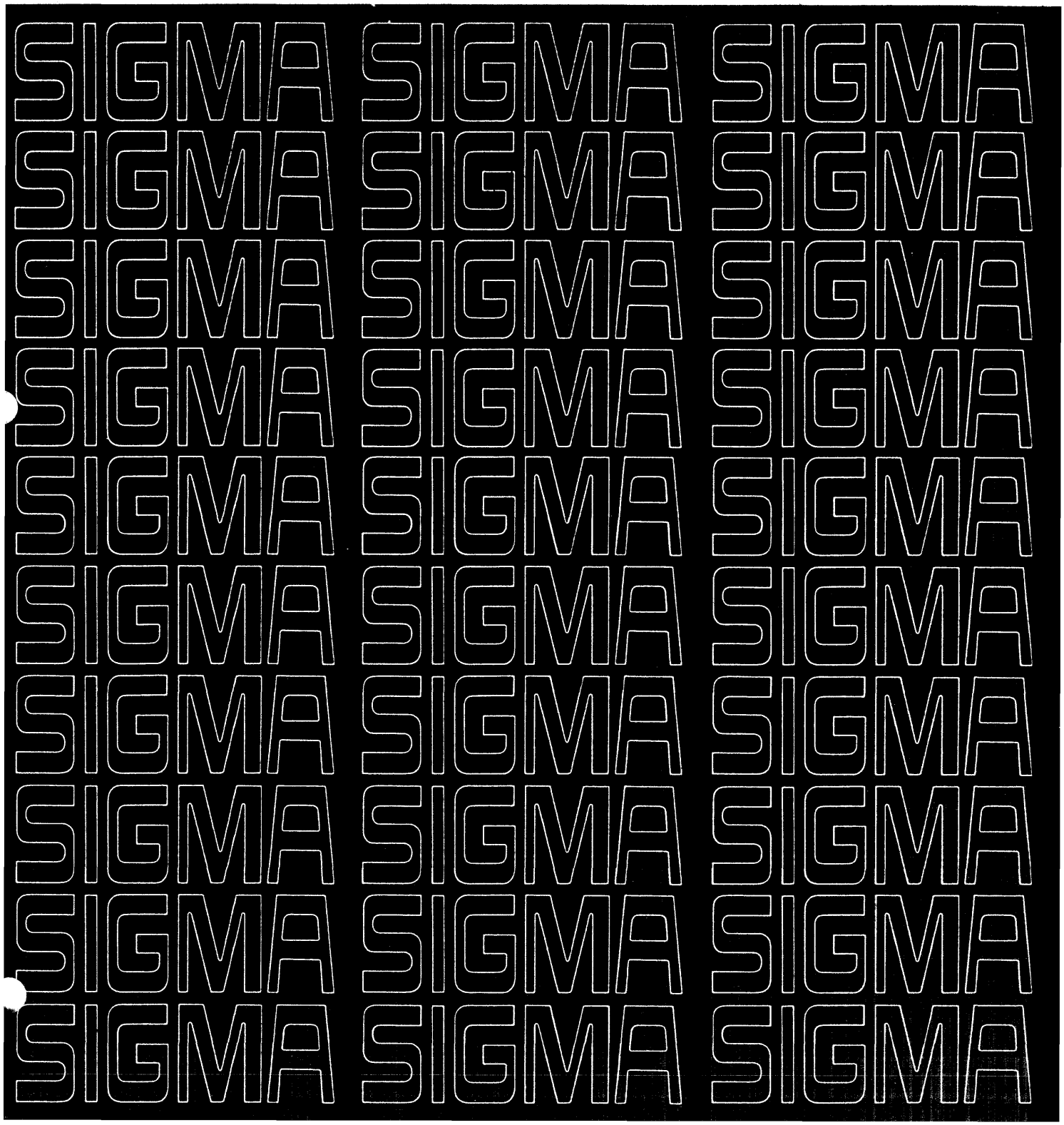
SDS

Scientific Data Systems
A XEROX COMPANY

XDS SIGMA BUFFERED LINE PRINTER
MODEL 7450

Reference Manual



LINE PRINTER ORDER CODES

Code (hexadecimal)	Function
01	Print
03	Format
05	Print with Format
41	Print and Interrupt on Data Transmission Completed
43	Format and Interrupt on Data Transmission Completed
45	Print with Format and Interrupt on Data Transmission Completed

FORMAT CONTROL CODES

Code (hexadecimal)	Function
60	Inhibit automatic upspace after printing
C0	Space 0 lines
C1	Space 1 line
C2	Space 2 lines
C3	Space 3 lines
C4	Space 4 lines
C5	Space 5 lines
C6	Space 6 lines
C7	Space 7 lines
E0	Space 0 lines and inhibit automatic upspace after printing
E1	Space 1 line and inhibit automatic upspace after printing
E2	Space 2 lines and inhibit automatic upspace after printing
E3	Space 3 lines and inhibit automatic upspace after printing
E4	Space 4 lines and inhibit automatic upspace after printing
E5	Space 5 lines and inhibit automatic upspace after printing
E6	Space 6 lines and inhibit automatic upspace after printing
E7	Space 7 lines and inhibit automatic upspace after printing
F0	Eject to bottom of page
F1	Eject to top of page

Price: $1.00

BUFFERED LINE PRINTER

Model 7450

REFERENCE MANUAL

for

XDS SIGMA COMPUTERS

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RELATED PUBLICATIONS

Title	Publication No.
XDS Sigma 2 Computer Reference Manual	90 09 64
XDS Sigma 3 Computer Reference Manual	90 15 92
XDS Sigma 5 Computer Reference Manual	90 09 59
XDS Sigma 7 Computer Reference Manual	90 09 50
XDS Sigma 5/7 Symbol and Meta-Symbol Reference Manual	90 09 52
XDS Sigma 2/3 Symbol Reference Manual	90 10 51

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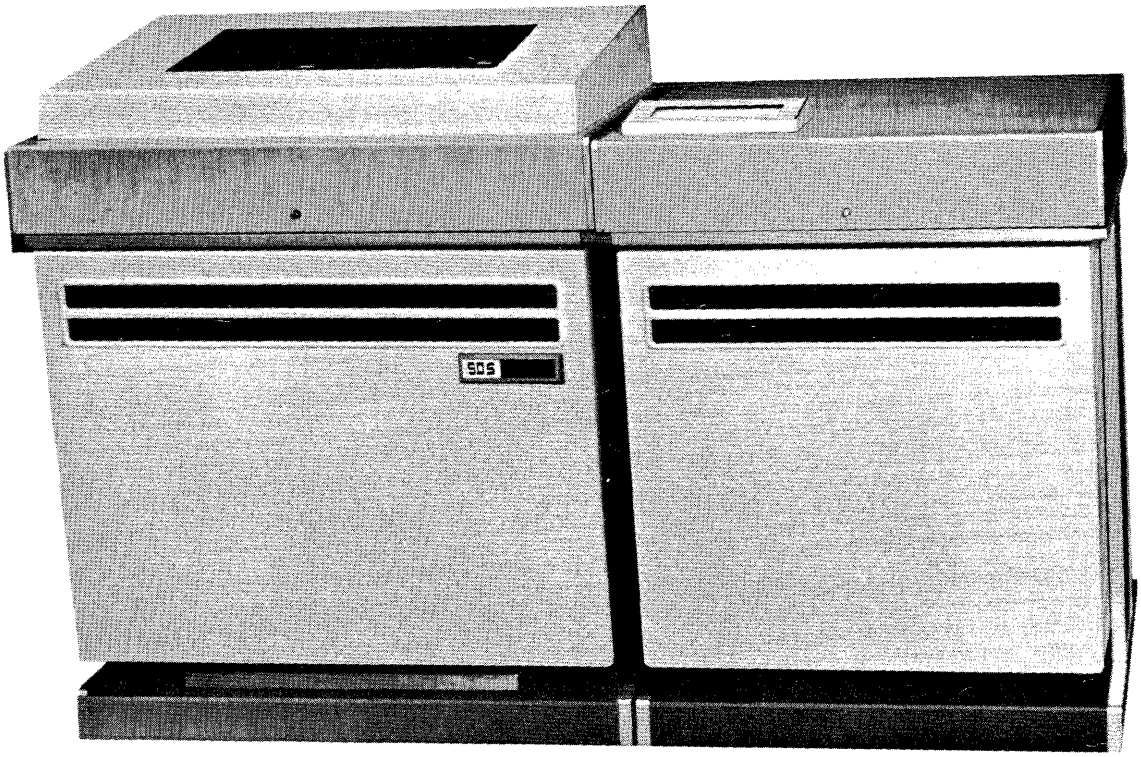

Model 7450 Line Printer

1. GENERAL DESCRIPTION

INTRODUCTION

XDS Model 7450 Buffered Line Printer for Sigma Computers, consists of a line printing device and controller. The controller accommodates only a single printer and may be connected to any Sigma I/O channel. The printer can print up to 128 columns of data, using a character set composed of 64 alphabetic, numeric, and special characters, including a blank. The printing rate is 225 lines per minute if all 64 characters are printed; higher rates are realized with a reduced character set size (see Table 1).

The system includes a half-line (64-character) buffer, which stores data for either the even- or odd-numbered columns. Therefore, the computer program must transmit a line image twice for each line of print.

A 2-track vertical format control tape unit provides for bottom of page and top of page positioning. Additional format control features permit spacing up to seven lines and inhibiting automatic upspacing after printing.

Table 1. Characteristics

Operating Characteristics	
Printing speed	
All 64 characters	225 lines/minute
First 50 characters	300 lines/minute
First 44 characters	450 lines/minute
Number of columns	128
Printable characters	64 (plus a blank)
Paper spacing rates	
Single line	18 ms
Multiple lines	18 + 10 (n-1) ms, where n = no. of lines (16-2/3 in./sec)
Vertical spacing	6 lines/in.
Vertical registration	± 0.010 in. (defined as vertical variation of average top edges of full-sized characters within a printed line)

Table 1. Characteristics (cont.)

