDWRT	694		694
SDFND	78		78
SFAR/SFARX	32	SEAR/SEARX	32
SFIO/SIOI/SIOAI/ SIOF/SIOAF/SIOFX/ SCOMP/SWRT/SRED/	1194		1190
SIOIX		SEIF	28
SFIF	26		22
SGOTO	22		36
SIAR/SIARX	36		24
SIIF	24		756
UFIO	758		

Figure 25. Core Requirements of Arithmetic and Functional Subroutines

Subroutines	No. Core Locations DM2 System	C/PT System	Uses (DM2 System)
CARD0	254	242	ILS00, ILS04
CARD1	258	246	ILS00, ILS04
READ0	96	-	ILS04
READ1	110	-	ILS04
PNCH0	206	-	ILS04, ILS00
PNCH1	218	-	ILS04, ILS00
OMPR1	336	-	ILS04
PAPT1	226	254	ILS04
PAPTN	306	294	ILS04
DISK0	-	356	ILS02
DISK1*	418	620	ILS02
DISKN*	688	808	ILS02
WRTY0	124	124	ILS04
TYPE0	278	296	ILS04, PRTY, HOLL
PLOT1	186	216	ILS03
PRNT1	424	386	ILS01
PRNT3	308	-	ILS04
ILS00	22	18	
ILS01	26	18	
ILS02*	17	18	
ILS03	28	18	
ILS04*	32	30	
ILSX0	24	-	
ILSX1	30	-	
ILSX2	24	-	
ILSX3	34	-	
ILSX4	44	-	
SPIR0	-	48	
SPIR1	-	62	
SPIRN	-	62	
FLIPR	102	-	DISKZ, DISK1, DISKN
PAUSE	22	22	
STOP	12	8	
SUBSC	30	30	
SUBIN	32	32	
TTEST/TSET	16	16	
DISKZ*	238	-	ILS02
CARDZ	176	80	ILS04, ILS00
PAPTZ	226	202	ILS04
PRNTZ	218	176	ILS01
TYPEZ	106	82	ILS04
WRYTZ	62	66	ILS04
READZ	58		ILS04
PNCHZ	66		ILS04, ILS00
PRNZ	186		ILS04
HOLEZ	64	54	
GETAD	16	14	
EBCTB	60	54	
HOLTB	54	54	
SYSUP	1338	-	FSLEN/FSYSU
FSLEN/FSYSU	535	-	DISKZ

* Part of Resident Monitor

Figure 26. Core Requirements of Miscellaneous and ISS Subroutines

Conversion Subroutines	No. Core Locations DM2 System	C/PT System	Uses
BINDC	72	72	
DCBIN	88	88	
BINHX	44	44	
HXBIN	66	66	
HOLEB	134	134	HOLL, EBPA
HOLPR	100	100	HOLL, PRTY
EBPRT	102	102	EBPA, PRTY
PAPEB	246	246	EBPA
PAPHL	244	244	EBPA, HOLL
PAPPR	192	192	EBPA, PRTY
ZIPCO	162	-	
SPEED	334	330	
HOLL	80	80	
EBPA	80	80	
PRTY	80	80	
EBCCP	128	-	
EBHOL	128	-	
EBPT3	128	-	
CPEBC	128	-	
CPHOL	128	-	
CPPT3	128	-	
HLEBC	128	-	
HOLCP	128	-	
HLPT3	128	-	
PT3EB	128	-	
PT3CP	128	-	
PTHOL	128	-	

