IBM

Series/1

GA34-0025-3

File No. S1-03

IBM Series/1
4974 Printer
Description

Fourth Edition (October 1978)

This is a major revision of, and obsoletes, GA34-0025-2. Significant changes in this new edition include:

- The addition of the Eight-line-per-inch data set
- The addition of the 96-character wire-image table (Appendix B)
- A complete rewrite of the wire-image table description (including new tables)
- The addition of the reference summary information (Appendix A)
- The addition of the error recovery procedure

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Preface

This publication provides general information about the IBM Series/1 4974 Printer and the 4974 Printer Attachment Feature. It explains how each major component functions and how those components function together. Enough machine-level language information is included to permit the experienced programmer to tailor new and existing programs to the 4974.

This publication assumes the reader already understands data processing terms, is familiar with binary and hexadecimal numbering systems, understands how printers are used and their relationship to a processor, and understands stored-program concepts.

Chapter 1 introduces the general characteristics and features of the 4974.

Chapter 2 describes the Series/1 machine-level language that the processor uses to transfer data to and from the 4974. Specific topics are:

- I/O commands and their operations
- Condition codes
- Status information
- The 8-lines-per-inch data set
- Wire-image

Appendix A contains reference summary information.

Appendix B provides the 96-character wire-image table.

Prerequisite Publications

IBM Series/1 Model 5 4955 Processor and Processor Features Description, GA34-0021

IBM Series/1 Model 3 4953 Processor and Processor Features Description, GA34-0022

IBM Series/1 System Summary, GA34-0035

Related Publications

IBM Series/1 Customer Site Preparation Manual, GA34-0050

IBM Series/1 Installation Manual—Physical Planning, GA34-0029

IBM Series/1 Configurator, GA34-0042

IBM Series/1 Operator's Guide, GA34-0039

Contents

Chapter 1. Introduction

The IBM Series/1 4974 Printer is a tabletop printer that provides medium-speed "hard copy" output for the Series/1. The printer attaches to the Series/1 by means of the 4974 Printer Attachment Feature, which can be plugged into either a Series/1 processor or the Series/1 4959 Input/Output Expansion Unit (see Figure 1-1).

Printer Characteristics

The 4974 Printer:

- Is a wire matrix printer
- Prints bidirectionally (left to right and right to left)
- Can skip to any line on the form
- Suppresses unprintable characters
- Uses the Extended Binary Coded Decimal Interchange Code (EBCDIC), which includes 64 standard characters and five characters for international use
- Provides alternate character substitution
- Allows for formatting individually tailored character sets
- Has a forms tractor that accepts up to six-part cut, continuous, or margin-punched forms
- Spaces up to 84 lines per single operation
- Can print up to 120 characters per second
- Prints a maximum of 132 characters per line
- Provides horizontal spacing of up to 10 characters per inch
- Prints either 6 or 8 lines per inch

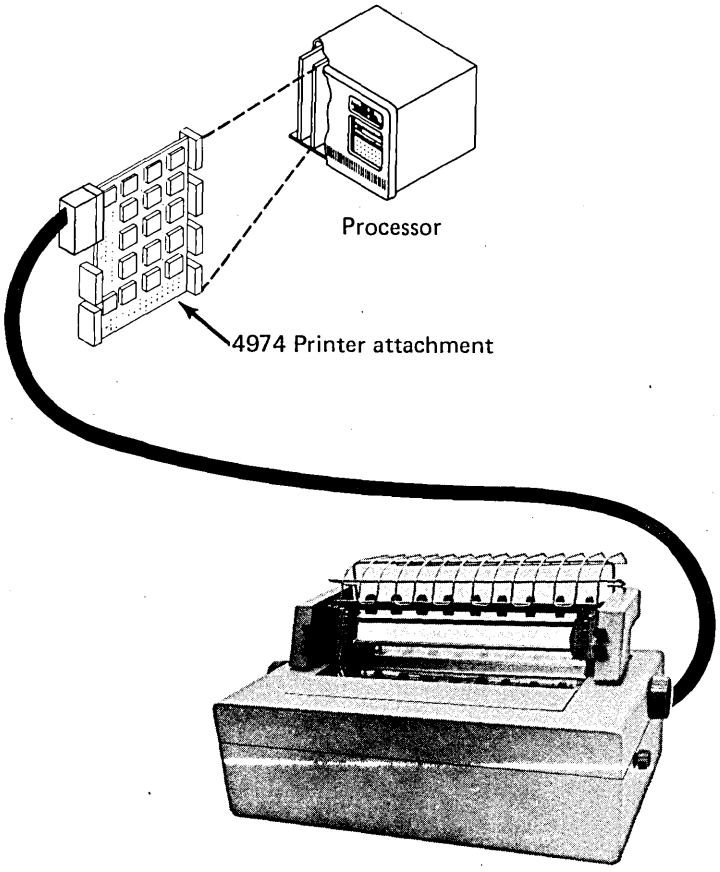


Figure 1-1. IBM Series/1 4974 Printer and attachment feature card

Attachment Feature Card

The attachment feature:

- Physically connects and logically adapts the printer to the processor I/O channel
- Interrupts and controls execution of printer operations
- Transfers data from the processor I/O channel to the printer in cycle-steal mode
- Provides a 132-character print buffer
- Furnishes status information and reports condition codes to the processor after executing Operate I/O instructions and following an interrupt request
- Uses a wire-image buffer to convert processor storage characters into a printable dot matrix
- Provides program control of forms movement

Functions

The major components of the 4974 are the printer, which forms the characters; the forms tractor, which positions the forms; and the controls, which allow the operator to make adjustments and control the operation.

The following paragraphs describe the functions of these components.

Printer

Print head movement and the printing of characters are controlled by the attachment feature, which transfers characters from the processor I/O channel to the printer. Characters are formed by printing a pattern of dots that correspond to a stored matrix in the attachment feature. Unless otherwise specified, the printer prints the standard 64 standard EBCDIC characters plus five others for international use. Alternate characters are selectable by programming. Formatting an individual character set is described in "Chapter 2. Operations."

The printing unit consists of a platen, a print head, and a ribbon. A print-head carrier moves the print head and ribbon horizontally along the print line. Printing occurs in either direction. The print head has eight vertically arranged print wires that are individually controlled by magnets. The print head moves while the magnets activate the wires against the ribbon to form characters. Figure 1-2 illustrates how the character A is printed. The printer activates seven of the eight print wires. The printing sequence is shown from left to right across the page. Note that no one magnet is activated in horizontally adjacent print head positions. Print wire 8 is only used for the underscore, the section sign, and the lowercase characters g, j, p, q, and y.

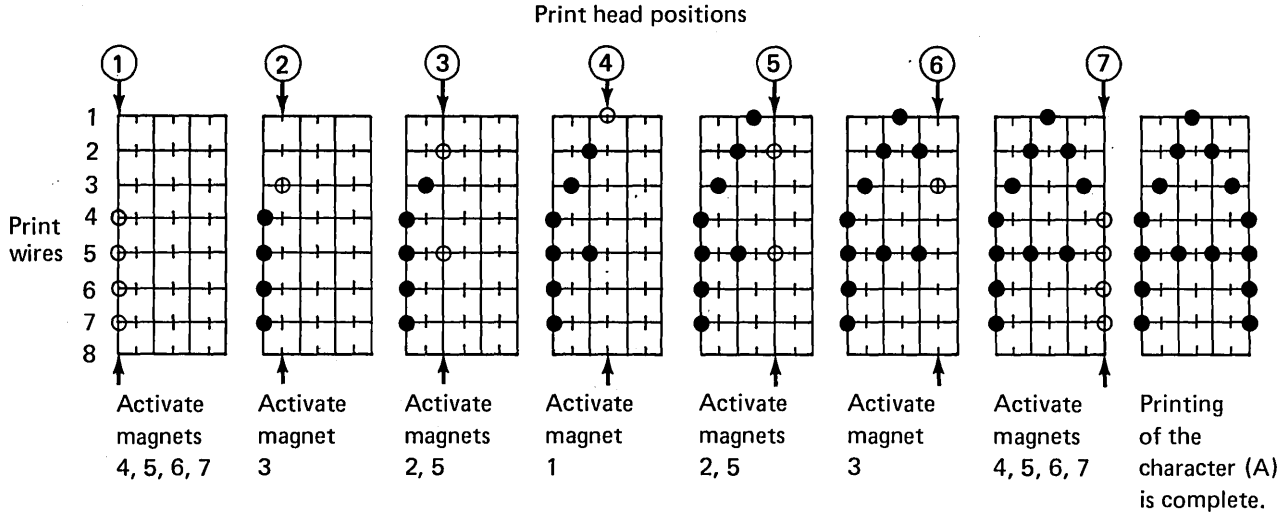


Figure 1-2. Printing a character

Forms Tractor

The forms tractor (Figure 1-3), mounted on top of the printer, vertically positions paper forms. The forms tractor is required for printing on multipart continuous forms or preprinted continuous forms and it is recommended for single-part continuous margin-punched forms. Forms requirements are shown in Figure 1-4.

The right and left tractor chains are adjustable to handle different widths of paper. The forms tractor is pivoted back out of the way when cut forms are used.

During an I/O operation, parameters can be specified for forms length, overflow line, and either the skip-to line on the next form or the number of lines to be spaced (84 lines maximum). "Chapter 2. Operations" discusses the parameters and how they are used.

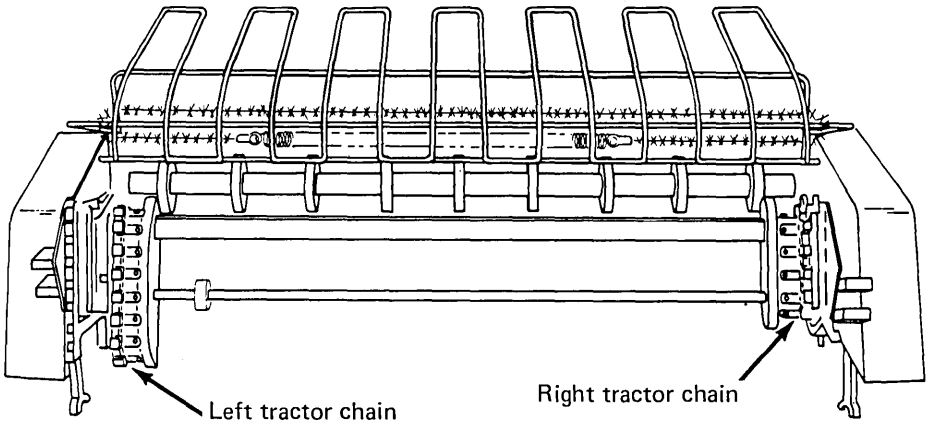


Figure 1-3. Forms tractor

ALL FORMS	
Minimum thickness	0.0762 mm (0.003 in.)
Maximum width	368.3 mm (14.5 in.)
Minimum length	76.2 mm (3.0 in.)
Maximum copies	Original plus five
CUT FORMS–SINGLE PART	
Maximum thickness	0.01905 mm (0.0075 in.)
Minimum width	152.4 mm (6.0 in.)
Maximum length	355.6 mm (14.0 in.)
CUT FORMS–MULTIPART	
Maximum thickness	0.4572 mm (0.018 in.)
Minimum width	152.4 mm (6.0 in.)
Maximum length	355.6 mm (14.0 in.)
Maximum copies	Original plus five
CONTINUOUS FORMS	
Maximum thickness	0.4572 mm (0.018 in.)
Minimum width	76.2 mm (3.0 in.)
Maximum distance between folds	355.6 mm (14.0 in.)
Maximum copies	Original plus three
Maximum forms weight	6804 kg per ream (15 lbs.)

Note. Using stapled forms, partially separated forms, or continuous-form card stock is not recommended. Multipart cut forms are glued at the top and not crimped.

Figure 1-4. Forms requirements

Controls

The printer has two switches and some knobs and levers for moving and adjusting printer ribbons and paper forms. Figure 1-5 shows the locations of these controls.

The two switches are:

- Power

  This switch has two positions:
  - Off
  - Power On

- Mode

  The mode switch is in front of the power switch and has three positions:
  - Print
  - Wait
  - TOF (top of forms)

The mode switch is left in the Print position for normal operation. With the switch in the Print position, the printer is ready to perform printer operations. If the printer receives no commands within approximately 6 seconds, the printer attachment feature moves the print head to the left-most print position. With the switch in the Wait position, the printer is no longer available to perform printer operations. The current operation is completed and all printer action is stopped. When execution is complete, the printer ignores any subsequent printer commands from the attachment.

When the switch is moved from the Wait position to the Print position, the attachment moves the print head to the left-most print position.

With the switch in the TOF position, the operator can logically set the printer to the first print line. As long as the switch remains in this position, the logical forms position remains at line 1 regardless of manual forms movement.

The other controls are described in the *Series/1 Operator's Guide*, GA34-0039.