Operating Characteristics (cont.)	
Horizontal spacing	10 characters/in.
Paper	
Type	Standard continuous form, edge-punched (0.5 in. centers)
Width	3.5 to 18 in., measured from feed hole to feed hole
Length	3.5 to 17 in., measured from perforation to perforation
Number of copies	Original and up to 5 carbons
Single-part paper weight	14 to 20 lb
Multiple-part paper weight	15 to 20 lb (original), 9 to 12 lb (each copy), 7.5 lb carbon-medium hardness
Vertical format unit	2 tracks
Physical Dimensions	
Height	50 in.
Width	75 in.
Depth	27 in.
Weight (approximate)	1100 lb
Environmental Characteristics	
Power requirements	120 vac ± 10%, single-phase, 60 ± 1 Hz (50 ± 1 Hz optional), 30 amp
Operating temperature	41° to 100° F
Operating humidity	10% to 80%

2. FUNCTIONAL DESCRIPTION

PHYSICAL DESCRIPTION

The line printer is housed in two cabinets, a mechanism cabinet and an electronics cabinet. The two cabinets are bolted together usually, but may be disassembled for shipment. There is space in the mechanism cabinet for storing paper. Paper that is being printed passes through a port and is stacked at the rear of the mechanism cabinet.

OPERATING DESCRIPTION

The line printer mechanism performs all mechanical operations associated with printing and paper motion. The typeline consists of a rotating, cylindrical drum approximately 6-1/2 inches in diameter and 14 inches long. The character font is engraved on the surface of the drum, with odd-numbered columns taking up one half (180°) of the circumference of the drum and even-numbered columns taking up the other half. The drum rotates at 450 rpm.

A bank of solenoid-operated hammers, located opposite the typeline, provides the means for imprinting on paper. One hammer is associated with each pair of columns, so that a given hammer causes printing of one odd-numbered and one even-numbered column.

A photoelectrically-read code disc is coupled to the typeline. The code disc has a unique 6-bit code for each character on the typeline and is used to indicate which character is coming into printing position. A timing track is also provided, as well as a sector track, which indicates whether the odd or even sector is in printing position.

The paper to be printed passes between the hammer bank and the typeline, while an inked ribbon passes between the typeline and the paper. When a hammer is fired, the paper is driven against the typeline through the ribbon. Two pairs of tractors, located above and below the print station, move the paper. A punched-tape vertical format unit controls top of paper and bottom of paper position.

Communication with the IOP or I/O channel is via the standard 8-bit data path interface. The printer, if "operational", advances to the "busy" condition on receiving an SIO instruction. If the printer is in the "automatic" mode and "idle" state (where internal control logic is reset), the controller will request an order from the IOP or I/O channel (see "Line Printer States, Conditions, and Modes" and "Print Orders").

DATA REPRESENTATION

The printer graphic character set consists of 64 standard alphabetic, numeric, and special characters including a blank. Each 8-bit byte represents one character code to the printer. However, only the six least-significant bits are used in character decoding. The remaining two most-significant bits are ignored by the printer. Thus, there are four hexadecimal codes corresponding to each character. Table 2 contains the character set and includes the 6-bit codes and the preferred hexadecimal codes. There are no undefined character codes.

Table 2. XDS 7450 Line Printer Character Set

Character	Hex. Code	6-Bit Code	Character	Hex. Code	6-Bit Code
blank	40	00 0000	E	C5	00 0101
¢	4A	00 1010	F	C6	00 0110
.	4B	00 1011	G	C7	00 0111
<	4C	00 1100	H	C8	00 1000
(	4D	00 1101	I	C9	00 1001
+	4E	00 1110	J	D1	01 0001
|	4F	00 1111	K	D2	01 0010
&	50	01 0000	L	D3	01 0011
!	5A	01 1010	M	D4	01 0100
$	5B	01 1011	N	D5	01 0101
*	5C	01 1100	O	D6	01 0110
)	5D	01 1101	P	D7	01 0111
;	5E	01 1110	Q	D8	01 1000
¬	5F	01 1111	R	D9	01 1001
-	60	10 0000	S	E2	10 0010
/	61	10 0001	T	E3	10 0011
^	6A	10 1010	U	E4	10 0100
,	6B	10 1011	V	E5	10 0101
%	6C	10 1100	W	E6	10 0110
‾	6D	10 1101	X	E7	10 0111
>	6E	10 1110	Y	E8	10 1000
?	6F	10 1111	Z	E9	10 1001
:	7A	11 1010	0	F0	11 0000
#	7B	11 1011	1	F1	11 0001
@	7C	11 1100	2	F2	11 0010
'	7D	11 1101	3	F3	11 0011
=	7E	11 1110	4	F4	11 0100
"	7F	11 1111	5	F5	11 0101
A	C1	00 0001	6	F6	11 0110
B	C2	00 0010	7	F7	11 0111
C	C3	00 0011	8	F8	11 1000
D	C4	00 0100	9	F9	11 1001

LINE PRINTER STATES, CONDITIONS, AND MODES

STATES

With logic power on, the line printer is in one of two states, "operational" or "not operational". The printer is "not operational" if the maintenance panel is in use, if a fault exists, or the FAULT/RESET switch is being depressed. Faults include paper runaway (paper remaining in motion more than approximately two seconds), failure of the code disc light-dark check, and insufficient hammer driver power supply output voltage.

Condition and mode status of the line printer are returned to the central processor in response to the I/O instructions, SIO, HIO, and TIO. Other I/O instructions, AIO and TDV, provide more detailed indications of the printer's status – paper runaway, for example.

The following conditions and modes apply only if the printer is "operational".

CONDITIONS

In the "ready" condition, the printer can accept an order from the controlling system to print or move paper if no interrupt is pending. In the "busy" condition, the printer is performing a print or paper movement operation ordered by the controlling system. The printer does not accept a new SIO instruction as long as this condition prevails.

MODES

The printer automatically enters the "manual" mode when any condition arises requiring operator intervention before it can function normally (that is, paper low, paper torn). The printer also enters the "manual" mode when the RESET or STOP switch on the control panel is pressed. Illumination of the STOP indicator on the control panel indicates the "manual" mode. The printer may accept an SIO instruction from the controlling system but cannot perform the operation while in this mode.

When the system is operational and no operator intervention is required, the operator may place the printer in the "automatic" mode by pressing the START switch on the control panel. The START indicator lights when the printer enters the "automatic" mode. In this mode, the printer can accept and perform any valid order specified by the controlling system.

TRANSITIONS BETWEEN STATES

The conditions that cause the printer to change from one operational state to another are summarized in Table 3. An operational state is a combination of the machine condition and mode.

DATA TRANSFER

The printer will accept an SIO instruction if the following conditions are satisfied:

1. Input/output address recognition occurs.
2. Printer is in "ready" condition.
3. No interrupt is pending.

When the printer is in the "busy automatic" state after accepting an SIO instruction, it will request an order; the order may be Print, Print with Format, or Format. Two print orders are required per line. "Channel end" is signalled after printing for the first order and after paper motion of the second order. Each of the two print orders for a line causes the printer to retain all the even or all the odd bytes. The determination (odds or evens) of which set to save for the first print order is based on the current position of the print drum (that is, save the even bytes if currently in the odd zone). The second print order will always retain the complementary set of bytes. The printer does not signal rate error should it fail to load its buffer prior to print time, but waits for the desired print drum zone to reappear. The "data transmission complete" interrupt, when requested (bit 1 of the order byte is 1), is signalled immediately following "count done".

Following the receipt of a Format order, the controller will accept one byte of data that represents a format control code. The proper motion operation is performed but no printing occurs for this order. The Print with Format order combines the functions of the Print and Format orders. The printer first obtains one byte of data representing a format control code and performs the indicated action. At the completion of paper motion, the printer then stores the proper bytes (odds or evens) in its buffer for printing. Two Print with Format orders are required to print a line. The format control byte is ignored during execution of the second order.

Table 3. Line Printer State Transitions

Present State (Condition and Mode)	Transition
Ready Manual	Entered on completion of power turn-on sequence. To Busy Manual: • On acceptance of SIO instruction To Ready Automatic: • On activation of START switch with no operator intervention required (i.e., paper low or paper torn).

Table 3. Line Printer State Transitions (cont.)

Present State (Condition and Mode)	Transition
Busy Manual	To Busy Automatic: • On activation of START switch with no operator intervention required. To Ready Manual: • On receipt of HIO instruction. • On receipt of I/O reset signal. • If FAULT/RESET switch activated. ("Unusual end" will be reported.)
Ready Automatic	To Ready Manual: • On activation of STOP switch.† • On activation of FAULT/RESET switch. To Busy Automatic: • On acceptance of SIO instruction.
Busy Automatic	To Ready Manual: • If FAULT/RESET switch is activated. • After printing both halves of current line and completing required paper motion, if command chaining is not invoked, but operator intervention is required or STOP switch was activated.† To Busy Manual: • After printing both halves of current line and completing required paper motion, if command chaining is invoked, but operator intervention is required or STOP switch was activated.† To Ready Automatic: • If an HIO instruction is received or an I/O reset signal is received. • After reporting "unusual end", if invalid order is received. • If current order list is completed, printer operations associated with the last order have been completed, and no operator intervention is required.

†If the printer expects a second order, it will not assume the "manual" mode on activation of the STOP switch or when operator intervention is required, unless both halves of the current line have been printed.

3. PROGRAM INTERFACE

PRINT ORDERS

Print orders specify the operation to be performed and the interrupt signals to be generated. Bit 1 of the print order represents the modifier (see "Print Order Modifier"), and bits 5 through 7 identify the specific operation. Bits 0, 2, 3, and 4 contain zeros.

The line printer recognizes three basic orders, Print, Format, and Print with Format. If the printer controller recognizes an invalid order, it generates an "unusual end" signal.

PRINT (01)

The Printer interprets the data associated with this order as a line image of from 1 to 128 characters long. If lines are longer than 128 characters, the printer truncates them with no notification to the controlling system. No printing will occur in unspecified columns for line images shorter than 128 characters.

Printing a complete line requires two print orders. Data associated with the second order must be identified with data associated with the first order. During the first order, the printer stores and prints bytes corresponding to the odd- or even-numbered columns, depending on the position of the typeline when the data transfer begins (e.g., if in odd sector, store even-numbered columns). During the second order, the printer stores and prints the opposite set of bytes.

An automatic upspace occurs at the completion of printing resulting from execution of the second order.