Figure 27. Core Requirements of Conversion Subroutines

Subroutines	No. Core Locations	Uses
Disk I/O		
SEQOP, SEQIO, SEQCL	458	DISKZ
DAOPN, DAIO, DACLS	246	DISKZ
ISLDO, ISLD, ISLDC	639	DISKZ
ISADO, ISAD, ISADC	1799	DISKZ
ISEQO, ISETL, ISEQ, ISEQC	721	DISKZ
ISRDO, ISRD ISRDC	460	DISKZ
RPG Decimal Arithmetic		
RGADD, RGSUB, RGNCP	464	
RGMLT	320	RGBTD, RGDTB
RGDIV	815	
RGMVR	118	RGBTD
RGBTD, RGDTB	112	
RPG Sterling and Edit		
RGSTI	258	RGBTD, RGDTB
RGSTO	464	RGBTD, RGDTB
RGEDT	315	
RPG Move		
RGMV1, RGMV5	148	
RGMV2	179	
RGMV3	48	
RGMV4	86	
RPG Compare		
RGCMP	82	
RPG Inidcators		
RGSI1	68	
RGSI2	78	
RGSI3, RGSI4	40	
RGSI5	92	
RPG Miscellaneous		
RGTSZ	72	
RGCVB	86	
RGERR	70	
RGBLK	58	
ALTSE (user-written)	(variable)	

Figure 28. Core Requirements of RPG Subroutines (DM2 only)

Appendix F. Execution Times of Subroutines

Execution times for the Synchronous Communications Adapter subroutines are listed in the adapter subroutine manual.

CONVERSION SUBROUTINES (see Figure 29).

Basic Definitions

1. All times are based on 3.6-μsec instruction cycle.

2. The table ordering for codes is as follows (except SPEED)

   Standard set: blank, +, &, -, 0-9, A-Z, other special

   Extended set: standard, non-FORTRAN special, control

3. Maximum number of characters checked varies with the set.

   Standard set
   Except SPEED: 49
   SPEED only: 16

   Extended set
   Except SPEED: 74
   SPEED only: 45

4. Conversion times given are

   Best time: Found as first character in set

   Worst time, standard set: Found as last character in set

   Worst time, extended set: Not found in set

5. Time per character is best time, plus table look-up time multiplied by the number of characters to be skipped.

   Example:
   If best = 211, look-up = 45.5 and character is fourth in table (-)
   Then, character time = 347.5 = 211 + 3(45.5)

1130 ISS TIMES (see Figures 30 and 31)

Basic Definitions

1. Only CPU time used by ISS (including transfer vector BSC L) and ILS (including forced BSI I) is given.

   All the remaining time, minus cycle steals, is available to the user.

2. ILS time is included in ISS interrupt processing calculations

C/PT System

ILS00 - CARD0 (col), CARD1 (col)
ILS01 - PRNT1
ILS02 - DISK0, DISK1, DISKN
ILS03 - PLOT1
ILS04 - CARD0 (op complt), CARD1 (op complt) WRTY0, TYPE0, PAPT1, PAPTN

Subroutine	Initialization	Time, Per Character			Table Look-Up
		Best	Worst		
			Std. Set	Extd. Set	
BINDC	1130	-	-	-	-
DCBIN	1110	-	-	-	-
BINHX	620	-	-	-	-
HXBIN	760	-	-	-	-
HOLPR	430	211	2395	3533	45.5
EBPRT	420	207	2487	3675	47.5
HOLEB					
EBCDIC output	550	159	2343	3481	45.5
EBCDIC input	550	161	2441	3629	47.5
SPEED					
Packed EBCDIC output	250	270	-	-	-
Unpacked EBCDIC output	270	260	-	-	-
Packed EBCDIC input	240	394	1594	3914	80.0
Unpacked EBCDIC input	240	404	1604	3924	80.0
ZIPCO (DM2 only)					
All codes except IBM Card Code	270	270	-	-	-
IBM Card Code input	270	374	-	-	-
IBM Card Code output	270	435	-	-	-
PAPPR	580				
Per shift char. input		180	-	-	-
Per graphic char. input		427	2707	3895	47.5
Per control char. input		407	2687	3875	47.5
PAPHL					
PTTC/8 input	490				
Per shift char. input		180	-	-	-
Per graphic char. input		306	2482	3870	49.5
Per control char. input		296	2472	3860	49.5
PTTC/8 output	490				
Per control char. output		266	-	3830	49.5
Per graphic char. output		316	2492	3880	49.5
Per shift/graphic char. output		446	2622	4010	49.5
PAPEB					
PTTC/8 input	440				
Per shift char. input		190	-	-	-
Per graphic char. input		366	2542	3930	49.5
Per control char. input		386	2562	3950	49.5
PTTC/8 output	440				
Control char. output		296	-	3860	49.5
Per graphic char. output		346	2522	3910	49.5
Per shift/graphic char. output		476	2652	4040	49.5