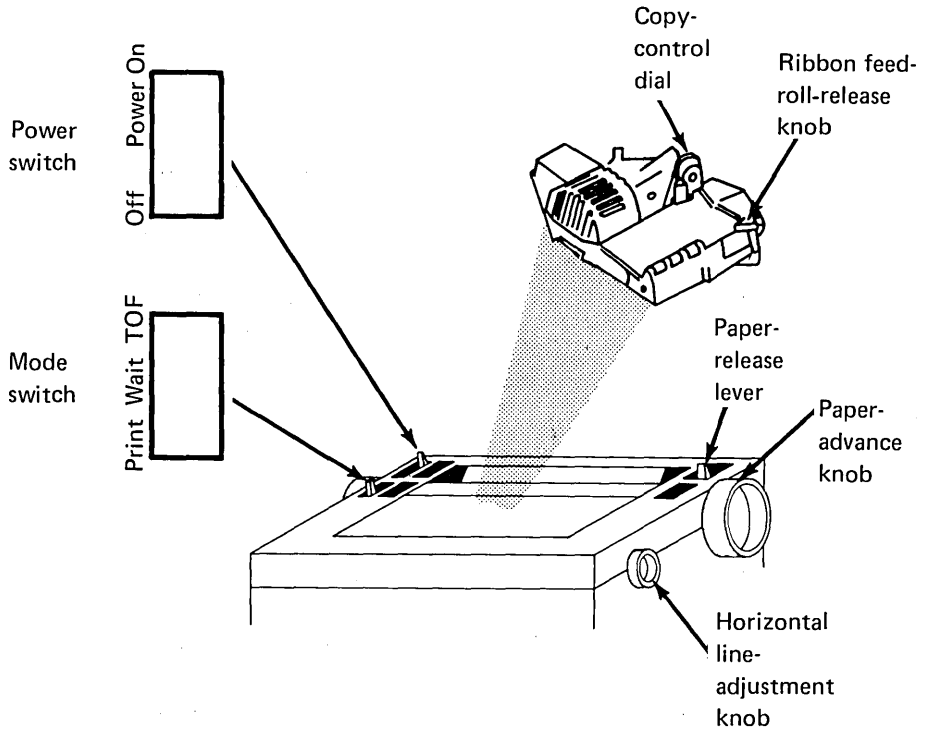


Figure 1-5. Printer controls

Chapter 2. Operations

This chapter describes how the processor transfers data to and from the printer. It includes descriptions of the Operate I/O instruction and its associated commands, status words, and condition codes. The processor initiates all printer operations by issuing an Operate I/O instruction, and then uses the processor I/O channel to transfer data to and from the printer.

The Operate I/O instruction is a privileged instruction. Its effective address (the combination of the R2 and address fields) points to an immediate device control block (IDCB) in processor storage. The IDCB contains a command, a device address, and an immediate data field (see Figure 2-1). The command defines the type of I/O operation: the device address identifies the device on which the operation is to be performed. The use of the information in the immediate data field depends on the mode of operation. For direct program control (DPC) operations, the immediate data field contains a data word; for cycle-steal operations, this field points to a device control block (DCB) that contains additional information needed to perform the operation. The IDCB must be on a fullword boundary. Refer to an appropriate processor description manual listed in the Preface under "Prerequisite Publications" for a more detailed description.

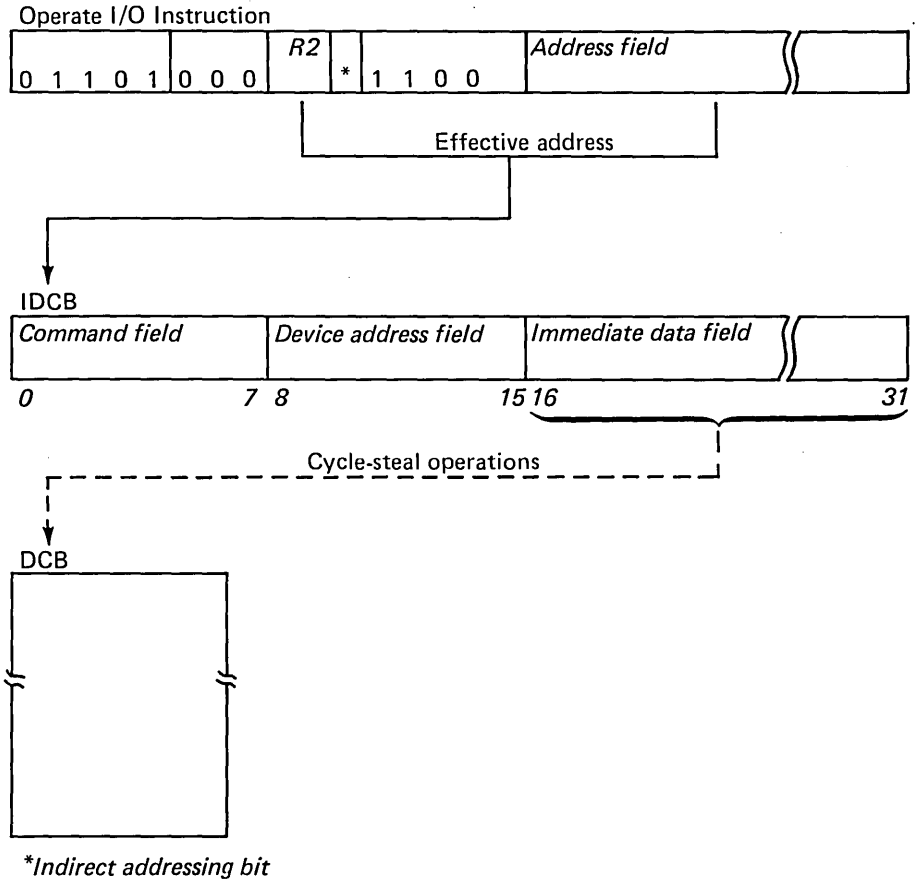


Figure 2-1. Operate I/O instruction

Direct Program Control (DPC)

A DPC operation causes an immediate transfer of data or control information to or from the printer.

An Operate I/O instruction must be executed for each data transfer. Each execution causes the following events (refer to Figure 2-2):

1. The Operate I/O instruction's effective address points the program to an IDCB in processor storage 1.
2. The I/O channel uses the IDCB's device address field 3 to select the printer and the command field 2 to determine the operation to perform.
3. The processor transfers the contents of the immediate data field to the printer, or transfers information from the printer to the immediate data field, depending on the command being executed 4.
4. The printer sends a condition code to the level status register (LSR) in the processor 5. Condition codes are explained under "Condition Codes" later in this chapter.

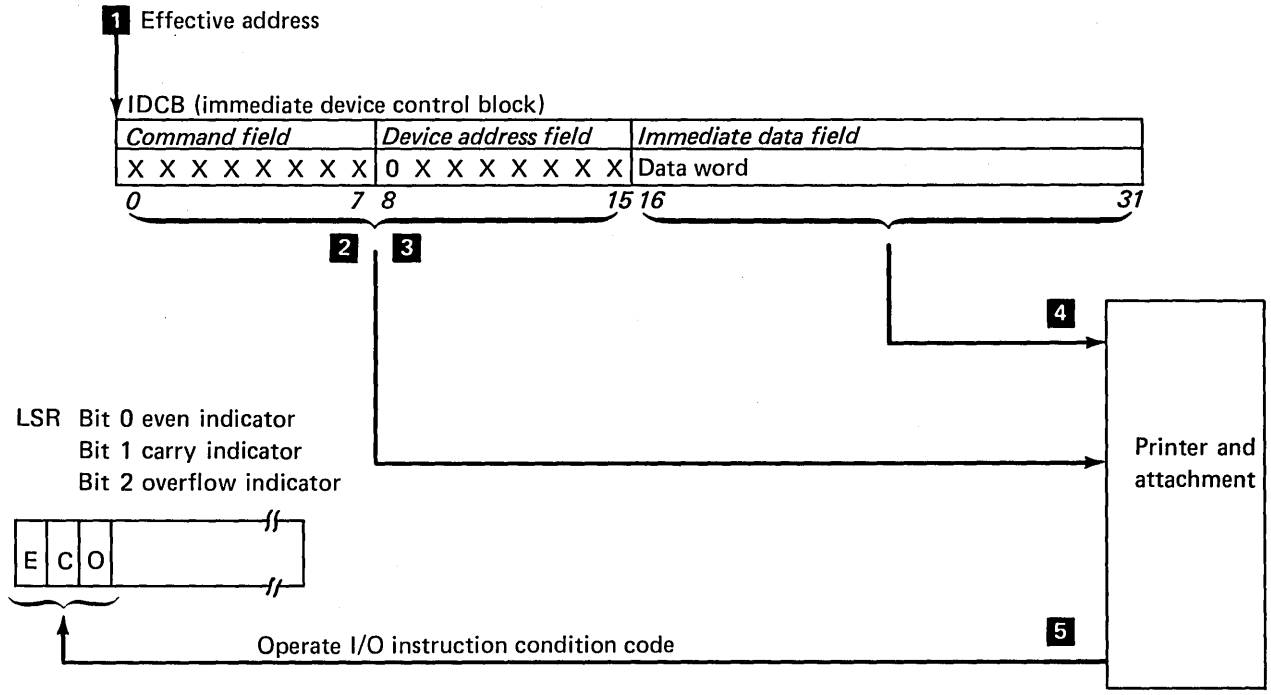


Figure 2-2. Direct program control (DPC) operation

The following commands cause printer DPC operations:

Prepare

IDCB (immediate device control block)

Command field	Device address field
0 1 1 0 0 0 0 0	0 X X X X X X X
0 7	8 15
60	00–7F

Immediate data field		
Zeros	Level	I
16 26	27 30	31

0 = interrupts disabled
1 = enable interrupts

Note. Refer to "Prerequisite Publications" in the Preface of this manual. Processor description manuals contain information about interrupt levels.

This command loads the interrupt level and I bit into the printer. The I bit (bit 31) defines whether the printer can present I/O interrupt requests. If the I bit equals 1, requests are presented on the level defined by the level field (bits 27–30); if the I bit equals 0, the printer cannot present interrupt requests.

Read ID

IDCB (immediate device control block)

Command field	Device address field
0 0 1 0 0 0 0 0	0 X X X X X X X
0 7	8 15
20	00–7F

Immediate data field
Data word
16 31

This command transfers the identification (ID) word for the printer to the immediate data field of the IDCB. After command execution, the immediate data field contains:

Immediate data field
0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 1 0
16 31

Device Reset

IDCB (immediate device control block)

Command field	Device address field
0 1 1 0 1 1 1 1	0 X X X X X X X
0 7	8 15
6F	00–7F

Immediate data field
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
16 31

This command resets any pending interrupt request or busy condition in the printer. The prepare level and the residual address are not affected. The immediate data field is not used.

Halt I/O

IDCB (immediate device control block)

Command field	Device address field
1 1 1 1 0 0 0 0	
0 7	8 15
F0	

Immediate data field
16 31

This is a channel-directed command that halts all I/O activity on the I/O channel and resets all devices. The IDCB's immediate data field is not used. Any pending interrupt request or busy condition is reset. The prepare level and the residual address are not affected.

Cycle Steal

Command execution in cycle-steal mode permits overlapping an I/O operation with processor operations and other I/O operations (see Figure 2-3). As is true for other commands, the processor transfers the IDCB under direct program control from processor storage to the printer 1, and after the printer accepts the IDCB, it sends a condition code back to the processor 2. But now the processor is free to continue with other operations while the printer uses the information in the IDCB to execute the command. The IDCB's immediate data field contains the address of a DCB. This eight-word DCB contains parameters that define and control the I/O operation. The printer "steals" the DCB words 3 and data 4 it needs to perform the operation. Each data transfer reduces a preset byte count in DCB word 6. When the data transfer ends (byte count equals 0), an interrupt request is sent to the processor. The processor then accepts the interrupt condition code and an interrupt ID word from the printer.

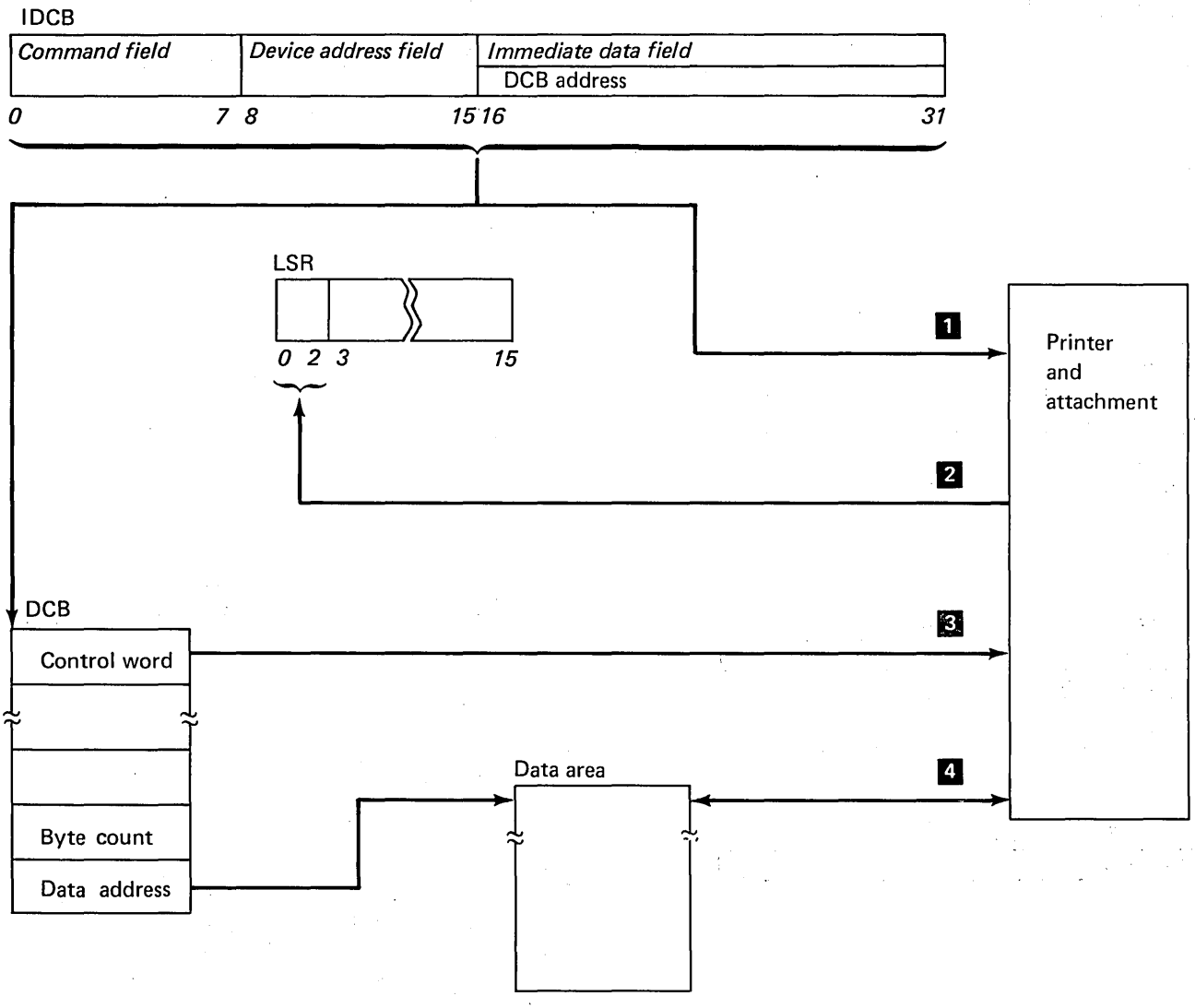


Figure 2-3. Cycle-steal operation

Start

IDCB

Command field	*Device address field*
0 1 1 1 0 0 0 0	0 X X X X X X X
0 *7*	*8* *15*
70	00–7F