FORMAT (03)

This order positions paper according to the format control code contained in a single output data byte addressed by the controlling system. A byte count of 1 is expected in this case, since the printer is concerned with only the one byte that specifies the format code. (Only one order is necessary). If the data byte does not contain a valid format control code, no action occurs. The printer recognizes the following control codes:

Hexadecimal Code	Function
60	Inhibit upspace after printing[†]
C0	Space 0 lines
C1	Space 1 line
C2	Space 2 lines
C3	Space 3 lines
C4	Space 4 lines
C5	Space 5 lines
C6	Space 6 lines
C7	Space 7 lines
E0	Space 0 lines and inhibit upspace after printing
E1	Space 1 line and inhibit upspace after printing
E2	Space 2 lines and inhibit upspace after printing
E3	Space 3 lines and inhibit upspace after printing
E4	Space 4 lines and inhibit upspace after printing
E5	Space 5 lines and inhibit upspace after printing
E6	Space 6 lines and inhibit upspace after printing
E7	Space 7 lines and inhibit upspace after printing
F0	Eject to bottom of page
F1	Eject to top of page

[†] Only meaningful when used with Print with Format order.

PRINT WITH FORMAT (05)

This order performs the function of a Format order followed by a Print order. The first data byte is interpreted as a format control code (see Format order). Following paper motion (if any), the controlling system requests the remaining data bytes and treats them as a line image (see Print order). It takes two Print with Format orders to print a complete line. Both orders must provide the format control byte; however, only the first order moves paper.

An automatic upspace will occur at the completion of printing during the second order, unless inhibited by the format control byte.

PRINT ORDER MODIFIER (DTC INTERRUPT)

The programmer may modify all three basic orders by writing a "1" in bit 1 of the order code (Print = 41, Format = 43, Print with Format = 45). The modifier specifies an interrupt signal to be generated by the printer on receipt of "count done", that is, at Data Transmission Complete (DTC).

Note: Sigma 2 or Sigma 3 programmers will use this interrupt. Since its function parallels that of "Interrupt on Zero Byte Count" (IZC), it is not recommended for Sigma 5 or Sigma 7 usage.

FORMATTING

The line printer provides both automatic and ordered formatting. In both cases, the proper format for a printer page must be defined by a paper tape loop at the Vertical Format Unit (VFU) station. The printer senses data punches in two tracks, as follows:

Track	Function
1	Bottom of page
6	Top of page

Additional information on preparation and use of VFU tapes is given in Chapter 4, "Operations".

AUTOMATIC FORM CONTROL

The printer provides two automatic form control features. One feature provides an upspace of one line following the printing of the second half of each line. This feature may be suppressed by using a Print with Format order in conjunction with a format control byte that specifies "inhibit upspace after printing".

The second automatic form control feature provides a page overflow slew operation from the bottom of the current page to the top of the next page. Upon sensing a punch in track 1 of the VFU tape (bottom of page) during a spacing operation, the printer aborts any spacing operation in process (automatic or ordered) and slews (ejects) paper until a punch is sensed in track 6 (top of page).

The overflow to the new page occurs on spacing off of the line defined as bottom of page. A hole, therefore, is punched in track 1 for the last line to be printed.

No provision is made for inhibiting the automatic page overflow.

ORDERED FORM CONTROL

The Format and Print with Format orders provide additional control over printing format. The format control byte specifies paper motion to take place, as given under "Print Orders". Ordered form control involves spacing a specified number of lines, or inhibiting the post-print automatic upspace, or skipping to the top or bottom of page, as defined by the VFU tape.

There is no objection to punching more than one hole in track 6 (top of page) between punches in track 1 (bottom of page). Each skip to top of page operation advances the paper until the next punch in track 6 is sensed. If, while printing, bottom of page is sensed, the paper is automatically advanced to the next punch in track 6, which defines the true top of page.

KEY EVENTS

The key events that occur during a print operation are described in the following paragraphs. No chronological order should be assumed from the order of presentation.

START INPUT/OUTPUT

The controlling system initiates a line printer operation with the execution of an SIO instruction. If I/O address recognition exists and the printer is in the "ready" condition with no interrupt pending, the controlling system sets its "I/O address recognition" and "SIO accepted" indicators; the printer advances from the "ready" to the "busy" condition. In the "automatic" mode, the printer requests an order byte from the controlling system and waits for the order byte to arrive.

UNUSUAL END CONDITIONS

Detecting any of the following conditions causes a "busy" line printer to return an "unusual end" indication to the controlling system:

1. IOP halt during data transmission (not applicable to Sigma 2)
2. Invalid order
3. "Fault" condition
4. FAULT/RESET switch operated

CHANNEL END CONDITIONS

The line printer indicates "channel end" to the controlling system at the following times:

1. For the first Print or Print with Format order, after printing is completed.
2. For the second Print or Print with Format order, after required paper motion is completed.
3. For a Format order, after paper motion is completed.
4. During an "unusual end".

FAULT CONDITIONS

A "fault" condition causes the line printer to become "not operational" and the FAULT indicator to illuminate. "Unusual end" will be reported if the printer is "busy". The following are "fault" conditions:

1. Paper runaway – paper remains in motion more than approximately two seconds.
2. Insufficient hammer driver power supply.
3. Code disc light and dark check failure – each data channel senses light and dark condition during each revolution of the typeline.

ERROR CONDITIONS

Detection of an abnormal condition during a print or format operation may be reported from either or both the I/O controlling system and the line printer controller. The effect of various error conditions is given below. The printer does not detect incorrect length and does not perform parity checking.

INVALID ORDER

The line printer attempts to interpret any order as a valid order. If not possible, the invalid order is reported as an "unusual end".

PAPER LOW AND PAPER TORN DETECTION

If either the paper low or paper torn condition is detected, the printer enters the "manual" mode at completion of printing both halves of the current line. The operator must replenish the paper supply to return the printer to the "automatic" mode.

INCORRECT LENGTH

The line printer does not detect incorrect length for any orders. It can print lines of fewer than 128 characters. The printer will truncate line images longer than 128 characters with no special notification to the computer. For Format orders, the printer requests only one byte of data. "Channel end" is then reported after performing the indicated action.

PARITY CHECKING

There is no parity check performed on incoming data from the computer, or on data stored in the buffer.

LINE PRINTER STATUS RESPONSE

The line printer can return various status flags in response to computer-executed I/O instructions. Sigma computer reference manuals contain detailed explanations of the I/O instructions that request status of the line printer.

I/O INSTRUCTION STATUS BITS

Execution of an I/O instruction by the controlling system provides two bits of information (condition codes) pertaining to the general status of the addressed I/O device and its controller. Table 4 lists the I/O instructions, the condition code settings applicable to each instruction, and the significance of each setting.

DEVICE STATUS BYTE

Eight bits of detailed status information are made available to the computer in response to the execution of each I/O instruction. Tables 5, 6, and 7 show the significance of each status flag returned to the controlling system by the line printer.

OPERATIONAL STATUS BYTE

In addition to the information contained in the Device Status Byte, the Operational Status Byte generated at the end of each I/O operation provides indicators to the controlling system (see Table 8).

PROGRAMMING CONSIDERATIONS

Figure 1 illustrates the sequential relationship of the key events that occur during a line printer operation.

Table 4. Line Printer I/O Instruction Execution Response

Instruction	Code†		Significance
	CC1 or O	CC2 or C	
SIO	0	0	I/O address recognized and SIO accepted.
	0	1	I/O address recognized, but SIO not accepted ("busy" or interrupt pending).
	1	0	Line printer attached to a "busy" selector IOP (not applicable to Sigma 2/3).
	1	1	I/O address not recognized.
HIO	0	0	I/O address recognized and printer was "not busy".
	0	1	I/O address recognized and printer was "busy".
	1	0	Invalid code.
	1	1	I/O address not recognized.
TIO	0	0	I/O address recognized and SIO can be accepted.
	0	1	I/O address recognized, but SIO cannot be accepted.
	1	0	Line printer attached to a "busy" selector IOP (not applicable to Sigma 2/3).
	1	1	I/O address not recognized.

† In Sigma 2/3 computers, "O" represents the Overflow bit and "C" represents the Carry bit; in Sigma 5/7 computers, "CC1" and "CC2" refer to condition code bits.

Table 4. Line Printer I/O Instruction Execution Response (cont.)

Instruction	Code† CC1 or O	Code† CC2 or C	Significance
TDV	0	0	I/O address recognized and subcontroller not in "test" mode.
	0	1	I/O address recognized and subcontroller in "test" mode.
	1	0	Line printer attached to a "busy" selector IOP (not applicable to Sigma 2/3).
	1	1	I/O address not recognized.
AIO	0	0	Normal interrupt condition present (no "unusual end").
	0	1	Unusual interrupt condition present ("unusual end").
	1	0	Invalid code.
	1	1	No interrupt condition present.

†In Sigma 2/3 computers, "O" represents the Overflow bit and "C" represents the Carry bit; in Sigma 5/7 computers, "CC1" and "CC2" refer to condition code bits.

Table 5. Status Response for SIO, TIO, and HIO

Bit Position	Function	State	Meaning
0	Interrupt Pending	1	Interrupt pending (issued but not yet acknowledged by an AIO instruction). A new order will not be accepted until the interrupt is cleared by an AIO or HIO instruction, or by manual intervention (I/O reset from computer control panel).
1, 2	Device Condition	0 0	Line printer "ready".
		0 1	Line printer "not operational" – "fault" condition, maintenance panel in use.
		1 0	Line printer unavailable – not applicable.
		1 1	Line printer "busy".
3	Mode	0	"Manual" mode
		1	"Automatic" mode
4	Device Unusual End	1	Execution of previous order terminated due to "unusual end" condition.
5, 6	Controller Condition		Same configurations as bits 1 and 2.
7	Unassigned	0	This bit is currently unassigned and is always zero.

Table 6. Status Response for TDV

Bit Position	Function	State	Meaning
0	Unassigned	0	This bit is currently unassigned and is always zero.
1	Typeline in Odd Sector	1	Typeline is in odd sector.
2	Paper Low	1	Form detection switch at print station indicates paper low condition exists.

Table 6. Status Response for TDV (cont.)