Figure 29. Execution Times of Conversion Subroutines

DM2 System

ILS00 - CARD0 (col), CARD1 (col)
PNCH0 (col), PNCH1 (col)
ILS01 - PRNT1
ILS02 - DISK1, DISKN
ILS03 - PLOT1, PLOTX
ILS04 - CARD0 (op complt), CARD1 (op complt), PNCH0 (op complt), PNCH1 (op complt), READ0, READ1, WRTY0, TYPE0, PAPT1, PAPTN, PAPTX, PRNT3, OMPR1

Note: In the DM2 system, the Z subroutines are considered to be ISSs and therefore use the appropriate ILSs, e.g., PRNTZ uses ILS01.

3. All times are based on a 3.6-μsec instruction cycle.

Subroutine and Function	Times (μsec) (n word count)
ILS00	112
ILS01	134
ILS02	112
ILS03	112
ILS04	148
CARD0	
Test	165
Read	14930 + 38.5 (n)
Punch	763 + 185 (n)
Feed	605
Sel. Stack.	290
CARD1	
Test	165
Read	14972 + 38.5 (n)
Punch	800 + 190 (n)
Feed	640
Sel. Stack.	325
WRTY0	
Test	165
Print	228 + 734 (n)
TYPE0	
Test	165
Read print	685 + ϵ (825 + 48.5y) + 390 a + 1595 b + 1224 c
	ϵ = sum of char. times for each graphic y = no. char. skipped in table look-up a = EOM character b = re-entry character c = backspace character
Print	344 + 920 (n)
PAPT1	
Test	152
Read	432 + 808* (n)
	*add +112 if check
Punch	480 + 680* (n)
	*add +96 if check
PAPTN	
Test	176
Read	408 + 952* (n)
	*add +112 if check
Punch	464 + 840* (n)
	*add +64 if check
PLOT1	
Test	130
Print	698 + { 418 = if char is 0-9; 472 = if char is A; 624 = if char is B; 752 = if char is C; 224 per dup. of previous pen motion }

Subroutine and Function	Times (μsec) (n = word count)
PRNT1	
Test	188
Print	44142 + 5971.2 (n-1)*
	*subtract 11.4 for each word where 1 char. does not match; 22.8 where both char. do not match.
Print Numeric	25950 + 2736.8 (n-1) +268 x
	x = no. idle cycles before 1st numeric char. on wheels is reached
Control	
Single space	708
Double space	998
Triple space	1288
Skip to channel 12	676*
Skip to channel 1	936*
	*add 208 for each channel crossed before correct one reached
DISK0	
Test	178
Read	1492
Write	
Without RBC	1778
With RBC	2050
Write Imm	1062
Seek	
1 to center	1076
By addr	1502
DISK1	
Test	178
Read	900 + 760 x + 478 y
	x = no. sectors y = no. seeks after 1st sector
Write Without RBC	1292 + 660 x + 822 y
Write With RBC	1562 + 1098 x + 908 y
Write Imm	660 + 622 x + 476 y
Seek	
1 to center	1072
By addr	1468
DISKN	
Test	178
Read	908 + 652 x + 1012 y
	x = no. sectors y = no. seeks after 1st sector
Write Without RBC	1516 + 610 x + 926 y
Write With RBC	1728 + 1022 x + 1178 y
Write Imm	820 + 606 x + 282 y
Seek	
1 to center	1076
By addr	1478