Immediate data field
DCB address
16 *31*

The Start command initiates I/O printer operations that transfer data to or from processor storage in cycle-steal mode. An interrupt request is sent to the processor when the I/O operation ends. The control information and parameters required for a particular printer operation must be stored in the DCB associated with that operation.

The eight words in the DCB and their bit configurations are explained here and illustrated in Figure 2-4.

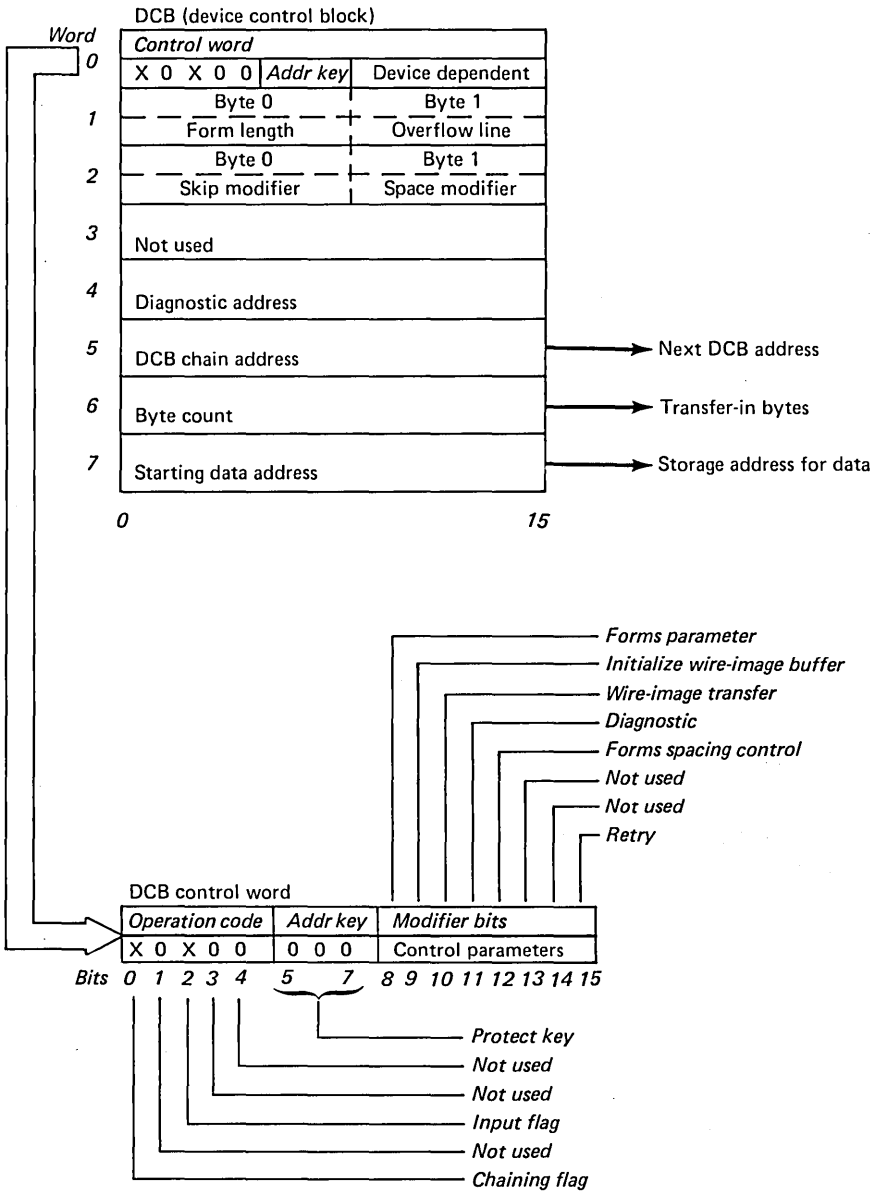


Figure 2-4. Device control block

DCB Word 0—Control Word

This is a 16-bit word that defines the cycle-stealing operation. This word contains two bytes of control parameters to be used with the particular Start command to be performed.

Bit 0 *Chaining flag.* When this bit equals 1, it tells the printer to perform a chaining operation. Chaining means the printer completes the current operation but does not present an interrupt request to the processor. Instead, the printer fetches the next DCB in the chain and performs the next operation. DCB word 5 tells the printer where to look for the next DCB. Chaining continues until a DCB is fetched that has the chaining bit in the control word (DCB word 0) equal to 0, indicating the last operation in the chain. If an error occurs, chaining to succeeding DCBs is automatically suspended, and an interrupt request is sent to the processor. Normally, an interrupt is not requested until the printer has completed the last operation in the chain. DCB chaining for the 4974 is valid only for a Start command.

Bit 1 This bit is not used and must be 0.

Bit 2 *Input flag.* This bit tells the printer which direction the data is to be transferred. When this bit equals 1, it tells the printer to transfer data from the printer into processor storage. When this bit equals 0, the cycle-steal data transfer is from processor storage to the printer.

Bit 3 This bit is not used and must be 0.

Bit 4 This bit is not used and must be 0.

Bits 5,6,7 *Address key.* This is a three-bit key that the printer presents during data transfers to verify that the program has authorization to access processor storage. An incorrect address key causes an exception interrupt request (condition code 2).

Bit 8 *Forms parameter.* When this bit equals 1, it tells the printer that DCB word 1 (forms parameter) contains the new forms parameters to be used. When this bit equals 0, it tells the printer that DCB word 1 is not used.

Bit 9 *Initialize wire-image buffer.* When this bit equals 1, it tells the printer to initialize its wire-image buffer. While the wire-image buffer is being initialized, no printing or forms movement takes place. The wire-image buffer is initialized two ways:

1. When the byte count equals 0, the printer initializes its wire-image buffer with the wire-image values of the 64 standard EBCDIC characters plus five for international use. The five additional characters are the opening and closing braces, the broken vertical line, the tilde, and the grave accent. See Figure 2-10 for the wire-image values associated with each character. See "Wire-Image" later in this chapter for an explanation of the format of the wire-image values. The processor does not supply any data in this mode.
2. When the byte count is 1 to 8, the printer initializes the wire-image buffer with the standard EBCDIC characters and then overlays characters in the buffer with alternate characters specified by the bytes of data transferred. The data transferred is bit significant, where each bit represents one of 42 alternate characters provided by the printer (see Figure 2-5). If the byte count is 6, 7, or 8, bits 43-64 of the data transferred are not used and must be 0's. If the first bit equals 1, the first alternate character's wire-image value replaces the appropriate EBCDIC-equivalent character in the standard character set. If the second bit equals 1, the second alternate character's wire-image value is placed in the buffer, and so on, up through bit 42. If more than one alternate character is specified with the same EBCDIC representation, the last character specified is the one placed in the wire-image buffer.

Figures 2-6 and 2-7 illustrate the international considerations for alternate character programming.

Note: The input flag bit must equal 0 when bit 9 equals 1. If the input flag bit equals 1, an exception interrupt request (condition code 2) with a DCB specification check is reported.

Bit 10 *Wire-image transfer.* When this bit equals 1, wire-image data designated by the data address in DCB word 7 is transferred from processor storage to the printer's wire-image buffer (see "Wire-Image" later in the chapter), and no printing takes place. The byte count must be 1792 or less, depending on the character set (see Appendix B for the 96-character wire-image table). When this bit equals 0, no data is transferred to the wire-image buffer.

Alternate char. bit positions	Hex code	Printed character
1	4A	# Number sign
2	4F	! Exclamation
3	5A	$ Dollar sign
4	5B	£ Pound sign
5	7B	Ä
6	7C	Ö
7	4A	$ Dollar sign
8	4A	[Open bracket
9	5A	] Close bracket
10	5F	^ Circumflex
11	7C	a
12	E0	ξ
13	4A	° Degree
14	5A	§ Section sign
15	7B	£ Pound sign
16	5A	é
17	7C	§ Section sign
18	4A	£ Pound sign
19	5B	¥ Yen sign
20	E0	$ Dollar sign
21	4A	§ Section sign
22	5A	⋈ Intern curr
23	5B	Å
24	E0	É
25	7B	AE
26	7C	φ
27	4C	ξ
28	7B	Ã
29	7C	Õ
30	5B	Pt
31	7B	Ñ
32	4A	É
33	5B	ξ
34	5A	/
35	A1	∞
36	E0	ь
37	7B	Õ
38	7C	Ã
39	4A	Ä
40	5A	Ü
41	4A	à
42	E0	Ö

Figure 2-5. Alternate characters for the 4974

Bit 11 *Diagnostic.* When this bit equals 1, it tells the printer to transfer diagnostic information from processor storage to the diagnostic address of the printer specified in DCB word 4. If the input flag bit (2) equals 0 and the last byte transferred is on a word boundary, it tells the printer to branch to the last diagnostic address accessed as soon as the byte count equals 0.

No printing takes place while bit 11 equals 1.

Bit 12 *Forms spacing control.* When this bit equals 1, it tells the printer to print 8 lines per inch. When this bit equals 0, it tells the printer to print 6 lines per inch. If 8-lines-per-inch printing is to be selected, the printer must be initialized and set by program control each time power is turned on. Initializing the 4974 for 8 lines per inch is described later in this chapter.

Bit 13 This bit is not used and must be 0.

Bit 14 This bit is not used and must be 0.

Bit 15 *Retry.* When this bit equals 1, it tells the printer to attempt to complete the execution of the last Start command issued; the remaining value of the DCB must be the same as the DCB being executed at the time of the exception interrupt request (condition code 2). The printer knows what step (DCB transfer, data transfer, carriage movement, or printing) of the execution is in process when the request occurs.

The 4974 finishes executing the Start command. The entire DCB is transferred to the 4974; data is transferred only if required. If the previous Start command was executed without an error, the retry bit is ignored and the DCB is executed. After a power-on reset, the Start command is executed as a normal DCB and the other words in the DCB are checked

and used if required. Start command execution is terminated with a normal device-end interrupt request unless other exception conditions are detected and reported by an exception interrupt request.

Character set	Bits 1-64 of alternate character I.D. code (8 bytes in hex)									
U.S./Canada - English	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
Japan - English	0 0	0 0	7 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
Austria/Germany	4 0	4 0	8 0	0 0	0 3	4 0	0 0	0 0	0 0	0 0
United Kingdom - English	1 2	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
Sweden	4 C	4 0	0 F	0 0	0 0	0 0	0 0	0 0	0 0	0 0
France	4 0	7 E	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
Belgium	4 1	F 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
Italy	4 0	5 B	8 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
Denmark/Norway	C 0	4 0	0 6	C 0	0 0	0 0	0 0	0 0	0 0	0 0
Spain	0 1	8 0	0 0	0 6	0 0	0 0	0 0	0 0	0 0	0 0
Spanish speaking	0 1	8 0	0 0	0 2	0 0	0 0	0 0	0 0	0 0	0 0

Note. The program must supply the alternate character identifying bits to the printer. Bits 43—64 must be 0's.

Figure 2-6. International alternate character I.D. codes

Country	Hex code							
	7B	7C	5B	4A	4F	5A	5F	E0
U.S.A./Canada - English	#	@	$	¢	|	!	¬	\
Japan - English	#	@	¥	£	|	!	¬	$
Austria/Germany	#	§	$	Ä	!	Ü	^	Ö
United Kingdom - English	#	@	£	$	|	!	¬	\
Sweden	Ä	Ö	Å	§	!	¤	^	É
France	£	à	$	°	!	§	^	ç
Belgium	#	à	$	[	!	]	^	ç
Italy	£	§	$	°	!	é	^	ç
Denmark/Norway	Æ	Ø	Å	#	!	¤	^	\
Spain	Ñ	@	Pt	[	|	]	¬	\
Spanish Speaking	Ñ	@	$	[	|	]	¬	\

Figure 2-7. International considerations for alternate characters

DCB Word 1—Forms Parameter

This word is used to control forms movement. The forms parameter is used only when bit 8 of control word 0 equals 1. DCB word 1 consists of two bytes: byte 0 (form length) and byte 1 (overflow line).