Bit Position	Function	State	Meaning
3	Top of Page	1	VFU sensed a punch in track 6, indicating paper is positioned at the first line of the page.
4	Paper Moving	1	An ordered or automatic format operation is in process and paper is currently in motion.
5	Paper Runaway	1	Previous format operation or automatic upspace failed to terminate within two seconds due to internal circuit failure or absence of punch in designated track of VFU tape. Paper movement terminated by printer and "fault" condition assumed.
6	Print Order Expected	0	Printer expects first Print order.
		1	Printer expects second Print order or Print with Format order.
7	Maintenance Panel Used	1	Maintenance panel is in use.

Table 7. Status Response for AIO

Bit Position	Function	State	Meaning
0	Unassigned	0	This bit is currently unassigned and is always zero.
1	Data Transmission Completed	1	Data Transmission Complete interrupt occurred as the result of receiving the last byte of data after an order specifying such an interrupt.
2-7	Unassigned	0	These bits are currently unassigned and are always zero.

Table 8. Operational Status Byte

Bit Position	Function	State	Meaning
0	Transmission Error		Not applicable.
1	Incorrect Length		Not applicable.
2	Chaining Modifier		Not applicable.
3	Channel End	1	Operations have been terminated and the printer has released the channel for any reason listed under "Channel End Conditions".
4	Unusual End	1	Execution of the previous order was terminated for any reason listed under "Unusual End Conditions".
5-7	Unassigned	0	These bits are currently unassigned and are always zero.

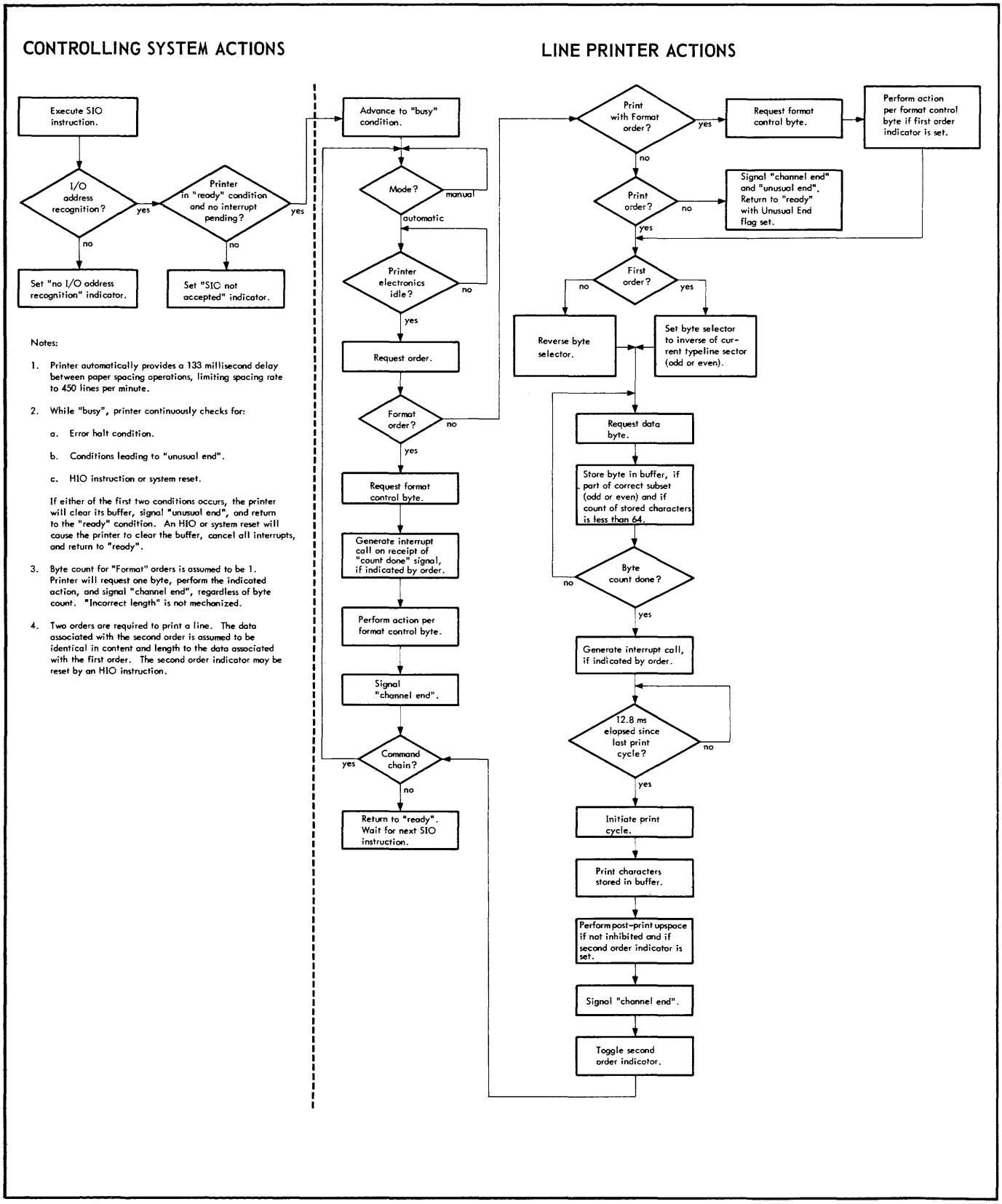

Figure 1. Controlling System/Line Printer Actions

4. OPERATIONS

CONTROLS AND INDICATORS

The line printer mechanism and electronics cabinets are shown in Figure 2. The mechanism controls (Figure 3), control panel (Figure 4), and maintenance panel (Figure 5) are described in this section.

MECHANISM CONTROLS

TRACTORS

The printer has four paper drive tractors: two in-feed tractors and two out-feed tractors, which transport the paper vertically through the mechanism. Each tractor can move laterally to accommodate various paper widths. When the operator positions the tractors for the required width of paper, he must lock them into position. Each tractor has a locking lever.

PAPER TENSION CONTROL

This control adjusts the vertical tension between input and output tractors. Various types of forms require different tensions. The control is calibrated on an arbitrary scale between 0 and 8. The operator adjusts horizontal tension by moving the tractors.

CHARACTER REGISTRATION CONTROL

This control adjusts the timing relations between the code disc character codes and the engraved characters on the typeline, to correct for early or late hammer contact with the typeline. Various types of forms require different adjustments.