Figure 30. Execution Times of 1130 ISS (C/PT System)

Subroutine and Function	Times (μ sec) (n = word count)
ILS00	112
ILS01	134
ILS02	102
ILS03	112
ILS04	163
CARD0	
Test	165
Read	14930 + 38.5 (n)
Punch	763 + 185 (n)
Feed	605
Sel. Stack.	290
CARD1	
Test	165
Read	14972 + 38.5 (n)
Punch	800 + 190 (n)
Feed	640
Sel. Stack.	325
READ0	
Test	173
Read	546
Feed	523
READ1	
Test	173
Read	576
Feed	553
PNCH0	
Test	165
Punch	763 + 185 (n)
Feed	605
PNCH1	
Test	165
Punch	800 + 190 (n)
Feed	640
WRTY0	
Test	165
Print	228 + 734 (n)
TYPE0	
Test	165
Read print	685 + ϵ (825 - 48.5y) + 390 a + 1595 b + 1224 c
	ϵ = sum of char. times for each graphic y = no. char. skipped in table look-up a = EOM character b = re-entry character c = backspace character
Print	344 + 920 (n)
PAPT1	
Test	152
Read	432 + 808* (n)
	*add + 112 if check
Punch	480 + 680* (n)
	*add + 96 if check
PAPTN	
Test	176
Read	408 + 952* (n)
	*add + 112 if check
Punch	464 + 840* (n)
	*add + 64 if check
PLOT1	
Test	130
Print	678 + { 418 = if char is 0-9; 472 = if char is A; 624 = if char is B }

Subroutine and Function	Times (μ sec) (n = word count)
PLOT1 (Cont'd)	678 + { 752 = if char is C; 224 = per dup. of previous pen motion }
PRNT1	
Test	188
Print	44142 + 5971.2 (n-1)*
	*subtract 11.4 for each word where 1 char. does not match; 22.8 where both char. do not match.
Print Numeric	25950 + 2736.8 (n-1) + 268 x
	x = no. idle cycles before 1st numeric char. on wheels is reached
Control	
Single space	708
Double space	998
Triple space	1288
Skip to channel 12	676*
Skip to channel 1	936*
	*add 208 for each channel crossed before correct one reached
PRNT3	
Test	183
Print	3743 + 45 (n-1)
Control	
Single Space	785
Double Space	6746
Triple Space	12704
Skip to channel 12	817
Skip to channel 1	817
OMPR1	
Test	227
Feed	710
Read	805 + 286 x c
	c = no. of chars. programmed to be read
Disconnect	506
Sel. Stack.	495
DISK1	
Test	158
Read	1021 + 491 x + 1226 y
	x = no. sectors y = no. seeks after 1st sector
Write	
Without RBC	1035 + 491 x + 1226 y
Write	
With RBC	1829 + 982 x + 2452 y
Write Imm	689 + 491 x + 489 y
Seek	
1 to-center	1843
By addr	2056
DISKN	
Test	244
Read	1500 + 725 x + 1973 y
	x = no. sectors y = no. seeks after 1st sector
Write	
Without RBC	1500 + 725 x + 1973 y
Write	
With RBC	2599 + 1450 x + 3947 y
Write Imm	1085 + 725 x + 1707 y
Seek	
1 to-center	1871
By addr	2151

Figure 31. Execution Times of 1130 ISS (DM2 System)

ARITHMETIC AND FUNCTION SUBROUTINES

The execution times of the arithmetic and function subroutines are shown in Figure 32. All times are based on a 3.6-μsec instruction cycle; the times containing a decimal point are milliseconds, all other are microseconds.

SPIR (C/PT SYSTEM)

The SPIRx subroutines take 220 μsecs (3.6-μsec instruction cycle) plus the DISKx time to read sector 0000.