Byte 0 contains the number of lines on one form (form length). If this value is less than the current line position, the current line position is set to line 1. The value of byte 0 can be 1 to 255. A value of 0 is invalid and generates an interrupt request with a specification check in the interrupt status byte (ISB). The ISB is described later in this chapter.

Byte 1 contains the line position where the printer is to stop form movement and/or printing. The printer generates an exception interrupt request with bit 0 equal to 1 in the ISB. Overflow interrupt requests are inhibited if byte 1 equals 0 or contains a value greater than the value of byte 0. The forms overflow bit (11) in cycle-steal status word 1 then equals 1, allowing the printer to skip over restricted printing areas that are 13 mm (0.5 in.) from the folds and print trailer or headers on forms.

DCB Word 2—Forms Control

This word specifies whether skipping or spacing is to take place before printing. Byte 0 contains the skip modifier. If this byte has a value between 00 and the value of the maximum form length, the printer skips the forms to the specified line. If the current line position is is equal to or less than the skip-modifier value, the printer skips to the next form. When the skip-modifier value is greater than the form length, an interrupt request is posted and the DCB specification is set on in the ISB.

If byte 0 contains 00, byte 1 is inspected for a space. If byte 1 contains 00, no forms movement takes place. If byte 1 contains a value greater than 00, the forms move the number of lines specified. If byte 0 contains a value greater than 00, byte 1 is not checked.

The forms should not be moved more than 84 lines using either a skip or space command. When a distance of more than 84 lines, 356 mm (14 in.), of paper is moved in one operation, stacking and feeding problems occur.

The speed of the forms movement is the same whether skipping or spacing.

DCB Word 3

This word is not used and must contain all 0's.

DCB Word 4—Diagnostic Address

This word contains the address in the printer where the diagnostic data transfer is to take place when the diagnostic bit (11) equals 1 in DCB control word 0.

DCB Word 5—Chaining Address

This is the location of the next DCB to be executed. If the chaining address is odd, an interrupt request is posted and a DCB specification check is set in the ISB. The address is not checked unless the chaining flag bit (0) equals 1 in control word 0.

DCB Word 6—Byte Count

This word contains a 16-bit unsigned integer representing the number of data bytes to be transferred for the current DCB. If the byte count equals 0, no data is transferred. When the byte count is greater than the maximum allowed for a particular operation, an interrupt request is posted and the DCB specification check bit (3) is set to 1 in the ISB.

For a Start command, the byte counts are:

Control word bits	Maximum byte count	Function
Bit 9 = 1	8	Initialize wire-image buffer
Bit 10 = 1	1792	Wire-image transfer
Bit 11 = 1	*2048	Diagnostic mode
Bits 9, 10, 11 = 0	132	Line printing

*If the diagnostic transfer address is 0, the maximum byte count is 2048. If the address is greater than 0, the maximum byte count will be equal to 2048 minus the diagnostic transfer address. The attachment stops cycle stealing when the byte count goes to 0.

DCB Word 7—Data Address

This word contains the starting storage address for the data associated with the operation to be performed.

Start Cycle Steal Status

IDCB (immediate device control block)

Command field	*Device address field*
0 1 1 1 1 1 1 1	0 X X X X X X X
0 *7*	*8* *15*
7F	*00–7F*

Immediate data field
DCB address
16 *31*

The Start Cycle Steal Status command initiates the transfer of up to eight words of status information from the printer to processor storage, in cycle-steal mode. This status information is used to determine why a given operation did not execute correctly. The processor storage address is specified in word 7 of the applicable DCB. This command causes the printer to generate an interrupt request when execution is complete.

The Start Cycle Steal Status command requires an Operate I/O instruction with the address of an IDCB, an IDCB with the address of the DCB, and a DCB. The format of the DCB is as follows:

DCB (device control block)

Word	
0	*Control word*
	0 0 X 0 0 *Addr key* 0 0 0 0 0 0 0 0
	4 5 7 8 15
1	Not used (zeros)
2	Not used (zeros)
3	Not used (zeros)
4	Not used (zeros)
5	Not used (zeros)
6	Byte count
7	Data address of status word 0
	0 *15*

The eight words of status information have the following format and meaning:

Status word		
0	Residual address	
1	Device status	
2	Byte 0 Residual line count	Byte 1 Current position
3	Byte 0 Form length	Byte 1 Overflow line
4	External interface status	
5	Printer interface status	
6	Current attachment marks	
7	Byte 0 Logical left margin	Byte 1 Logical right margin
	0	*15*

Word 0—Residual Address

This address is the storage location of the last attempted cycle-steal transfer associated with a Start command. This address might be a DCB address or data address. If the last transfer attempted was a word transfer, the residual address points to the odd byte of the word. If an error occurs during a start-cycle-steal-status operation, this address is not altered. A device reset, a system reset, or a Halt I/O command might cause an unpredictable residual address. Only a power-on reset resets the residual address to 0's.

Word 1—Device Status

When bit 0 of the ISB equals 1, the device status word defines the condition that caused the exception interrupt request (condition code 2). This status is not reset until the next Start command is issued. The information in the device status word reflects the status at the time of the last noncycle-steal-status interrupt request; it does not necessarily reflect current status.

Bit 0 *Printer not ready (power off or disconnected).* When this bit equals 1 and bit 9 (external interface check bit) equals 0, the printer power is off. If bit 9 equals 1, the printer signal cable is disconnected.

The remaining status bits in the device status word might not be valid if bit 0 or bit 9 equals 1.

Bit 1 *Print-wire check.* When this bit equals 1, it means a print-coil driver was on for more than 610 μs. This condition sets a print-wire check, turns off the 24-volt regulator, and causes a printer power check. When the problem is corrected, the power check is reset.

Bit 2 *Printer power check.* This bit equals 1 if:

- The printer 24 V is not within tolerance.
- The printer 5 V is not present.
- The printer 10.8 V is not within tolerance.
- A wire check occurred.

This bit is reset when the condition causing the power check is corrected.

Bit 3 *Wait.* This bit equals 1 when the printer Mode switch is not in the Print position. The printer cannot print or move the forms. To determine the completion status of the current command, the residual line count is checked to see if the forms operation is completed. If the count is not 0 or the residual address points to the first print character, no printing has taken place and an exception interrupt request is posted.

Bit 4 *Forms-emitter check.* The position of the forms is monitored whenever the printer is ready (not in a wait state). When the forms position is altered, either manually or under program control, the current line position is updated. If the two forms emitters move simultaneously, the current line position cannot be updated correctly and the forms-emitter check bit is set to 1.

Bit 5 *Margin check.* This bit equals 1 whenever the left margin is not detected at the expected time. When this check occurs, it is possible that the previously printed line was not printed correctly. The check might occur after a normal device-end interrupt is posted.

Bit 6 *Print-emitter check.* This bit equals 1 if the print-emitter pulses occur too frequently or out of sequence.

Bit 7 *Forms stalled.* This bit equals 1 if the forms should be moving under program control but no movement is detected at the forms emitter during a 250-millisecond period.

Bit 8 *Attachment wire check.* This bit equals 1 when the printer detects an active signal that should be inactive or an inactive signal that should be active.

Bit 9 *External interface check.* Periodically the attachment does a diagnostic checkout of the attachment-to-printer cable. Bit 9 equals 1 if the cable is disconnected, if a grounded or open signal line exists, or if there is a defective line driver. This condition does not cause an exception interrupt request.

Bit 10 *Printer interface check.* When the printer activates or deactivates a stepper-motor driver line or reset line, the printer checks to see if the appropriate lines are switched. Bit 10 equals 1 if a line does not switch correctly.

Bit 11 *Overflow.* This bit equals 1 if the forms stop on the overflow line. If the forms move beyond the overflow line, there is a residual line count in device status word 2 and no printing occurs for the current DCB.

Bit 12 *End of forms.* At the completion of a forms-movement operation, the forms switch is checked. Bit 12 equals 1 if this switch is open (indicating no forms) and an exception interrupt request is posted. Printing is stopped when this condition is detected.

This bit equals 1 when there is 25–76 mm (1–3 in.) of paper remaining in the printer.

Bit 13 *Invalid wire image.* This bit equals 1 when:

- The characters transferred to the print-line buffer are not valid wire-image characters.
- An invalid sequence of check bytes was detected.
- The wire-image buffer calls for the same wire to be activated in two adjacent emitter times. An exception interrupt request with device status is posted.

Bit 14 *No print emitter.* This bit equals 1 if no print emitter pulses are detected when print head movement is initiated.

Bit 15 This bit is not used.

Residual Line Count/Current Position—Word 2

The residual line count (byte 0) is the number of lines the forms have to move to complete the forms control of the last operation. This count is not valid if an error occurred during the transfer of the last DCB. Normally this count is 00.

When an overflow interrupt request occurs, if the carriage is to move beyond the overflow line, the residual line count is the number of remaining lines required to be moved to complete the operation. If a forms-stalled error occurs during forms movement, the residual line count is the number of lines that remain to be moved to complete the forms operation.

The current position (byte 1) is always the current line position of the forms. This position is changed by programmed or manual form movement.

Forms Length/Overflow Line—Word 3

The forms length (byte 0) and the overflow line (byte 0) are the most recent forms parameters successfully transferred to the printer from the processor. If the program assigns no forms parameters, the default values are 66 for forms length and 60 for the overflow line.

External Interface Status—Word 4

See *Note.*

Printer Interface Status—Word 5

See *Note.*

Current Attachment Marks—Word 6

See *Note.*

Logical Left Margin/Logical Right Margin—Word 7

The logical left margin (byte 0) and logical right margin (byte 1) represent the boundaries of the characters remaining to be printed when an exception interrupt request has terminated a print operation. The logical margin values are equal to the physical print position plus 16. When the print line is transferred from storage, the printer suppresses unprintable characters and blanks, and adjusts the logical margins to reflect the boundary of the printable characters. As printing takes place, the contents of bytes 0 and 1 are modified by 1 each time a character is printed.

Note: Status words 4, 5, and 6 are used for diagnostic purposes and are not explained in this manual.

Condition Codes and Status Information

Condition Codes

A condition code is reported to the processor (1) after execution of every Operate I/O instruction and (2) upon presentation of a priority interrupt request. The condition code is available in the even, carry, and overflow bit positions of the level status register (LSR) in the processor. For information on the LSR, refer to an appropriate processor description manual listed under "Prerequisite Publications" in the Preface. For operations that do not cause interrupt requests, the condition code reported after the instruction is executed is the only status information required or available.

Operate I/O Instruction

Condition Code 0—Device Not Attached

This code is reported by the channel when the addressed 4974 is not attached to the Series/1.

Condition Code 1—Busy

This code is reported by the 4974 when it is unable to execute a command because it is in the busy state. The 4974 enters the busy state when it's performing an operation that generates an interrupt request after execution. The 4974 exits the busy state when the processor accepts the interrupt request.

Condition Code 2—Busy After Reset

This code is reported by the 4974 when it is unable to execute a command because of a reset and the printer has not had sufficient time to return to the inactive state. There is no interrupt request to indicate termination of this condition.

Condition Code 3—Command Reject

This code is reported by the printer or the channel when:

- A command is issued that is not part of the 4974 command set.
- The printer is not in the correct state to execute the command.
- The IDCB contains an incorrect parameter. For example, an odd-byte DCB address, or an incorrect function-modifier combination.

When the 4974 rejects a command, the printer does not fetch the DCB.

Condition Code 4—Not Used

Condition Code 5—Interface Data Check

This code is reported by the printer or the channel when a parity error is detected on the I/O data bus during a data transfer.

Condition Code 6—Not Used

Condition Code 7—Satisfactory

This code is reported by the printer when it accepts a command.

Interrupt

Condition Codes 0 and 1—Not Used

Condition Code 2—Exception

This code is reported when an error or exception condition is associated with the priority interrupt request. This condition is described in the interrupt status byte (ISB) and further described in the 16 bytes of status information.

Condition Code 3—Device End

This code is reported when no error exception or attention conditions occur during the I/O operation and a normal termination of the operation has occurred.

Condition Code 4—Attention

This code is reported when the 4974 becomes ready after being in the not-ready state. Along with the interrupt condition code, the printer also transfers an interrupt ID word that provides additional information about the interruption conditions.

Condition Codes 5, 6, and 7—Not Used

Status

Status information is transferred from the printer to the processor as the result of:

- A start-cycle-steal-status operation (see "Start Cycle Steal Status" in this chapter)
- A priority interrupt request

Interrupt Identification Word

Acceptance of an I/O interrupt request causes the printer to present an interrupt ID word to the processor. The interrupt ID word consists of an interrupt information byte (IIB) and the 4974 device address and is stored in processor register 7. The format is as follows:

Interrupt ID word

IIB/ISB								*Device address*							
X	X	X	X	X	X	X	X	0	X	X	X	X	X	X	X
0							*7*	*8*							*15*

For an Operate I/O instruction condition code 2, the eight-bit IIB takes on a different format called an interrupt status byte (ISB). The IIB contains 0's for all other condition codes.

Interrupt Status Byte

The ISB stores accumulated status information.