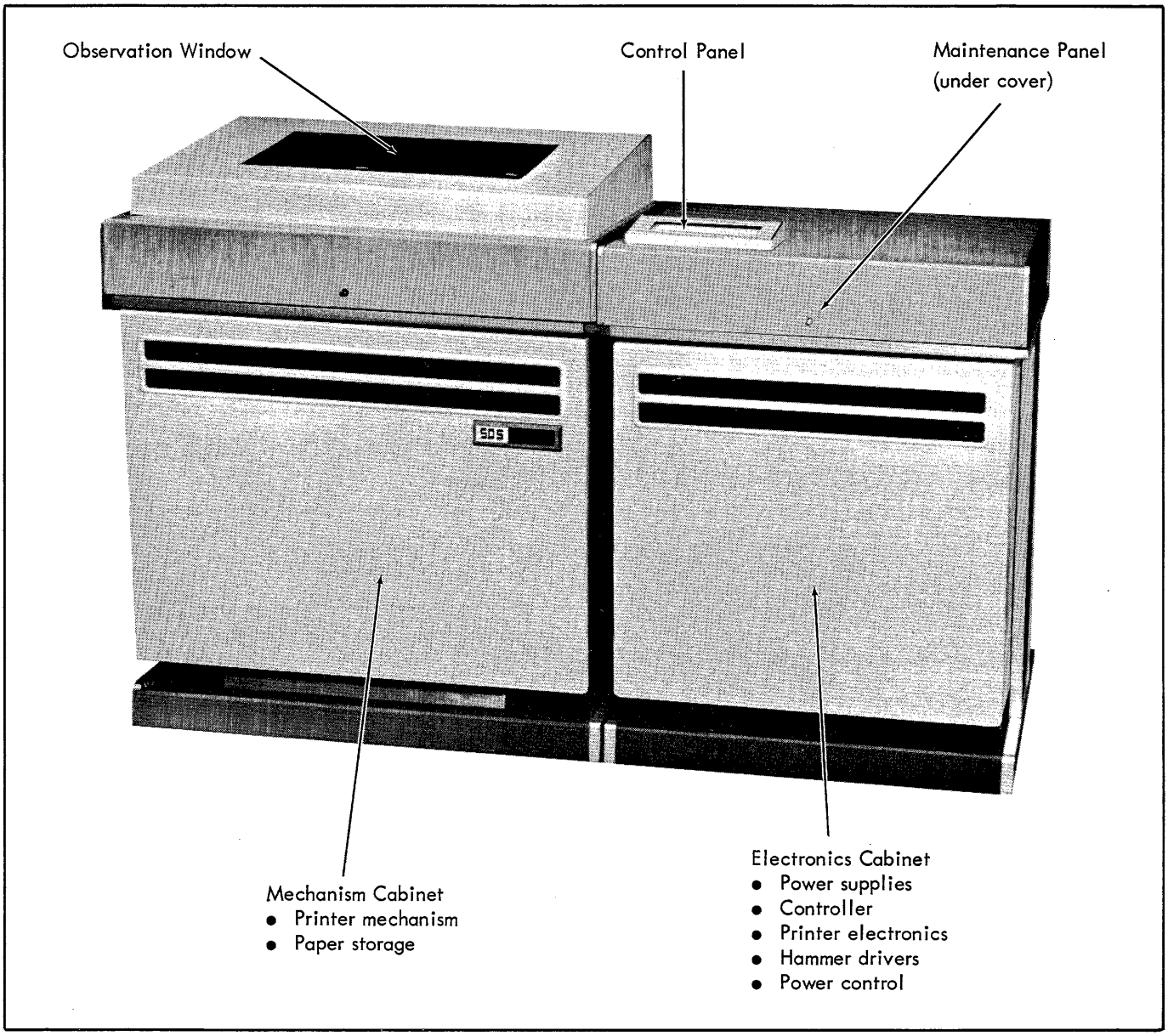

Figure 2. Mechanism and Electronics Cabinets

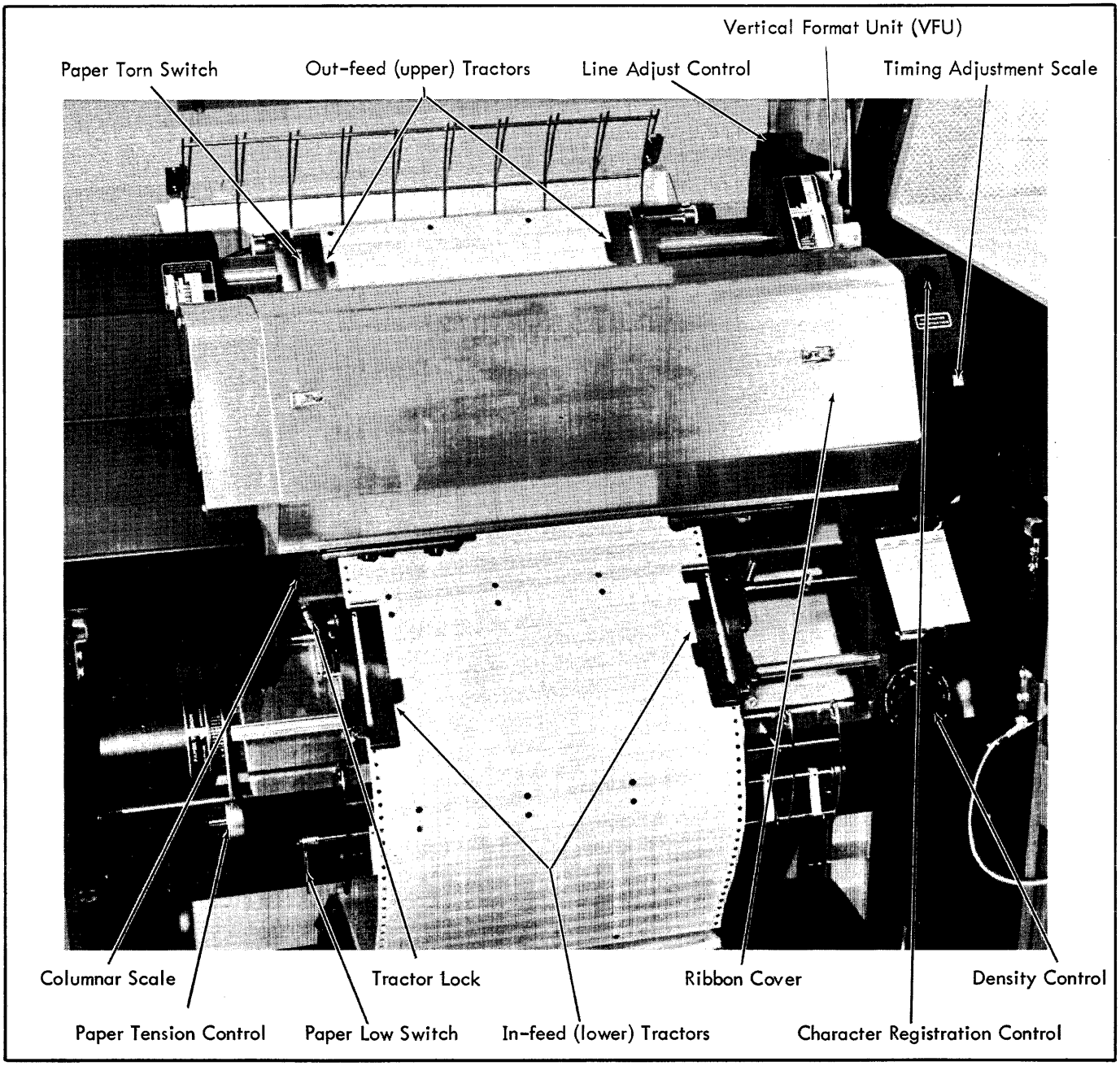

Figure 3. Line Printer Mechanism with Paper Loaded

LINE ADJUST CONTROL

This control permits alignment of the printed line with preprinted lines on paper by changing the timing of line marker clocks with respect to the tractors.

DENSITY CONTROL

This control changes the printing impact force for different thicknesses of paper or different numbers of copies. Operation of this control adjusts the gap between the typeline and the hammer bank. An arbitrary reference scale is provided. The control can be turned back (clockwise) approximately five turns to open the gap to one-half inch for ease of paper loading. There are stops on the adjustment for full open and closed positions.

PAPER LOW SWITCH

A sense switch, located below the lower paper tractors, detects the end of the form. The form is pressed against the sensor by a bracket on the front door of the mechanism cabinet. Therefore, whenever the door is opened, the printer will sense a paper low condition and enter the "manual" mode. The paper low interlock may be overridden by pulling out the lever below the lower left tractor.

PAPER TORN SWITCH

A sense switch, located on the upper left paper tractor, detects torn forms. The printer interprets this condition as a paper low condition and will enter the "manual" mode when the current line is printed.

CONTROL PANEL

The control panel (Figure 4) is located in the top of the electronics cabinet. The discussion of the switches and indicators in the following paragraphs assumes that all maintenance panel toggle switches are in the down position.

POWER

This switch/indicator is an alternate snap-action switch that controls the application of power to the typeline motor and the hammer driver power supply. Note that this switch does not control logic power. When the switch is actuated with logic power on, the indicator will illuminate. (Also see "Power Control" later in this chapter.)

START

Operating this switch/indicator places the printer in the "automatic" mode, if no conditions exist that prohibit this mode (paper low, paper torn, not operational). The indicator will illuminate when the printer is in the "automatic" mode.

STOP

Operating this switch/indicator places the printer in the "manual" mode. If printing is in progress, this mode is not entered until both halves of the current line are printed and paper motion is completed. The indicator will illuminate when the printer is in the "manual" mode.

FAULT/RESET

The fault indicator will illuminate if a "fault" condition is detected in the printer. The detectable faults are:

1. Light-dark check failure.
2. Insufficient hammer driver power supply.
3. Paper runaway.

Operating this switch/indicator causes the printer to enter the "ready-manual" state, resets the fault indicators, clears the 64-character buffer, and reinitializes the printer electronics logic. Printing is aborted and if paper is in motion, it continues until the next line marker clock occurs. If this switch is activated while the printer is in the "busy" condition, "unusual end" will be reported. The switch will not reset the "unusual end" or pending interrupt flags.

TOP OF PAGE

Operating this switch/indicator causes the paper to be advanced to the top of the page, as defined by the tape in the Vertical Format Unit (VFU). If no tape is present in the VFU, this switch causes the paper to advance one line. The switch is enabled only when the printer is in the "manual" mode. The indicator will illuminate when the paper is at top of page, regardless of printer mode.

PAPER ADVANCE

Operating this switch causes the paper to advance one line, if the printer is in the "manual" mode. If bottom of page is encountered as defined by the VFU tape, the next operation of this switch will cause the paper to advance to top of page.

OPER'L

This indicator will illuminate when the printer is "operational"; that is, power turn-on is completed, no "fault" conditions are present, and the maintenance panel PRINT TEST and FORMAT TEST switches are both down.

PAPER LOW

This indicator will illuminate when a paper low or paper torn condition exists.

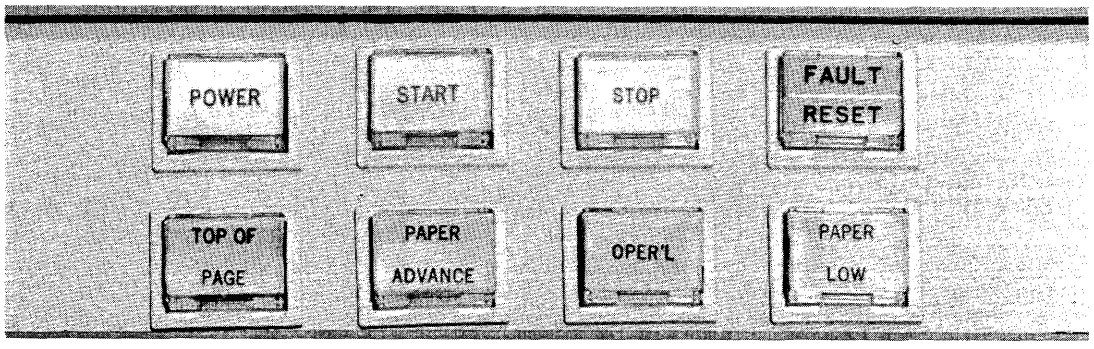

Figure 4. Control Panel

MAINTENANCE PANEL

The maintenance panel is shown in Figure 5.

PRINT TEST

This switch provides off-line printing capability to aid in fault isolation and hammer adjustment. Setting the switch to the up position places the printer in a self-test mode and extinguishes the OPER'L indicator. When the START switch is operated, a test pattern will be printed. The pattern is selected by the RIPPLE/SOLID E switch. In the up position, the PRINT TEST switch causes "unusual end" and "not operational" to be reported.

RIPPLE/SOLID E

This switch is used with the PRINT TEST switch and determines the test pattern to be printed. With the switch in the SOLID E position, 128 columns of E's will be printed in a broadside pattern to aid in hammer adjustment. With the switch in the RIPPLE position, all characters on the typeline will be printed in ascending binary order. Columns 1 and 2 will contain blanks, columns 3 and 4 will contain A's, columns 5 and 6 will contain B's, etc.

FORMAT TEST

This switch provides a means of self-checking the format control logic in the printer. Setting the switch to the up position places the printer in a self-test mode and extinguishes the OPER'L indicator. This switch modifies the operation of the TOP OF PAGE and PAPER ADVANCE switches on the control panel. When the TOP OF PAGE switch is depressed with the FORMAT TEST switch up, the paper will advance to the bottom of the form, as determined by the VFU tape. If the PAPER ADVANCE switch is depressed with the FORMAT TEST switch up, the paper will advance seven lines rather than one. In the up position, this switch causes "unusual end" and "not operational" to be reported.

SINGLE CYCLE

This switch provides a means of halting the printer at the end of an operation, prior to reporting "channel end". The printer will halt in the operation complete state (State F) and will be forced to the "manual" mode. At this time, the maintenance panel indicators should be examined. When this switch is in the down position, the printer will report "channel end" and return to the idle state (State A), where internal control logic is reset. Normal operation may be resumed by depressing the START switch. The SINGLE CYCLE switch does not cause "unusual end" to be reported.