STANDARD		EXTENDED	
FADD/FADDX }	460	EADD/EADDX }	440
FSUB/FSUBX }	560	ESUB/ESUBX }	490
FMPY/FMPYX	560	EMPY/EMPYX	790
FDIV/FDIVX	766	EDIV/EDIVX	2060
FLD/FLDX }	180	ELD/ELDX }	160
FSTO/FSTOX }	180	ESTO/ESTOX }	170
FLOAT	330		330
IFIX	140		140
NORM	260		260
FSBR/FSBRX	650	ESBR/ESBRX	740
FDVR/FDVRX	1090	EDVR/EDVRX	2520
SNR	80		80
FABS/FAVL	50	EABS/EAVL	60
IABS	100		100
FGETP	330	EGETP	320
FARC	60		60
XMDS	260		--
FIXI/FIXIX	465		465
XSQR	550 av. (860 max.)		550 av. (860 max.)
XMD	520		520
XDD	1760		1760
FSIN/FSINE }	3.0	ESIN/ESINE }	5.4
FCOS/FCOSN }	3.4	ECOS/ECOSN }	5.9
FATAN/FATN	5.2	EATAN/EATN	8.9
FSQRT/FSQR	4.5	ESQRT/ESQR	10.4
FALOG/FLN	5.1	EALOG/ELN	8.0
FEXP/FXPN	2.0	EEXP/EXPN	4.4
FAXI/FAXIX	3.8	EAXI/EAXIX	4.7
FAXB/FAXBX	8.0	EAXB/EAXBX	13.3
FTANH/FTNH	4.3	ETANH/ETNH	8.1
FBTD (bin. to dec.) }	40.0		40.0
FDTB (dec. to bin.) }	20.0		20.0

Figure 32. Execution Times of Arithmetic and Function Subroutines

Appendix G. Re-enterable Code

Re-enterable Code

Re-enterable code is defined as code that can be executed by more than one program at a time and that does not modify itself. Such code makes it possible for the programmer to write subroutines that can be called from more than one level of program operation; that is, from the mainline level (no interrupt) and an interrupt priority level or from two different interrupt priority levels. Two problem areas in writing re-enterable code are (1) obtaining temporary storage, and (2) modifying storage locations and/or instructions.

It is necessary, in this discussion of re-enterable code, to point out the following facts about the 1130 and its method of operation:

- Instructions have direct and indirect addressing. The operand of an instruction can address a location that contains either the value or the address of the location that contains the value to be addressed, multiplied, etc..
- Index registers occupy storage locations that can be addressed.
- Register housekeeping is performed for interrupts. IBM Disk Monitor interrupt-programming saves and restores the index registers, accumulator, and accumulator extension.
- Interrupts on same or lower level of priority are inhibited. Once the CPU has executed the hardware-forced branch for a level of interrupt priority, no hardware-forced branch for that level, or a lower, level can occur until the programmer exits from the level.
- Storage can be modified by a single instruction (MDX instruction) that cannot be interrupted.
- The subroutine call instruction (BSI instruction) is not re-enterable. The call instruction stores the return link (address of next instruction following the call) in a storage location. This return-link storage location cannot be varied by the subroutine. Therefore, a second call to the same subroutine stores the return link for the second call in the same location where the return link for the first call was stored. (The subroutine-call instruction is also the instruction executed for the hardware-forced branch that initiates processing for a level of interrupt priority.)
- Index istructions cannot be indexed. The index instructions (load index, store index, modify index) cannot specify an index register to address the storage location from which the register is to be loaded or modified, or into which the register is to be stored.
- There are no register-to-register instructions. The index registers and accumulator must be loaded from, stored into, or modified from core storage.
- There is no indirect addressing for load-index and modify-index instructions. These two instructions have only immediate operands, and directly-addressed operands.
- There is no instruction to inhibit interrupts. There is no mask instruction to selectively or completely inhibit levels of interrupt, and no instruction to force an interrupt level on.