The format of the ISB is:

0	Device-dependent status available
1	Delayed command reject
2	Not used
3	DCB specification check
4	Storage data check
5	Invalid storage address
6	Protect check
7	Interface data check

Bit 0 *Device-dependent status available.* This bit equals 1 when additional status information (residual address and status bits) is available from the 4974. A Start Cycle Steal Status command must be issued to get this information.

Bit 1 *Delayed command reject.* This bit equals 1 when the printer cannot execute a command because of an incorrect parameter in the IDCB.

This bit is only set in the ISB when the printer is incapable of recording the condition with condition codes during the I/O instruction execution. The operation in progress is terminated and an interrupt request is generated. Condition code 2 is reported when the request is accepted. The residual address is not relevant to error recovery (see cycle-steal status word 0).

Bit 2 This bit is not used and must be 0.

Bit 3 *DCB specification check.* This bit equals 1 when the printer cannot execute the command because a parameter in the DCB is incorrectly specified to perform the desired operation.

Examples: An odd-byte chaining address, an odd address for a start-cycle-steal-status word, an invalid modifier in the control word, or an incorrect count. Condition code 2 is reported when the interrupt request is accepted. The residual address will be the last word of the DCB.

Bit 4 *Storage data check.* This bit equals 1 during cycle-steal output operations only. It indicates that the storage location accessed during the current output cycle contained incorrect parity. The parity in processor storage is not corrected. The printer issues the status in the ISB and terminates the operation. Condition code 2 is reported when the interrupt request is accepted.

Bit 5 *Invalid storage address.* This bit equals 1 if during a cycle-steal I/O operation, the main storage address presented by the printer for data or DCB access exceeds the storage size specified on the system. The printer records the status and terminates the operation. Condition code 2 is reported when the interrupt request is accepted.

Bit 6 *Protect check.* This bit equals 1 when the printer attempts to access a storage location without the correct storage-protect key. Refer to an appropriate processor description manual listed in the Preface under "Prerequisite Publications" for a more detailed description. The operation is terminated and condition code 2 is reported when the interrupt request is accepted.

Bit 7 *Interface data check.* This bit equals 1 when a parity error is detected on a cycle-steal data transfer. The condition can be detected by the printer or by the channel. In either case, the operation is terminated and an interrupt request is reported to the processor.

Condition code 2 is presented when the interrupt request is accepted. (See Appendix A "Reference Summary" for a summary of condition code and status information.)

Error Recovery Procedure

When an exception interrupt occurs, inspect the ISB to determine what kind of an error caused the printer to request the interrupt. Figure 2-8 shows what to do to recover from the error condition. Refer to the figure and perform the steps associated with the bits that equal 1 in the ISB. Perform the steps in the indicated sequence until the problem is found. The following paragraphs provide additional information for each step.

1. *Issue Start Cycle Steal Status command.* The residual address (word 0) and device status (word 1) provide additional information to use for error recovery.
2. *Inspect cycle-steal status word 1.* Refer to Figure 2-8 and perform the steps associated with the bits that equal 1 in this word.
3. *Modify DCB for error recovery.* To prevent losing printed data, overprinting, and multiple form movement, it might be necessary to modify the DCB before reissuing the command. If the I/O operation fails and the DCB's chaining bit equals 1, the residual address is checked to determine which DCB in the chain was used at the time the exception interrupt request occurred. The I/O operation must be modified to point to this DCB.
4. *Set retry bit.* The print data necessary to complete the printing of the line is contained in the printer buffer. When the retry bit equals 1 and the check condition is corrected, the printer finishes printing the line.
5. *Inspect print quality.* After a successful program recovery from a check condition, the last line printed might be misaligned or have a malformed character. Inspection of the printed output is not required but it is recommended.
6. *Retry three times.* The error-recovery-modified DCB should be retried three times to verify a machine check condition. It is necessary to count the number of times a command is retried. After three unsuccessful retries, the check condition is considered a hardware check.
7. *Visually check.* The printer should be checked for obvious problems (power off, forms jammed, objects in print head path).
8. *Make printer ready.* Operator intervention is required to make the printer ready to execute print commands.
9. *Retry error recovery DCB.* When the printer becomes ready to execute commands, it generates an attention interrupt request (condition code 4). This request can be caused by the printer power supply becoming ready or by the Mode switch (on the printer) being moved to the Ready position. Both conditions must occur before the interrupt request is posted. When the printer posts the request, the error recovery DCB should be retried.
10. *Return check condition.* When check conditions are a result of program error or program-specified parameters (overflow), the check condition should be returned to the programmer.
11. *Define check condition.* The printer is not receiving satisfactory data transfers from the processor channel and further definition of the check condition is required.
12. *Suspect malfunction.* Printer diagnostic tests and MAP charts might be necessary to isolate a failing unit if error recovery attempts are unsuccessful. If diagnostic tests are not performed immediately, power should be removed from the printer until tests can be made.

Example:

Exception interrupt occurs. Inspect the ISB. Invalid storage address bit(5) is equal to 1.

1. Issue Start Cycle Steal Status command.
2. Modify DCB for error recovery.
3. Set retry bit.
4. Retry three times.
5. Define check condition.

Note: Perform steps 2, 3, 4, and 5 until the problem is found.

Example:

Exception interrupt occurs. Inspect the ISB. Device status available bit(0) is equal to 1.

1. Issue Start Cycle Steal Status command.
2. Inspect cycle steal status word 1 (Wait bit(3) is equal to 1).
3. Modify DCB for error recovery.
4. Set retry bit.
5. Make printer ready.
6. Retry error recovery DCB.

Note: Perform steps 3, 4, 5, and 6 until the problem is found.

Recovery steps	Interrupt status byte (ISB)								Cycle-steal status word 1															
	0 - Device status available	1 - Delayed command reject	2 - Not used	3 - DCB specification check	4 - Storage data check	5 - Invalid storage address	6 - Protect check	7 - Interface data check	0 - Printer not ready	1 - Print-wire check	2 - Printer power check	3 - Wait	4 - Forms-emitter check	5 - Margin check	6 - Print-emitter check	7 - Forms stalled	8 - Attachment wire check	9 - External interface check	10 - Printer interface check	11 - Overflow	12 - End of forms	13 - Invalid wire image	14 - No print emitter	15 - Not used
1. Issue Start Cycle Steal Status command	X					X	X	X	X															
2. Inspect cycle steal status word 1	X																							
3. Modify DCB for error recovery						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
4. Set retry bit						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
5. Inspect print quality									X	X	X		X	X	X	X	X	X	X	X	X			
6. Retry three times						X	X	X	X				X	X	X	X	X	X	X	X	X			
7. Visually check									X				X	X	X	X	X	X						
8. Make printer ready									X			X											X	
9. Retry error recovery DCB									X	X	X	X	X	X	X	X	X	X	X	X				
10. Return check condition		X		X																		X		X
11. Define check condition						X	X	X	X															
12. Suspect malfunction									X	X			X	X	X	X	X	X	X	X	X			X

Figure 2-8. Error recovery procedure

The 8 Lines Per Inch Data Set

The 8-lines-per-inch data set enables the 4974 to print or space either 6 or 8 lines per inch. After the 8-lines per inch data set is initialized, the user selects either 6 or 8 lines per inch when setting the forms parameters. DCB word 0 controls the spacing as follows:

When bit 12 equals 0, the printer prints 6 lines per inch.

When bit 12 equals 1, the printer prints 8 lines per inch.

Initialization

Issuing a Start command with an IDCB referencing a unique DCB (see Figure 2-9) initializes the 8-lines-per-inch data set to allow selection of 6 or 8 lines per inch.

DCB word 7 must be coded with a starting address in processor storage of a 22-word data set.

The data set must be coded as follows:

Data in hex

4219
F001
5573
E8AD
98F1
498F
F8AC
4219
498E
F8AC
4239
D115
45A4
E8B5
42E4
45D4
E8BB
4294
D339
D8AF
D89B
D897

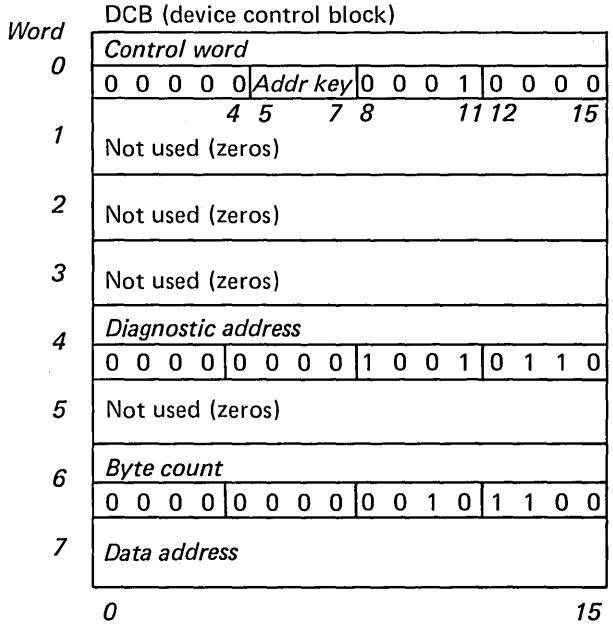


Figure 2-9. Initialization DCB

Programming Considerations

Turning on power automatically initializes the printer to print 6 lines per inch. If 8-lines-per-inch printing is to be selected, the 4974 must be initialized and set by program control each time the power is turned on.

Alternating between 6 and 8 lines per inch within a single forms definition can cause a loss of top-of-forms synchronization.

Using the 8-lines-per-inch function can cause print overlapping of certain special characters that use print wire 8 on one line and print wire 1 on the next line. Using multipart forms increases the probability.

Wire-Image

If DCB control word bit 10 equals 1, wire-image values are loaded from the Series/1 processor storage to the printer's wire-image buffer (see "DCB Word 0—Control Word" in this chapter). The printer converts the wire-image values into wire-image character patterns.

Character Pattern

The printer uses an 8-by-7 dot matrix pattern to print all characters. Seven bytes of data are used to represent the wire-image character pattern for each character. Each byte corresponds to one column of the matrix, starting with byte 1 as the left-most column and bit 0 as the uppermost bit. For example, an "E" is shown as:

		Bytes						
		1	*2*	*3*	*4*	*5*	*6*	*7*
Bits	*0*	X		X		X		X
	1	X						
	2	X						
	3	X		X		X		
	4	X						
	5	X						
	6	X		X		X		X
	7							

Column 1 has bits 0 through 6 equal to 1, making its hexadecimal value FE. Column 2 has all bits equal to 0; therefore its value is 00. Column 3 is represented by a 92, 4 by a 00, 5 by a 92, 6 by a 00, and 7 by an 82. The wire-image code of hex FE 0092 0082 for the "E" is represented in the last seven bytes of an eighte-byte wire-image value within a wire-image table (see Figure 2-10).

Two rules must be considered when creating characters:

- Adjacent dots within a row may not be used. (Adjacent dots within a column are permissible.) Attempting to use adjacent dots results in an invalid wire-image check.
- No more than 25 dots may be used within any one character.

Table Formatting

Each character to be printed requires a wire-image value of eight bytes of data, using the following format:

Bits 0, 1	check bits
Bits 2–7	displacement field
Bits 8–63	wire-image code

When a character is to be printed, the 4974 uses the check bits and displacement field to access the correct wire-image code within a wire-image table.

The entry point into the wire-image table is determined by the following formula:

Entry point = 8 x (value of bits 2 through 7 of the specified character code)

The check bits at this address are compared to bits 0 and 1 of the specified character code. If they compare, the correct point in the table is reached, and the character is printed using the wire-image code in bits 8 through 63. If the check bits do not compare, a new address is generated using the displacement field located at the entry point.

New address = entry point address + 8 x (displacement field + 3)

The check bits at the new address are compared to bits 0 and 1 of the requested character. If they still do not compare, the indexing procedure is repeated using the new displacement field.

Next address = previous address + 8 x (displacement field + 3)

A total of four accesses into the table are allowed. Exceeding this limit causes an invalid wire-image check. A 0 in the displacement field indicates no indexing is to occur. The minimum index possible is four character positions.

As an example, consider the standard EBCDIC wire-image table (Figure 2-10). If the character to be printed is a dash, the EBCDIC code for a dash is hex 60, or binary 0110 0000. Therefore, the check bits are 01, and the table is accessed at a hex (20 x 8), or hex 0100.

Wire-image table

	Address	Wire-image value
	0000	0000 0000 0000 0000
Entry point →	0100	DF80 4020 1008 0402

Bits 0 and 1 at location 0100 are 11, which does not compare with the 01 of the character to be printed. This indicates indexing to a new address is required, using bits 2 through 7 as the displacement.

Next address = 0100 + [8 x (1F + 3)] = 0210

Wire-image table

Address	Wire-image value
0000	3D00 0000 0000 0000
0100	DF80 4020 1008 0402
0210	4010 0010 0010 0010

Bits 0 and 1 at location 0210 are 01, indicating that this is the desired character. The wire-image pattern 10 0010 0010 0010, corresponding to a dash, is printed.

The wire-image table must consist of not fewer than 512 bytes (64 characters) and not more than 768 bytes (96 characters). If fewer than 64 characters are desired, "null" characters must be used to complete the 64-character set. A null character is defined as one having a wire-image value of all 0's.

The following steps should be followed when formatting a wire-image table.