HAMMER DISABLE

In the up position, this switch disables all hammer drivers and the clutch and brake drivers. The printer will respond to orders or to use of the PRINT TEST switch, but paper will not move and no printing will occur. The +48-volt power supply monitor is disabled, so that the supply may be turned off. The printer will not attempt to perform the post-print automatic upspace. However, operation of the TOP OF PAGE or PAPER ADVANCE switches, or receipt of a Format order specifying paper movement, will result in a paper runaway indication.

LIGHT-DARK CHECK

This indicator will illuminate when the light-dark check logic initiates a fault shutdown. The light-dark check logic monitors the output of the code disc solar cells.

+48V SUPPLY LOW

This indicator will illuminate when the +48-volt power supply monitor circuit initiates a fault shutdown, which occurs when the supply drops below approximately +40 volts.

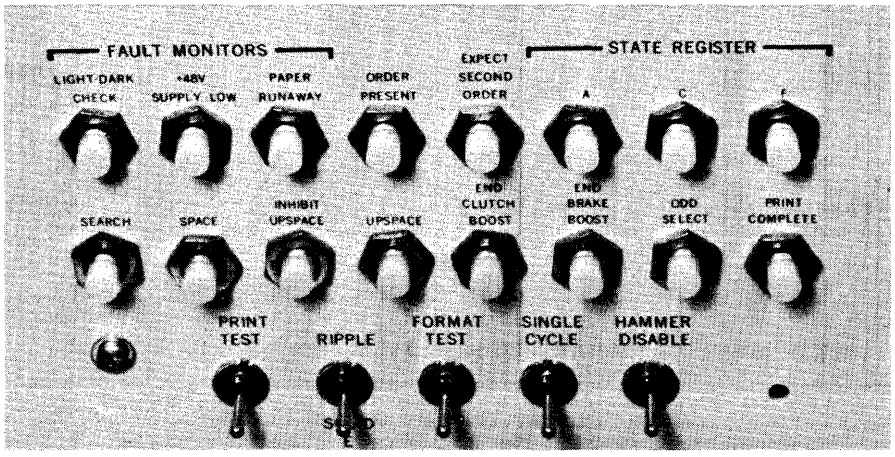

Figure 5. Maintenance Panel

PAPER RUNAWAY

This indicator will illuminate when a paper runaway condition initiates a fault shutdown. This condition exists if the clutch is engaged for longer than approximately two seconds. (Also see "Hammer Disable", explained previously.)

ORDER PRESENT

This indicator will illuminate when an order has been received from the IOP (or I/O channel) or PET, or when an order is being simulated by the PRINT TEST, TOP OF PAGE, or PAPER ADVANCE switches.

EXPECT SECOND ORDER INDICATOR

This indicator will illuminate when the printer is expecting the second of a pair of Print or Print with Format orders.

STATE REGISTER A

This indicator will illuminate when the printer is in internal State A (idle).

STATE REGISTER C

This indicator will illuminate when the printer is in internal State C (print and upspace).

STATE REGISTER F

This indicator will illuminate when the printer is in internal State F (operation complete).

SEARCH

This indicator will illuminate when a format control byte specifying "search-to-channel n" is received.

SPACE

This indicator will illuminate when a format control byte specifying "space-n-lines" is received.

INHIBIT UPSPACE

This indicator will illuminate when a format control byte specifying "inhibit upspace" is received.

UPSPACE

This indicator will illuminate when the post-print automatic upspace is initiated.

END CLUTCH BOOST

This indicator will illuminate at the end of the clutch boost portion of a paper movement cycle.

END BRAKE BOOST

This indicator will illuminate at the end of the brake boost portion of a paper movement cycle.

ODD SELECT

This indicator will illuminate at the beginning of print data transfer if odd-numbered columns are to be stored and printed.

PRINT COMPLETE

This indicator will illuminate at the end of a print or buffer clear operation.

OPERATING PROCEDURES

The procedures for operating the line printer are given in the following paragraphs.

POWER CONTROL

The ON/OFF/REMOTE switch is located on the power control assembly, under the shroud of the electronics cabinet. In the OFF (center) position, power is removed from all subassemblies except the power control assembly. In the ON position, ac power is applied to the logic power supply and the cooling fans. Further power sequencing is controlled by the POWER switch on the control panel. In the REMOTE position, power is not applied to the printer until 115 vac is present at the remote control input connector. In the REMOTE position, the printer is under control of the Sigma remote power system.

POWER TURN-ON PROCEDURE

1. Set the ON/OFF/REMOTE switch to the ON position (or REMOTE position with power present at the remote control input connector).
2. Turn the density control to full counterclockwise position.
3. Depress the POWER switch on the control panel. The indicator will illuminate when the switch is in the "on" state. After a delay of between 3 and 20 seconds, the OPER'I and STOP indicators will illuminate. (The OPER'L indicator will remain off if the maintenance panel PRINT TEST or FORMAT TEST switches are up.)

The line printer is now in an "operational" state.

POWER TURN-OFF PROCEDURE

Depress the POWER switch on the control panel. Power will be removed from the typeline motor and the hammer driver power supply. The cooling fans will continue to operate and the logic power supply will remain on. All indicators on the control panel will be extinguished.

It is unnecessary to turn the printer POWER switch off before turning off the computer.

PAPER LOADING

The following procedure assumes that power has been applied to the printer.

1. With no paper installed, depress TOP OF PAGE switch. Tractors and VFU tape should move, then stop, and the TOP OF PAGE indicator should illuminate.
2. Turn the density control clockwise until it reaches its stop.
3. Place the paper tension control in the minimum tension position (up).
4. Determine the size of the form to be loaded. Most standard forms are 51 lines (8-1/2 inches) or 66 lines (11 inches) between perforations.
5. Position all four tractors to the approximate dimensions required by the form width. Each tractor has a latch which must be unlocked to move the tractor.
6. Refer to the label mounted on the front left tractor cover. The scale on this label indicates the approximate number of lines below the print station and is used as a guide during paper loading. Load the paper so that the first line to be printed is opposite the number on the scale corresponding to the form length. The columnar scales, located on the platen below the typeline and on the ribbon cover above the typeline, may be used as a reference in horizontal positioning of the form. After paper is loaded, the tractors must be locked in position and the tractor covers must be closed. Refer to "Operational Adjustments" for final form position adjustments.

RIBBON LOADING

The following procedure is used to load a new ribbon into the printer. Refer to the decal on the left of the Character Registration control. See Figures 3 and 6.

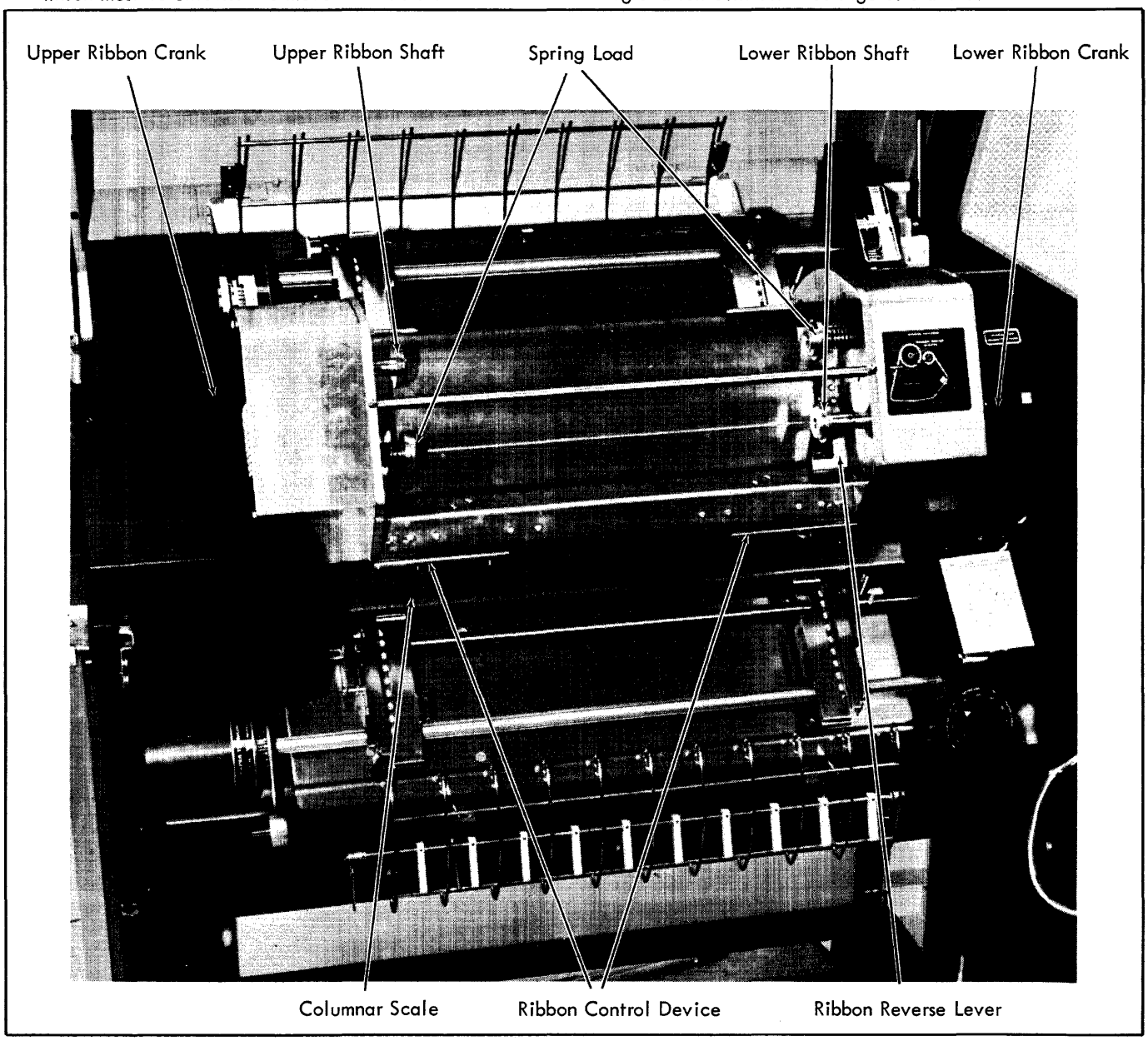

Figure 6. Line Printer Mechanism

Warning: The typeline motor must be off before replacing or installing the ribbon.