The definition of re-enterable code given earlier can be extended to include code that modifies itself as long as the modification does not affect the output of the code. Such an extension permits the code to be executed by more than one program at a time. Using this extended definition of re-enterable code, the remainder of this discussion illustrates how re-enterable code can be written for the 1130.

The Disk Monitor, the Card/Paper Tape System, and their subroutines are <u>not</u> re-enterable. This does not prevent the user from writing his own re-enterable subroutines as long as these subroutines do not call, either directly or indirectly (for example, LINK), any Disk Monitor or Card/Paper Tape subroutines.

For discussion purposes, there are two areas in writing re-enterable code: (1) getting to (calling) the code, and (2) writing the code. Assuming the existing assemblers and compilers, re-enterable code can only be written in assembler language. However, re-enterable subroutines may be called by either assembler or FORTRAN language programs as described below.

CALLING A RE-ENTERABLE SUBROUTINE

The subroutine calls (LIBF and CALL) cause the following BSI instructions to be generated:

CALL	Generated Code	System
CALL subr	BSI I subr TV locat	Disk Monitor System,Version 2
CALL subr	BSI L subr	Card/Paper Tape System
LIBF subr	BSI 3 subr TV disp	both systems

For a re-enterable call, the subroutine call instruction should be preceded by another instruction which places the return link in a location saved and stored by interrupt programming, such as in an index register, the accumulator, or the accumulator extension. Through conventions agreed upon between the calling program and subroutine, the re-enterable subroutine called expects the return link to be in a pre-defined register and ignores the return link stored by the subroutine-call (branch) instruction. The added instruction in the calling sequence can be a load-index or load-accumulator instruction, or even a load-double (accumulator and accumulator extension) instruction. This combination (load instruction + subroutine call) gives the programmer a re-enterable call that can be used in 1130 programming.

The re-enterable call (two instructions) can be generated for the assembler user by (a) writing and then using a macro, or (b) by actually coding the two instructions. For example, if index register 2 is selected for the return link, the following code could be used:

Actual Coding	or Macro
LDX L2 *+2 CALL subr	RCALL subr

The RCALL macro is defined by the following code:

Label	Operation	F	T	Operands & Remarks
	SMAC			
	RCALL			Z
	LDX	L	2	*+2 load XR 2 w/return addr
	CALL			Z
	MEND			

The FORTRAN user must write a special subroutine in assembler language and then call that subroutine in FORTRAN. That subroutine is not re-enterable. Consequently, there must be a separate special subroutine for each level (mainline or interrupt) from which FORTRAN calls may be executed. To call re-enterable subroutine A with parameters X and Y, the FORTRAN user would name subroutine A in an EXTERNAL statement and then call special subroutine B with parameters A, X, and Y, in that order. Subroutine B would load the pre-defined register with the address of the location immediately following the A parameter and, using the A parameter, would call subroutine A. If subroutine A is called as follows:

```
CALL A (X, Y)
```

then this call can be replaced by the following code to obtain a re-enterable call:

```
EXTERNAL A
•
•
•
CALL B (A, X, Y)
```

If index register 2 is selected for the return link, special subroutine B is defined as follows:

Label	Operation	F	T	Operands & Remarks
	ENT			B
B	DC			*-*
	LDX	I	2	B XR2=addr of CALL A
	MDX		2	2 XR2=addr of addr X
	BSC	L	2	-2 exit to CALL A
	END			

The re-enterable calling sequence allows the return address stored by the call (BSI) to be modified by the interrupt without affecting subroutine operation since a re-enterable subroutine ignores the effective address (EA) location and uses the contents of XR2 as the return address.