1. Define the character set. Each character must be assigned an eight-bit character code and a seven-byte wire-image character pattern. Only printable characters are included in the character set. A "space" is not included.
2. Place the character set into a properly formatted table. Figure 2-11 is a flowchart of a procedure for formatting the character set into a usable format. The tables in Figures 2-12 and 2-13 are provided in conjunction with Figure 2-11 for your convenience when formatting a wire-image table.
3. Calculate the check bits and displacement field for each character in the table. The check bits for each character are bits 0 and 1 of the character code. Figure 2-14 is a flowchart of a procedure for calculating the displacement fields for the character set formatted in step 2.

Note: If a table-overflow error occurs while following the procedure in Figure 2-14, reformat the table to eliminate any indexes having fewer than four table positions.

Example: Position 95 indexes to position 96.

The table is reformatted as shown below, and the displacement fields recalculated.

Old Format		**New Format**	
Table Entry	#91	Table Entry	#91
	92		95
	93		92
	94		93
	95		94
	96		96

Address	Hex code	Printed character	Wire-image value			
0000	00	Null character	3D00	0000	0000	0000
0008	C1	A	C01E	2048	8048	201E
0010	C2	B	C082	7C82	1082	106C
0018	C3	C	C07C	8200	8200	8244
0020	C4	D	C082	7C82	0082	007C
0028	C5	E	C0FE	0092	0092	0082
0030	C6	F	C0FE	0090	0090	0080
0038	C7	G	C07C	8200	8210	825C
0040	C8	H	C0FE	0010	0010	00FE
0048	C9	I	C000	8200	FE00	8200
0050	4A	¢ Cent	4038	4400	C600	4400
0058	4B	. Period	4000	0006	0006	0000
0060	4C	< Less than	4000	1028	4482	0000
0068	4D	(Left parenthesis	4000	0038	4482	0000
0070	4E	+ Plus	4010	0010	6C10	0010
0078	4F	| Logical or	4000	0000	FE00	0000
0080	D0	} Closing brace	EE00	8200	826C	1000
0088	D1	J	C004	0200	0200	02FC
0090	D2	K	C0FE	0020	1048	0482
0098	D3	L	C0FE	0002	0002	0002
00A0	D4	M	C0BE	4020	1020	40BE
00A8	D5	N	C0BE	4020	1008	04FA
00B0	D6	O	C07C	8200	8200	827C
00B8	D7	P	C0FE	0090	0090	0060
00C0	D8	Q	C07C	8200	8208	847A
00C8	D9	R	C0FE	0090	0098	0462
00D0	5A	! Exclamation point	4000	0000	F600	0000
00D8	5B	$ Dollar	4020	5400	D600	5408
00E0	5C	* Asterisk	4010	4438	0038	4410
00E8	5D	) Right parenthesis	4000	0082	4438	0000
00F0	5E	; Semicolon	4000	00DA	04D8	0000
00F8	5F	¬ Logical not	4010	0010	0010	001C
0100	E0	\ Reverse slash	DF80	4020	1008	0402
0108	A1	~ Tilde	9F08	1020	1008	1020

Address	Hex code	Printed character	Wire-image value			
0110	E2	S	C064	9200	9200	924C
0118	E3	T	C080	0080	7E80	0080
0120	E4	U	C0FC	0200	0200	02FC
0128	E5	V	C0F0	0804	0204	08F0
0130	E6	W	C0FC	0204	1804	02FC
0138	E7	X	C082	4428	1028	4482
0140	E8	Y	C080	4020	1E20	4080
0148	E9	Z	C082	048A	10A2	4082
0150	6A	¦ Broken vertical line	4000	0000	EE00	0000
0158	6B	, Comma	4000	001A	0418	0000
0160	6C	% Percent	40C2	04C8	1026	4086
0168	6D	_ Underscore	4001	0001	0001	0001
0170	6E	> Greater than	4000	0082	4428	1000
0178	6F	? Question mark	4040	8000	8A00	9060
0180	F0	0	C038	4482	0082	4438
0188	F1	1	C000	4200	FE00	0200
0190	F2	2	C042	8402	8802	9062
0198	F3	3	C084	0280	12A0	528C
01A0	F4	4	C008	1028	4088	7608
01A8	F5	5	C0E4	02A0	02A0	029C
01B0	F6	6	C00C	1220	5280	120C
01B8	F7	7	C080	0284	0890	20C0
01C0	F8	8	C06C	9200	9200	926C
01C8	F9	9	C860	9002	9408	9060
01D0	7A	: Colon	4000	006C	006C	0000
01D8	7B	# Number sign	4028	00EE	00EE	0028
01E0	7C	@ At sign	4038	4482	308A	403A
01E8	7D	' Apostrophe	4000	00D0	20C0	0000
01F0	7E	= Equal	4028	0028	0028	0028
01F8	7F	" Double quotation	4000	E000	0000	E000
0200	C0	{ Opening brace	C000	106C	8200	8200
0208	50	& Ampersand	400C	52A0	5208	040A
0210	60	– Dash	4010	0010	0010	0010
0218	61	/ Slash	4002	0408	1020	4080
0220	79	` Grave accent	4000	0080	4020	0000

Note. The space character has a hex code of 40. It is an unprintable character and, therefore, has no wire-image value.