1. Turn typeline motor power off by depressing the control panel POWER switch (indicator not illuminated).
2. Remove ribbon cover (see Figure 6).
3. Turn density control completely clockwise to obtain maximum clearance between the typeline and the hammer bank.
4. Wind ribbon completely on either mandrel (cardboard tube on which ribbon is wound) by means of ribbon crank.
5. Slide full ribbon mandrel against spring load and lift out.
6. Insert new ribbon on upper ribbon shaft and feed around support shafts and through ribbon control device to lower ribbon mandrel.
7. Align ribbon at lower mandrel with the roll on the upper mandrel, and tape ribbon symmetrically to the lower mandrel. Turn the lower ribbon crank a few turns until the reversing strip on the ribbon is above the reversing switch.
8. Replace ribbon cover.

VFU TAPE LOADING

The following procedure should be used to load a standard, prepunched, precut vertical format control tape loop.

1. Apply power to printer. Printer must be in "manual" mode (STOP indicator illuminated).
2. Lift the VFU read head (see Figures 6 and 7) and install tape on the sprocket pins. The markings on the tape should be on the outside of the loop with the arrows pointing to the operator's left, toward the center of the mechanism. Close the read head.
3. Depress the TOP OF PAGE switch. The tractors should move and the tape should advance until a top of page hole (track 6) is sensed by the VFU.

   Note: If the TOP OF PAGE switch is operated with the VFU cover raised, a paper runaway will result.

OPERATIONAL ADJUSTMENTS

Good printing quality depends on proper adjustment of the mechanism controls. These adjustments are as follows:

1. Initiate printing in the local mode by turning on the maintenance panel PRINT TEST switch, setting the RIPPLE/SOLID E switch to the SOLID E position, and depressing the START switch.

   Note: The printer will report "not operational" if it receives an SIO instruction during local mode printing. The OPER'L indicator will be extinguished.

2. While printing, adjust the density control to obtain the proper print density. Setting the density control too high may cut paper and reduce ribbon life.

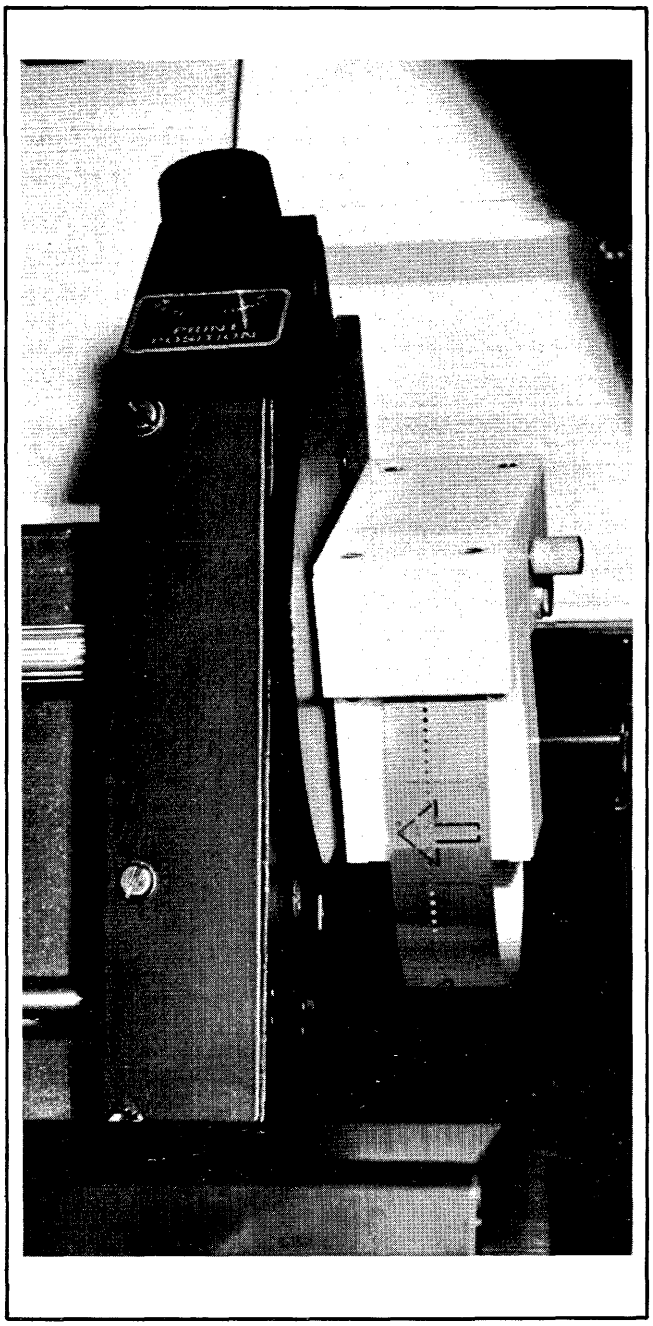

Figure 7. Vertical Format Unit

3. Adjust paper tension so that the sprocket holes in the paper are slightly deformed. Vertical paper tension is controlled by the paper tension lever, horizontal tension is controlled by the spacing of the tractors. Excessive tension will cause paper tearing. Too little tension will cause irregular printing.
4. While printing, adjust the character registration control to obtain a Solid E pattern with no clipping of either tops or bottoms of the characters. Readjust the density control if necessary. Set the RIPPLE/SOLID E switch to RIPPLE, which causes all characters on the typeline to be printed, and verify that no clipping of characters occurs. Return RIPPLE/SOLID E switch to the SOLID E position.

5. While printing, adjust the line adjust control so that the printed pattern is properly aligned with the form.

6. When these adjustments are completed, depress the STOP switch and turn off the PRINT TEST switch. The OPER'L indicator should illuminate.

ON-LINE OPERATION

After the paper, ribbon, and VFU tape have been loaded and the mechanism controls adjusted, the printer is ready for on-line operation with a computer system.

1. Verify that the OPER'L indicator is illuminated, all maintenance panel switches are down, and that the PAPER LOW indicator is off.

2. Depress the START switch and verify that the START indicator is illuminated.

Note: The following switches should be checked before starting operation. Verify that the on-line/off-line switch, located on the LT 94 module, position 23A in the controller, and the test mode switch, located on LT 95, position 22A in the controller, are both up. Verify that the expected address is set into the address switches on the LT 26 module, position 24A in the controller.

VERTICAL FORMAT TAPE PREPARATION

The Vertical Format Unit (VFU) and tapes are made so that each sprocket hole on the tape corresponds to a printed line on the paper. For every line the paper is advanced, the tape is advanced a sprocket hole. The VFU generates a signal each time a punch is sensed in the tape. These signals determine the position of the form.

VFU tapes (P/N 148609) are supplied in lengths of approximately 24 inches with sprocket holes prepunched at 10 lines per inch. The tape must be cut and spliced to form a loop of the proper length for a specific form, as follows:

1. Determine the form length in inches, from perforation to perforation. Multiply the form length by the vertical line spacing (6 lines per inch). The product is the number of sprocket holes required on the tape loop.

   Example:

   Form length of 11 inches. 11 x 6 = 66 lines (or 6.6 inches)

2. The minimum length of tape that should be used to make up the loop is 9 inches. To meet this requirement, a multiple of the number of sprocket holes required may be used.

   Example:

   66 x 2 = 132 lines (or 13.2 inches)

   Note: Best wear conditions are achieved by using a tape that approximates 132 lines in length.

3. The tape, which is marked at every tenth sprocket hole to simplify counting, must be cut so that when formed into a loop, the correct number of sprocket holes are encompassed in one revolution (132 lines in the example). At this time the tape should be marked at the proper length but should not be cut to length until punching is complete.

4. The line printer senses holes only in track 1 (three tracks to left of sprocket track, and in track 6 (three tracks to right of sprocket track). Track 1 is interpreted as bottom of page and track 6 as top of page.

5. The punching procedure is illustrated by the following example.

   Example:

   Assume that top of page is defined as 7 lines below the physical top of the perforated sheet and bottom of page as 7 lines above the physical bottom. Considering line 0 on the tape as corresponding to the perforation, a hole is punched in track 6 (top of page) on line 7. Another hole is punched in track 1 (bottom of page) on line 59, that is, 7 lines above line 66.

   Since the total length of the tape is equivalent to two pages, the pattern must be repeated. A hole is punched in track 6 on line 73, 7 lines below line 66 (which corresponds to a perforation) and a hole is punched in track 1 on line 125, 7 lines above line 132. Note that when the tape is spliced to form a loop, lines 0 and 132 will coincide.

VERTICAL FORMAT TAPE SPLICING

After the tape has been punched, it should be cut to the proper length (line 132 in the above example). The tape should then be formed into a loop, and a splice (XDS Part Number 154502) applied to each side. After splicing, the markings on the tape should be on the outside of the loop.

Note: Devices are available for tape punching and splicing. Consult an XDS representative for a recommended splicer-punch.

APPENDIX. PROGRAMMING EXAMPLES

SIGMA 5/7 PROGRAMMING EXAMPLE

The following coding sequence illustrates a line printer program for use with an XDS Sigma 5/7 computer. The program will print one line of 128 characters and upspace to the next line. This program is written as a subroutine entered by a Branch and Link instruction using register 15 (i.e., BAL,15 PRINT).