OBTAINING TEMPORARY STORAGE

The temporary storage locations that are easy to use are the areas saved and restored by interrupt programming: index registers, accumulator, and accumulator extension. There are times when these are not adequate:

- When there are not enough registers
- When registers must be loaded with or modified by calculated values (variable rather than constant value)
- When registers must be loaded from, stored into, or modified by locations addressed via index registers

Work areas in storage may be assigned to each subroutine or program (common to many subroutines) to provide temporary storage for each level of operation. Such areas may be used for storage of intermediate results, parameters, data, calculated addresses, etc.. These areas may be accessed via index registers or address constants.

Current 1130 interrupt programming does not provide for level or program work areas. Such areas can be provided for each level by modifying the interrupt programming, by requiring locations in COMMON, or by other changes. However, it might be easier for the user to establish work areas within each re-enterable subroutine as it is written, rather than to modify already-written programs and systems.

A number (X) of subroutine work areas of length (N+1) can be defined: where X is the number of work area words needed for subroutine execution, and N is the number of interrupt levels. The subroutine increments the address of each area by 1 for each entry and decrements the addresses by 1 for each exit. Any instruction can then directly or indirectly reference the area.

Access via index register. If index register 2 is used to locate a 4-word area to be used for up to three concurrent entries, then word 1 might be used for the address of a parameter and word 2 for an intermediate value, as shown in the following code:

```
Label  Operation  F T  Operands & Remarks
       MDX        L    INSTR+1,4  incr addr work area
INSTR  LDX        L 2  WORKA-4    XR2=current entry area
       .
       .
       .
       LD           2  2          add value (n) to addr
       A               ADDRC      constant (A)
       STO          2  1          save calculated addr
       LD         1 2  1          get parameter
       .
       .
       .
       MDX        L    INSTR+1,-4 decr work area addr
                                  exit
       .
       .
       .
ADDRC  DC              A          addr constant
WORKA  BSS             3*4        work area
```

Access via Address Constants. Assume two words needed for each of three concurrent entries. Note that an address constant is required for each word. Index register 2 is used here to access call parameters rather than work area words.

```
Label  Operation  F T  Operands & Remarks
       .
       SUBR                       entrance by RCALL macro seq
       .
       .
       .
       MDX        L    TEMPA,2    incr addr work word 1

       MDX        L    SB100+1,2  incr addr work word 2
       .
       .
       .
       STX        1 1  TEMPA      store XR1 in work word 1
       LD         1    TEMPA      acc=contents XR1
       .
       .
       .
       STO        1    SB100+1    addr (A) to work word 2
SB100  LD         1    TEMP-1     acc=contents (A)
       .
       .
       .
       LD           2  0          obtain 1st call parameter
       SLA             8          left-justify 2nd byte
       STO        1    TEMPA      save justified byte
       LD           2  1          obtain 2nd call parameter
       AND             H00FF      isolate 2nd byte
       OR         1    TEMPA      combine with 1st byte
       .
       .
       .
       MDX        L    TEMPA,-2   decr addr work word 1
       MDX        L    SB100+1,-2 decr addr work word 2
                                  exit
       .
       .
TEMPA  DC              TEMP-2     addr of current work word 1
TEMP   BSS             2*3        space for 3 entries
H00FF  DC              /00FF      mask to isolate rightmost
                                  byte
```

Note: Interrupts (and the subsequent call from interrupt processing) can occur after any instruction; therefore, each direct reference to the work area should address a different area. Otherwise, at any time, a sequence that should address a particular word in the work area can end up referencing different words in the work area and overlaying the contents of words used for a previous, and yet unfinished call. The following example avoids this problem:

```
Label  Operation  F T  Operands & Remarks
       MDX        L    REST1+1,1 incr work area addr
       .
       .
       .
       STO        I    REST1+1   save value
       .
       .
       .
REST1  LD         L    WORKA-1   get value
       .
       .
       .
REST2  LD         I    REST1+1   get value
```

MODIFYING STORAGE OR INSTRUCTIONS

Storage and/or instructions can be modified in a re-enterable subroutine if the sequence shown in Figure 32.1 is used.