Figure 2-10. Standard EBCDIC wire-image table

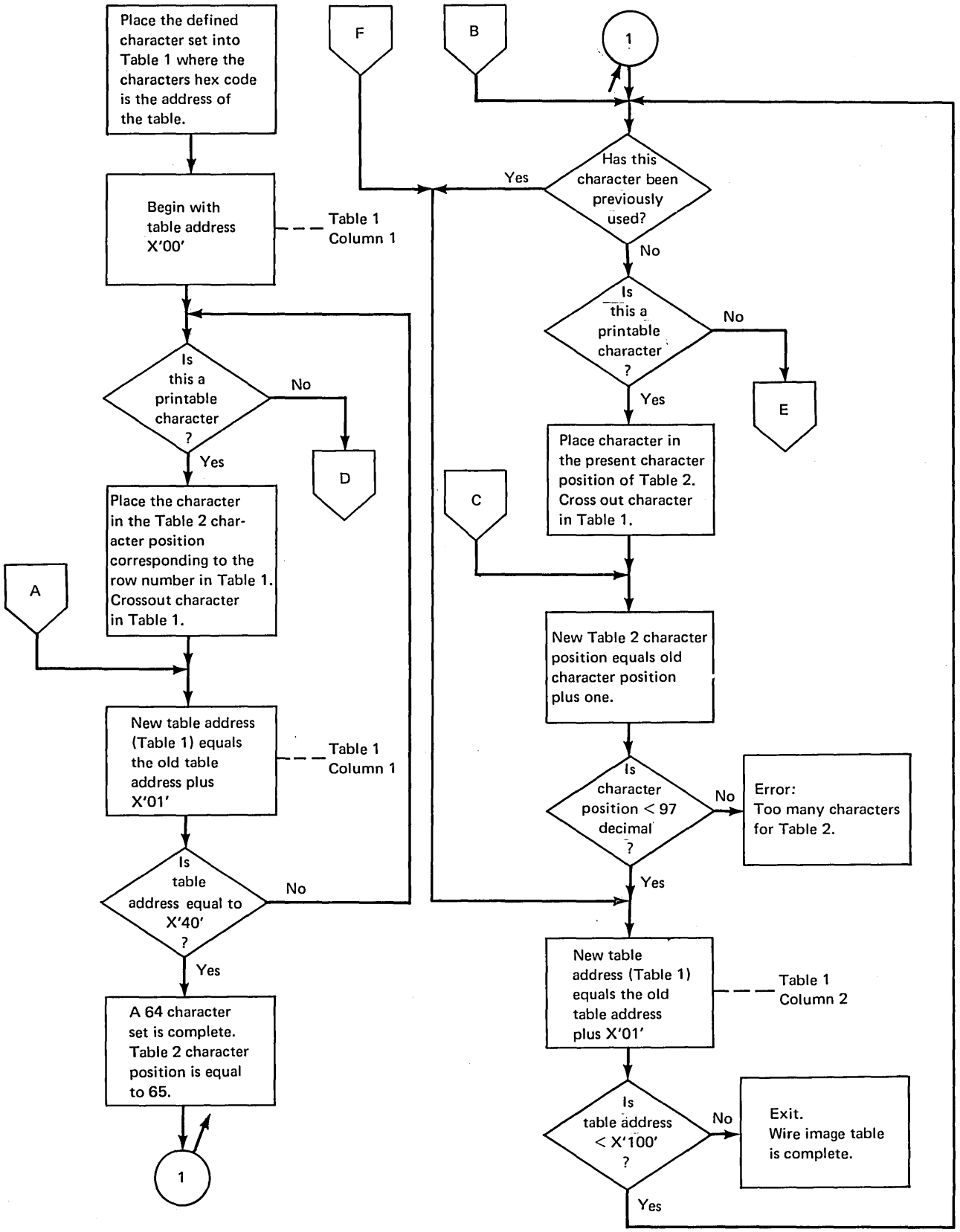


Figure 2-11 (Part 1 of 3). Flowchart procedure for formatting a character set

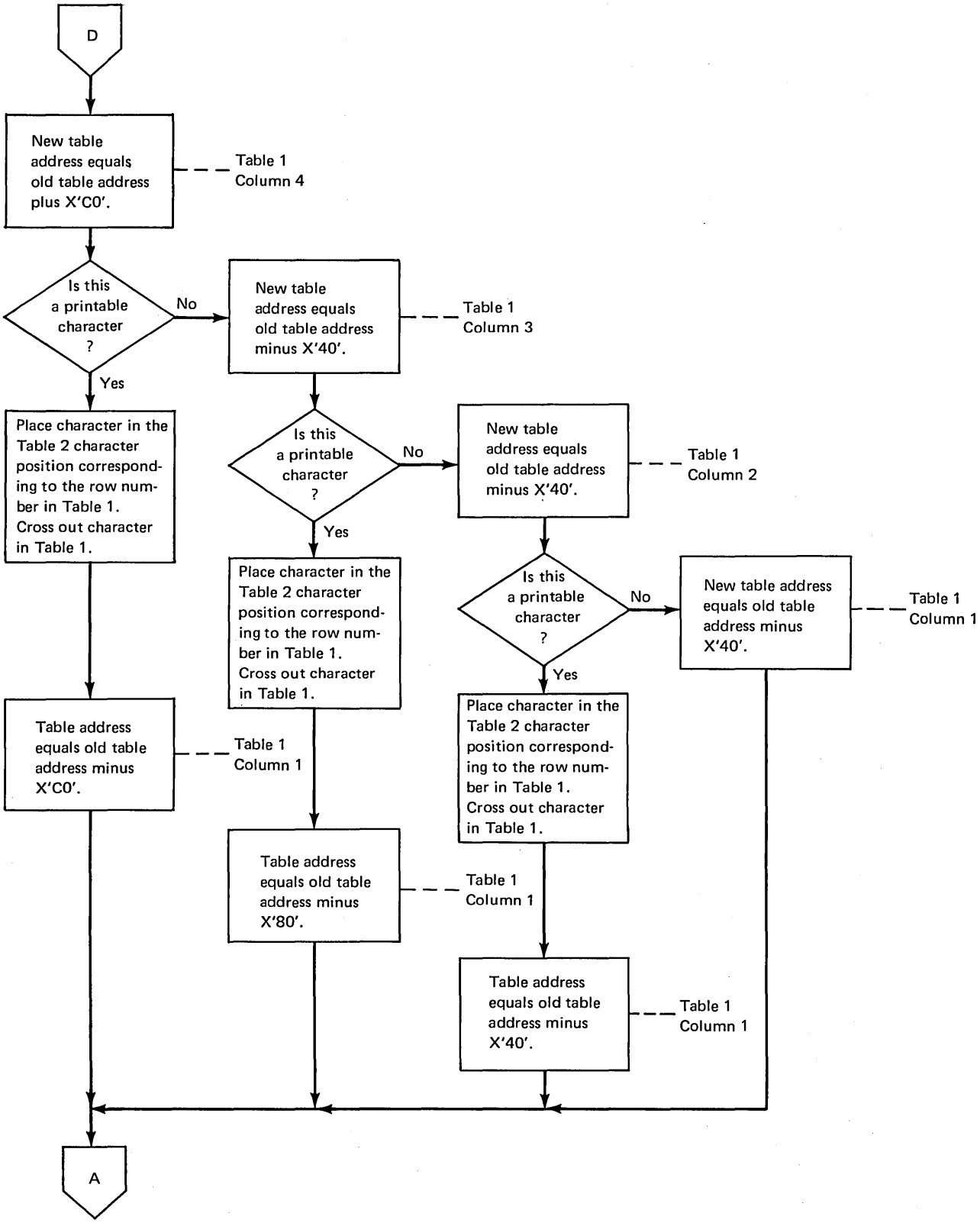


Figure 2-11 (Part 2 of 3). Flowchart procedure for formatting a character set

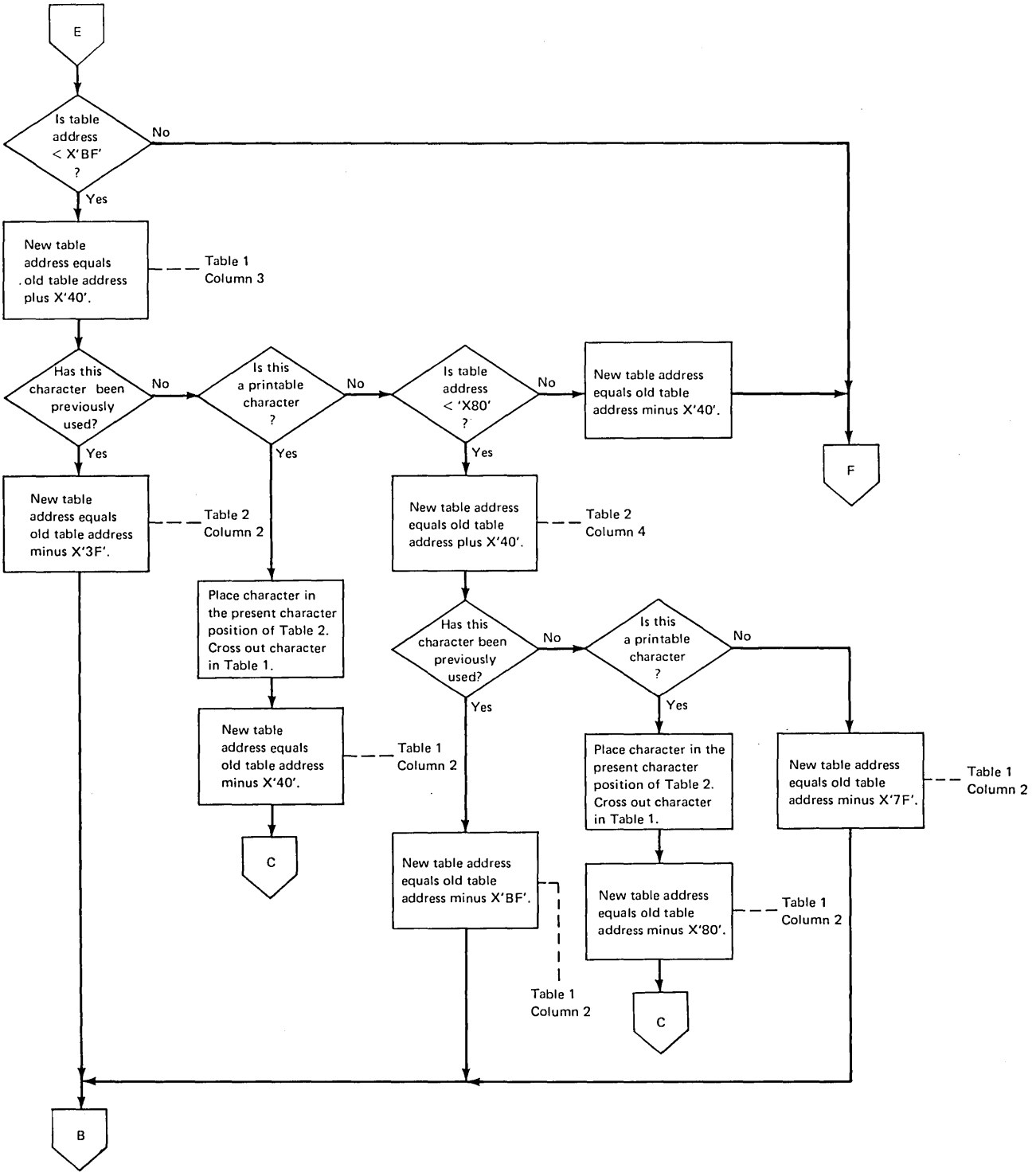


Figure 2-11 (Part 3 of 3). Flowchart procedure for formatting a character set

Row	Table address (character hex code)			
	Column 1	Column 2	Column 3	Column 4
1	00	40	80	C0
2	01	41	81	C1
3	02	42	82	C2
4	03	43	83	C3
5	04	44	84	C4
6	05	45	85	C5
7	06	46	86	85
8	07	47	87	C7
9	08	48	88	C8
10	09	49	89	C9
11	0A	4A	8A	CA
12	0B	4B	8B	CB
13	0C	4C	8C	CC
14	0D	4D	8D	CD
15	0E	4E	8E	CE
16	0F	4F	8F	CF
17	10	50	90	D0
18	11	51	91	D1
19	12	52	92	D2
20	13	53	93	D3
21	14	54	94	D4
22	15	55	95	D5
23	16	56	96	D6
24	17	57	97	D7
25	18	58	98	D8
26	19	59	99	D9
27	1A	5A	9A	DA
28	1B	5B	9B	DB
29	1C	5C	9C	DC
30	1D	5D	9D	DD
31	1E	5E	9E	DE
32	1F	5F	9F	DF

Row	Table address (character hex code)			
	Column 1	Column 2	Column 3	Column 4
33	20	60	A0	E0
34	21	61	A1	E1
35	22	62	A2	E2
36	23	63	A3	E3
37	24	64	A4	E4
38	25	65	A5	E5
39	26	66	A6	E6
40	27	67	A7	E7
41	28	68	A8	E8
42	29	69	A9	E9
43	2A	6A	AA	EA
44	2B	6B	AB	EB
45	2C	6C	AC	EC
46	2D	6D	AD	ED
47	2E	6E	AE	EE
48	2F	6F	AF	EF
49	30	70	B0	F0
50	31	71	B1	F1
51	32	72	B2	F2
52	33	73	B3	F3
53	34	74	B4	F4
54	35	75	B5	F5
55	36	76	B6	F6
56	37	77	B7	F7
57	38	78	B8	F8
58	39	79	B9	F9
59	3A	7A	BA	FA
60	3B	7B	BB	FB
61	3C	7C	BC	FC
62	3D	7D	BD	FD
63	3E	7E	BE	FE
64	3F	7F	BF	FF

Figure 2-12. Table 1

Character position	Address	Hex code	Printed character	Wire-image value			
1	0000						
2	0008						
3	0010						
4	0018						
5	0020						
6	0028						
7	0030						
8	0038						
9	0040						
10	0048						
11	0050						
12	0058						
13	0060						
14	0068						
15	0070						
16	0078						
17	0080						
18	0088						
19	0090						
20	0098						
21	00A0						
22	00A8						
23	00B0						
24	00B8						
25	00C0						
26	00C8						
27	00D0						
28	00D8						
29	00E0						
30	00E8						
31	00F0						
32	00F8						
33	0100						
34	0108						
35	0110						
36	0118						
37	0120						
38	0128						
39	0130						
40	0138						
41	0140						
42	0148						
43	0150						
44	0158						
45	0160						
46	0168						
47	0170						
48	0178						

Character position	Address	Hex code	Printed character	Wire-image value			
49	0180						
50	0188						
51	0190						
52	0198						
53	01A0						
54	01A8						
55	01B0						
56	01B8						
57	01C0						
58	01C8						
59	01D0						
60	01D8						
61	01E0						
62	01E8						
63	01F0						
64	01F8						
65	0200						
66	0208						
67	0210						
68	0218						
69	0220						
70	0228						
71	0230						
72	0238						
73	0240						
74	0248						
75	0250						
76	0258						
77	0260						
78	0268						
79	0270						
80	0278						
81	0280						
82	0288						
83	0290						
84	0298						
85	02A0						
86	02A8						
87	02B0						
88	02B8						
89	02C0						
90	02C8						
91	02D0						
92	02D8						
93	02E0						
94	02E8						
95	02F0						
96	02F8						

Figure 2-13. Table 2

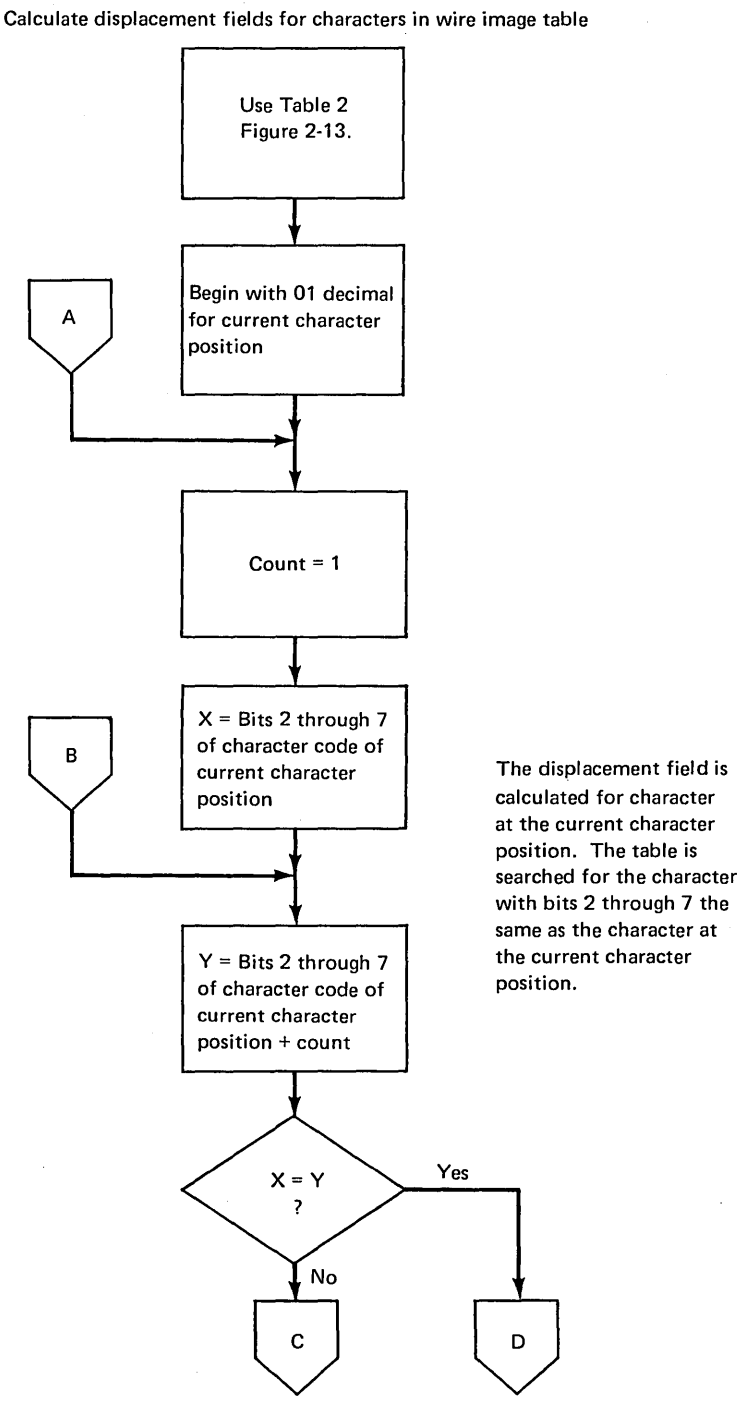


Figure 2-14 (Part 1 of 3). Flowchart for calculating displacement fields for characters in the wire-image table

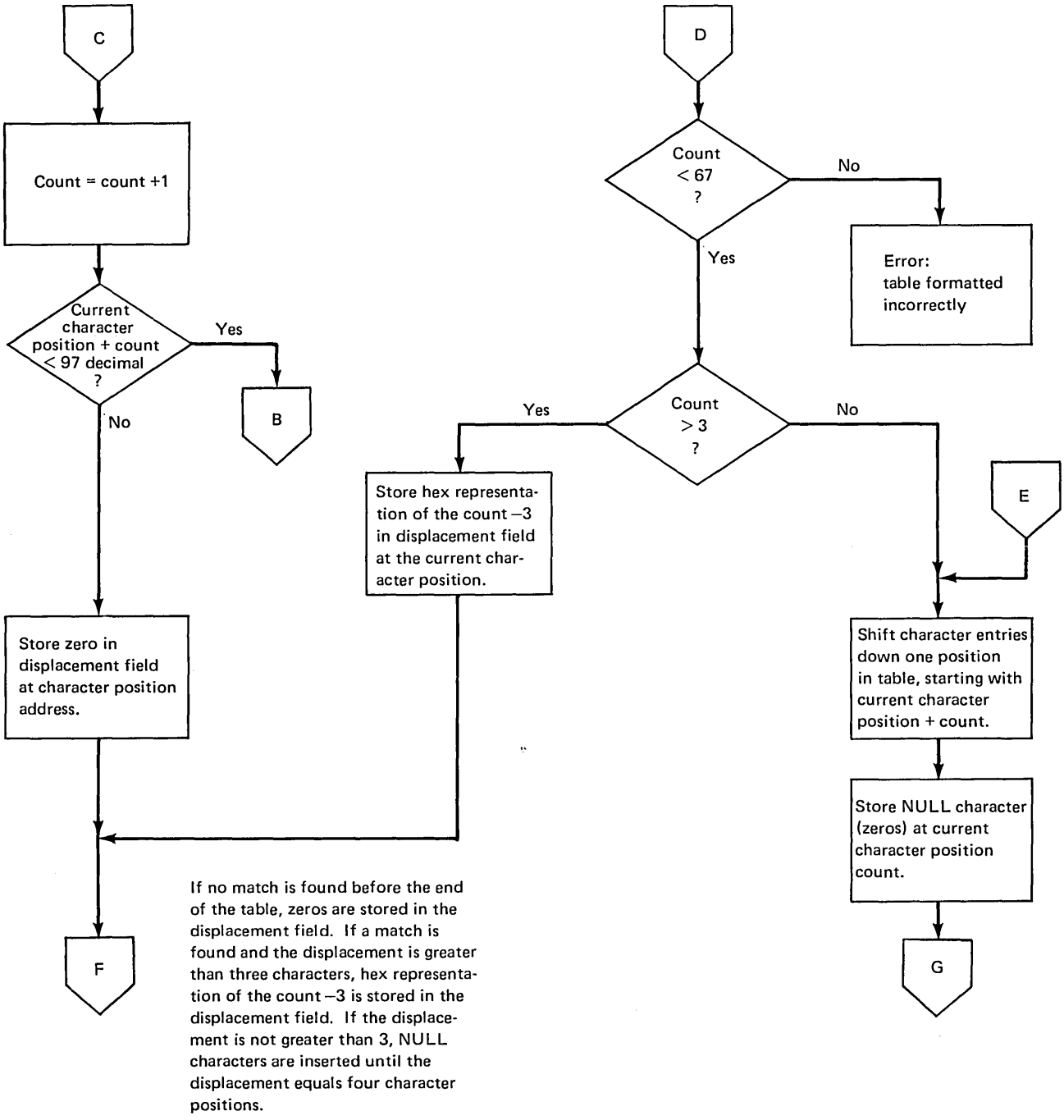


Figure 2-14 (Part 2 of 3). Flowchart for calculating displacement fields for characters in the wire-image table