1. Save the location or instruction to be modified in temporary storage (work area, index register, accumulator, or accumulator extension)

2. Modify the location or instruction

3. Execute, using the modified location or instruction

4. Restore the location or instruction from temporary storage

An example best illustrates the techniques of temporary storage and storage/instruction modification. The coding examples below illustrate four ways of loading index register 1 with the address of table D, assuming the following address chain and that only location A is directly accessible.

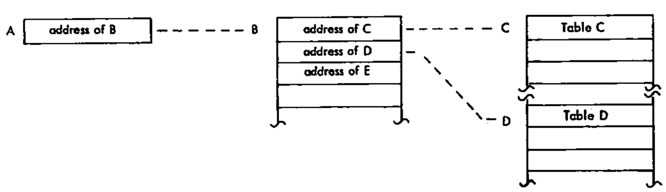

Figure 32.1 Modifying Storage or Instructions

```
Label  Operation  F T  Operands & Remarks
A      DC              B
       .
       .
       .
B      DC              C
       DC              D
       DC              E
       .
       .
       .
C      BSS             X
       .
       .
       .
D      BSS             Y
       .
       .
       .
DØØØ1  DC              1
```

The load-index instruction has one less level of indirect addressing than the load-accumulator instruction. Using the symbol A as an operand, an indirect load-accumulator instruction can obtain the address of C, while an indirect load-index instruction can only obtain the address of B. The coding examples illustrated below show that using work area words is the most expensive method, both in number of instructions required, and in the time it takes to execute those instructions. The technique selected depends on the temporary storage available at the time (accumulator extension, or second index register, or neither).

Example 1. Using work area words:

Label	Operation	F	T	Operands & Remarks
	MDX	L		INST1+1,1 incr addr work area A
	MDX	L		INST2+1,1 incr addr work area B
	•			
	•			
	•			
	LD			A acc=addr B
	A			DØØØ1
	STO	I		INST1+1 acc=addr B+1
INST1	LD	I		WORKA-1 acc=addr D
	STO	I		INST2+1
INST2	LDX	I	1	WORKB-1 index reg 1=addr D
	•			
	•			
	•			
	MDX	L		INST1+1,-1 decr addr work area A
	MDX	L		INST2+1,-1 decr addr work area B
	•			
	•			
	•			
WORKA	BSS			n work area 1
WORKB	BSS			n work area 2

Example 2. Using the accumulator extension:

Label	Operation	F	T	Operands & Remarks
	LD			INST1+1 get contents of INST1+1
	RTE			16 save in acc ext
	LD			A acc=addr B
	A			DØØØ1
	STO			INST1+1 acc=addr B+1
INST1	LDX	I	1	*-* index reg 1=addr D
	RTE			16
	STO			INST1+1 restore contents of INST1+1

Example 3. Using a second index register:

Label	Operation	F	T	Operands & Remarks
	LDX	I	2	INST1+1 save contents of INST1+1 in
				XR2
	LD			A acc=addr B
	A			DØØØ1
	STO			INST1+1 acc=addr B+1
INST1	LDX	I	1	*-* index reg 1=addr D
	STX		2	INST1+1 restore contents of INST1+1

Example 4. Taking advantage of the fact that 1130 index register occupy storage locations that can be addressed:

Label	Operation	F	T	Operands & Remarks
	LD			A acc=addr B
	STO	L		1 XR1=addr B
	LD		1	1 acc=addr D
	STO	L		1 XR1=addr D

1800 COMPATIBILITY

Each MDX instruction used to increment or decrement addresses must be immediately followed by a NOP instruction because of the skip that occurs if the addresses cross the 32K boundary (positive value less than 32K, negative value equal to or greater than 32K. The example 4 technique of modifying storage and/or instructions cannot be written since the 1800 index registers do not occupy addressable storage locations.

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