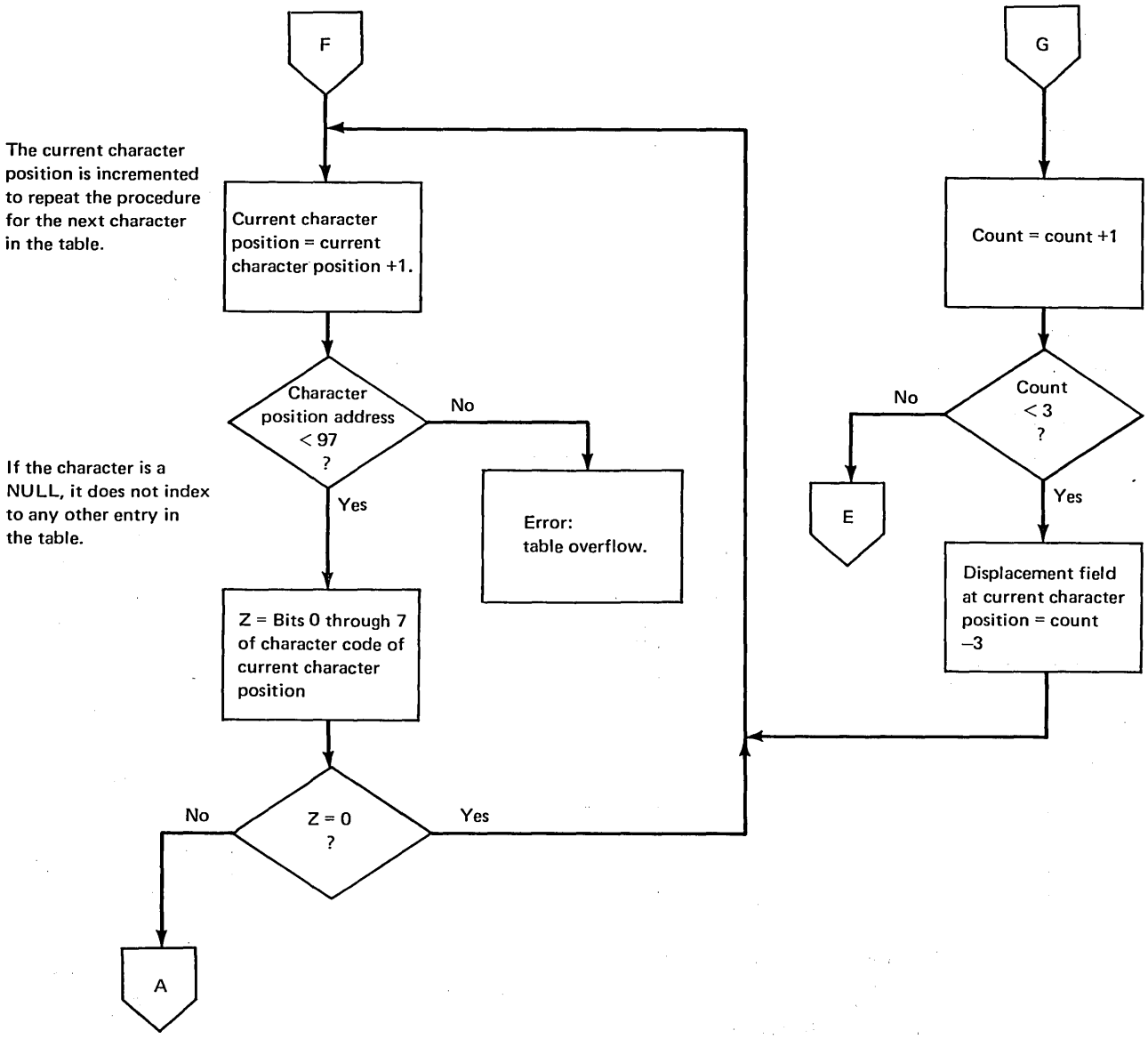


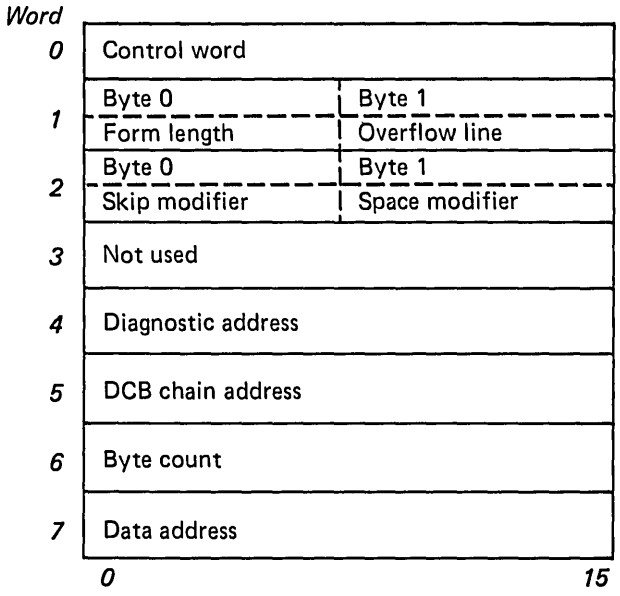
Figure 2-14 (Part 3 of 3) Flowchart for calculating displacement fields for characters in the wire-image table

Appendix A. Reference Summary

I/O Commands

Hex	Command	IO instruction CCs reported
20	Read ID	0, 1, 2, 3, 5, 7
60	Prepare	0, 1, 2, 3, 5, 7
6F	Device Reset	0, 1, 2, 3, 5, 7
F0	Halt I/O	0, 1, 2, 3, 5, 7
70	Start	0, 1, 2, 3, 5, 7
7F	Start Cycle Steal Status	0, 1, 2, 3, 5, 7

Device Control Block (DCB)



Control Word

Bit	Meaning
0	Chaining flag
1	Not used—must be 0
2	Input flag
3–4	Not used—must be 0's
5–7	Cycle-steal address key
8	Forms parameter bit
9	Initialize wire-image buffer
10	Wire-image transfer
11	Diagnostic information
12	Forms spacing control
13–14	Not used—must be 0's
15	Retry

Cycle Steal Status Words

Word 0

Bit	Meaning
0–15	Residual address

Word 1

Bit	Meaning
0	Printer not ready
1	Printer wire check
2	Printer power check
3	Wait
4	Forms-emitter check
5	Margin check
6	Print-emitter check
7	Forms stalled
8	Attachment wire check
9	External interface
10	Printer interface check
11	Forms overflow
12	End of forms
13	Invalid wire image
14	No print emitter
15	Not used

Word 2

Bit	Meaning
0–7	Residual line count
8–15	Current forms position

Word 3

Bit	Meaning
0–7	Forms length
8–15	Overflow line

Word 4–6

Reserved for diagnostic information

Word 7

Bit	Meaning
0–7	Logical left margin
8–15	Logical right margin

Interrupt Condition Codes Reported

CC2, CC3, CC4

Interrupt Information Byte (IIB)

Conditon code	IIB contents
2	Cycle-steal interrupt status byte with bit 2 not used
3, 4	Always 0's

Appendix B. 96-Character Wire-Image Table

Address	Hex code	Printed character	Wire-image value			
0000	00	Null character	3D00	0000	0000	0000
0008	C1	A	FD1E	2048	8048	201E
0010	C2	B	FD82	7C82	1082	106C
0018	C3	C	FD7C	8200	8200	8244
0020	C4	D	FD82	7C82	0082	007C
0028	C5	E	FDFE	0092	0092	0082
0030	C6	F	FDFE	0090	0090	0080
0038	C7	G	FD7C	8200	8210	825C
0040	C8	H	FDFE	0010	0010	00FE
0048	C9	I	FD00	8200	FE00	8200
0050	4A	¢ Cent	4038	4400	C600	4400
0058	4B	. Period	4000	0006	0006	0000
0060	4C	< Less than	4000	1028	4482	0000
0068	4D	(Left parenthesis	4000	0038	4482	0000
0070	4E	+ Plus	4010	0010	6C10	0010
0078	4F	| Logical or	4000	0000	FE00	0000
0080	D0	} Closing brace	F700	8200	826C	1000
0088	D1	J	F704	0200	0200	02FC
0090	D2	K	F7FE	0020	1048	0482
0098	D3	L	F7FE	0002	0002	0002
00A0	D4	M	F7BE	4020	1020	40BE
00A8	D5	N	F7BE	4020	1008	04FA
00B0	D6	O	F77C	8200	8200	827C
00B8	D7	P	F7FE	0090	0090	0060
00C0	D8	Q	F77C	8200	8208	847A
00C8	D9	R	F7FE	0090	0098	0462
00D0	5A	! Exclamation point	4000	0000	F600	0000
00D8	5B	$ Dollar	4020	5400	D600	5408
00E0	5C	* Asterisk	4010	4438	0038	4410
00E8	5D	) Right parenthesis	4000	0082	4438	0000
00F0	5E	; Semicolon	4000	00DA	04D8	0000
00F8	5F	¬ Logical not	4010	0010	0010	001C
0100	E0	\ Reverse slash	F180	4020	1008	0402
0108	A1	~ Tilde	B108	1020	1008	1020
0110	E2	S	F164	9200	9200	924C
0118	E3	T	F180	0080	7E80	0080
0120	E4	U	F1FC	0200	0200	02FC
0128	E5	V	F1F0	0804	0204	08F0
0130	E6	W	F1FC	0204	1804	02FC
0138	E7	X	F182	4428	1028	4482
0140	E8	Y	F180	4020	1E20	4080
0148	E9	Z	F182	048A	10A2	4082
0150	6A	¦ Broken vertical line	4000	0000	EE00	0000
0158	6B	, Comma	4000	001A	0418	0000
0160	6C	% Percent	40C2	04C8	1026	4086
0168	6D	_ Underscore	4001	0001	0001	0001

Address	Hex code	Printed character	Wire-image value			
0170	6E	> Greater than	4000	0082	4428	1000
0178	6F	? Question mark	4040	8000	8A00	9060
0180	F0	0	C038	4482	0082	4438
0188	F1	1	C000	4200	FE00	0200
0190	F2	2	C042	8402	8802	9062
0198	F3	3	C084	0280	12A0	528C
01A0	F4	4	C008	1028	4088	7608
01A8	F5	5	C0E4	02A0	02A0	029C
01B0	F6	6	C00C	1220	5280	120C
01B8	F7	7	C080	0284	0890	20C0
01C0	F8	8	C06C	9200	9200	926C
01C8	F9	9	E260	9002	9408	9060
01D0	7A	: Colon	4000	006C	006C	0000
01D8	7B	# Number sign	4028	00EE	00EE	0028
01E0	7C	@ At sign	4038	4482	308A	403A
01E8	7D	' Apostrophe	4000	00D0	20C0	0000
01F0	7E	= Equal	4028	0028	0028	0028
01F8	7F	" Double quotation mark	4000	E000	0000	E000
0200	C0	{ Opening brace	C000	106C	8200	8200
0208	81	a	8004	0A20	0A20	1E00
0210	82	b	80FE	0022	0022	1C00
0218	83	c	801C	2200	2200	2200
0220	84	d	801C	2200	2200	FE00
0228	85	e	8000	1C22	0822	1800
0230	86	f	8020	007E	8020	8000
0238	87	g	8018	2401	2401	3E00
0240	88	h	80FE	0020	0020	1E00
0248	89	i	8000	0000	BE00	0000
0250	50	& Ampersand	400C	52A0	5208	040A
0258	91	j	8000	0001	0001	BE00
0260	92	k	8000	FE00	0814	2200
0268	93	l	8000	0000	FE00	0000
0270	94	m	801E	2000	3E00	201E
0278	95	n	8000	3E00	2000	201E
0280	96	o	8000	1C22	0022	1C00
0288	97	p	803F	0024	0024	1800
0290	98	q	8018	2400	2400	3E01
0298	99	r	8020	1E00	2000	2000
02A0	60	- Dash	4010	0010	0010	0010
02A8	61	/ Slash	4002	0408	1020	4080
02B0	A2	s	8010	2A00	2A00	2A04
02B8	A3	t	8000	2000	FC02	2000
02C0	A4	u	8000	3C02	0002	3C00
02C8	A5	v	8000	3804	0204	3800
02D0	A6	w	803C	0200	0E00	023C
02D8	A7	x	8000	2214	0814	2200
02E0	A8	y	8020	110A	0408	1020
02E8	A9	z	8000	2204	2A10	2200
02F0	79	` Grave accent	4000	0080	4020	0000
02F8	00	Null	0000	0000	0000	0000

Note. The space character has a hex code of 40. It is an unprintable character and, therefore, has no wire-image value.

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