Label	Command	Argument	Comments
PRINT	NOP		Entry to print subroutine.
TESTIO	TIO,8	PRINTER	Test printer status (general register 9 will contain status response).
	STCF	TEMP	Save condition codes.
	BCR,8	$+3	Check address recognition. If successful, branch to check printer mode. If unsuccessful, execute next instruction in sequence.
HALT1	WAIT BCR,0	0 TESTIO	Wait for manual intervention, then try again.
	CW,9	AUTO	Check printer mode. Bit position 3 of register 9 will contain a 1 if the printer is in "automatic" mode. This instruction will set the condition code according to the results of the comparison.
	BCS,4	$+3	If CC2 is set to 1, the printer is in "automatic" mode; therefore, proceed to $+3. Otherwise, execute next instruction in sequence.
HALT2	WAIT	0	The printer is in "manual" mode. Wait for operator to press START switch.
	BCR,0	TESTIO	Unconditional branch to TESTIO.
	LC	TEMP	Load condition codes that were saved previously.
	BCR,4	STARTIO	If SIO is possible (i.e., CC2 is 0), branch to STARTIO; otherwise, execute next instruction in sequence.
	BCR,0	TESTIO	Loop waiting for printer.
STARTIO	LI,0	DA(COMM1)	Load register 0 with the address of the first command doubleword.
	LW,10 STW,10	IOINT1 X'5C'	Set up I/O interrupt linkage.
	LI,10 WD,10	X'20' X'1200'	Arm and enable I/O interrupts.
	SIO,8	PRINTER	Start the printer.
	BCR,4	HALT5	If SIO was successful, branch to HALT5 to wait for interrupt; otherwise, execute next instruction in sequence.
HALT4	WAIT BCR,0	0 STARTIO	Wait for operator intervention, then branch unconditionally to STARTIO.
HALT5	WAIT BCR,0	0 EXIT	Wait for "channel end" interrupt to AKNIO. If no interrupt occurs, the operator should clear the halt to force subroutine to exit.
AKNIO	AIO,8	0	Enter here on I/O interrupt and acknowledge.
	BCR,8	$+2	If CC1 is zero (i.e., I/O interrupt recognition by the AIO), skip the next instruction in sequence; otherwise, execute it.
	LPSD,3	WFP	Load program status doubleword with contents of WFP. The highest priority interrupt currently in the active state is cleared, and the interrupt level is armed. Thus, the "no interrupt recognition" causes a return to HALT5 to wait for "channel end".
	BCR,4	$+3	If the AIO indicated a normal interrupt, branch to determine if it is a printer interrupt; otherwise, execute the next instruction in sequence.

Label	Command	Argument	Comments
HALT6	WAIT LPSD,3	0 RETRY	When an abnormal condition interrupt occurs, wait for operator intervention; then try again.
	STH,R8	R9	Following normal interrupt, isolate address.
	LH,R8	R9	Address isolated.
	CI,8	PRINTER	Check for printer interrupt.
	BCR,3	$+2	If it is printer, branch to $+2 to continue; otherwise, execute next instruction in sequence.
	LPSD,3	WFP	Return to HALT5 to wait for "channel end".
	LPSD,3	AIOK	Interrupt was from printer. Clear interrupt and proceed to TDVIO.
TDVIO	TDV,8	PRINTER	Obtain printer device status.
	BCR,4	$+3	Test for device fault (i.e., branch if no fault reported).
WAIT7	WAIT	0	If device fault, stop for operator invervention.
	BCR,0	TDVIO	Unconditional branch to TDVIO to try again.
	CW,9	PMBIT	Determine whether bit position 4 of register 9 contains a 1, indicating that printer paper is moving.
	BCS,4	TDVIO	If paper is moving, branch to TDVIO and loop, waiting for it to stop; otherwise, execute next instruction in sequence.
	CW,9	FAULTS	Double check for buffer parity error, paper runaway, or paper low.
	BCR,4	$+2	If no fault condition exists, branch to $+2.
HALT8	WAIT	0	If any fault condition exists, wait for operator intervention; then proceed.
EXIT	BCR,0	*15	Return to main program.
*PROGRAM CONSTANTS AND STORAGE			
PRINTER	EQU	X'102'	Printer address = IOP1, device 2.
AUTO	DATA	X'10000000'	Bit 3 = auto/manual flag.
PMBIT	DATA	X'08000000'	Bit 4 = paper moving flag.
FAULTS	DATA	X'24000000'	Bit 2 = paper low; bit 5 = paper runaway.
TEMP	DATA	0	Temporary storage.
IOINT1	XPSD,0	CEINT	I/O interrupt at "channel end".
	BOUND	8	Set on doubleword boundary.
COMM1	GEN,8,24 GEN,8,24 GEN,8,24 GEN,8,24	X'01',BA(LINE) X'20',128 X'01',BA(LINE) X'1C',128	Command doubleword to print one line of 128 characters and automatically upspace to the next line: - Interrupt on "unusual end" or "channel end" - Halt on transmission error - Message to be printed begins at symbolic location LINE - Prints 128 contiguous bytes in columns 1-128.
CEINT	DATA DATA	0,0 AKNIO,0	PSDW exchange on I/O interrupt to location X'5C'.
WFP	DATA	HALT5,0	PSDW – Return to wait for printer "channel end".
RETRY	DATA	STARTIO,0	PSDW – Try printer operation again.
AIOK	DATA	TDVIO,0	PSDW – Proceed on printer "channel end".
LINE	RES	33	Reserve for print message.

SIGMA 2/3 PROGRAMMING EXAMPLE

The following coding sequence illustrates a line printer program for use with an XDS Sigma 2 or Sigma 3 computer. The program will print one line of 128 characters and upspace to the next line. It is written as a subroutine entered by a branch instruction using link register 2.

Label	Command	Argument	Comments
PRINT	B	$+1	Entry point to subroutine.
TESTIO1	LDA	PRINTER	Printer address.
	TIO		Test printer status (register 7 will contain status response).
	BNO	$+3	If overflow is 0, skip the next two instructions; otherwise, execute the next instruction in sequence.
HALT1	WD	X'D0'	Wait for manual intervention; then try again.
	B	TESTIO1	
	BNC	$+2	If SIO is possible (i.e., carry is 0), branch to test for "automatic"; otherwise, execute the next instruction in sequence.
	B	TESTIO1	Loop waiting for printer.
	AND	AUTO	Check printer mode. Bit 3 of register 7 will contain a 1 if the printer is in "automatic" mode. This instruction isolates bit 3 in register 7.
	BAZ	$+2	If register 7 is 0, the printer is in the "manual" mode; therefore, proceed to $+2. Otherwise, execute the next instruction in sequence.
	B	STARTIO1	Branch to STARTIO1.
HALT2	WD	X'D0'	The printer is in "manual" mode. Wait for operator to press START switch.
	B	TESTIO1	Loop to TESTIO1.
STARTIO1	LDA	IOINT1	Set up I/O interrupt linkage.
	STA	X'106'	
	LDA	ARMIO	Arm and enable I/O interrupt.
	WD	X'1200'	
	LDA	COMM1	Address of I/O table.
	WD	EVENCHAN	Enter address into even channel register.
	LDA	COUNT1	I/O byte count = 129 (order byte plus data bytes).
	WD	ODDCHAN	Enter I/O byte count into odd channel register.
	LDA	PRINTER	Printer address.
	SIO		Start printer (first SIO).
	BNC	TESTIO2	If SIO was successful, branch to test for printer "ready"; otherwise, execute the next instruction in sequence.
HALT3	WD	X'D0'	Wait for operator intervention; then branch to STARTIO1.
	B	STARTIO1	
TESTIO2	LDA	PRINTER	Printer address.
	TIO		Check for printer "ready".
	BNC	$+2	If carry is 0, the printer is "ready", and branch to STARTIO2; otherwise, execute the next instruction in sequence.
	B	TESTIO2	Loop waiting for printer.
STARTIO2	LDA	COMM1	Address of I/O table.
	WD	EVENCHAN	Enter address into even channel register.

Label	Command	Argument	Comments
	LDA	COUNT2	I/O byte count = 129 (interrupt at channel end).
	WD	ODDCHAN	Enter byte count into odd channel register.
	LDA	PRINTER	Printer address.
	SIO		Start printer (second SIO).
	BNC	HALT5	If SIO accepted (carry is 0), branch to HALT5 to wait for interrupt; otherwise, execute the next instruction in sequence.
HALT4	WD B	X'D0' STARTIO2	Wait for operator intervention; then branch to STARTIO2.
HALT5	WD RCPY	X'D0' L,P	Wait for I/O interrupt. If no interrupt, operator should clear the halt to force subroutine exit.
AKNIO	DATA DATA	0 0	Program status doubleword (PSDW) storage.
	AIO		Enter here for I/O interrupt.
	BNO	$+3	If overflow is 0 (i.e., interrupt recognition by AIO), skip the next two instructions; otherwise, execute the next instruction in sequence.
	WD LDX	X'D8' WFP	Return to HALT5 to wait for interrupt.
	BNC	$+4	If the AIO indicates a normal interrupt, execute this instruction (i.e., skip the next three instructions); otherwise, execute the next instruction in sequence.
HALT6	WD WD LDX	X'D0' X'D8' RETRY	Wait for operator intervention; then try again.
	AND	MASK	Isolate AIO address.
	CP	PRINTER	Check for printer interrupt.
	BNC	$+3	If carry is 0, skip the next two instructions; otherwise, execute the next instruction in sequence.
	WD LDX	X'D8' AIOK	Interrupt was from printer. Clear interrupt and proceed to TDVIO.
	WD LDX	X'D8' WFP	Return to HALT5 to await printer interrupt.
TDVIO	LDA	PRINTER	Printer address.
	TDV		Obtain printer status.
	BNC	$+3	Test for device fault (i.e., branch if no fault exists).
HALT7	WD	X'D0'	Wait for operator intervention.
	B	TDVIO	Loop to TDVIO to try again.
	RCPY	7,6	Save status in register 6.
	AND	PMBIT	Determine whether bit 4 of register 7 is a 1 (i.e., printer paper is moving).
	BAZ	$+2	Paper is not moving.
	B	TDVIO	Loop to TDVIO to await paper motion end.
	RCPY	6,7	Fetch TDV status.
	AND BAZ	FAULTS $+2	Check for parity error, paper runaway, or paper low condition.

Label	Command	Argument	Comments
HALT8	WD	X'D0'	Fault exists; wait for operator intervention.
EXIT	RCPY	L,P	Return to main program.
*PROGRAM CONSTANTS AND STORAGE			
PRINTER	DATA	X'D02'	Printer address.
AUTO	DATA	X'1000'	Bit 3 = "auto/manual".
PMBIT	DATA	X'0800'	Bit 4 = paper moving.
FAULTS	DATA	X'2400'	Bit 2 = paper low; bit 5 = paper runaway.
MASK	DATA	X'00FF'	Address mask.
IOINT1	DATA	AKNIO	I/O interrupt handler address to location X'106'.
ARMIO	DATA	X'200'	I/O interrupt bit 6 = 1.
COUNT1	DATA	X'0081'	Byte count = 129
COUNT2	DATA	X'2081'	Byte count = 129, I/O interrupt.
EVENCHAN	EQU	10	Even I/O channel register.
ODDCHAN	EQU	11	Odd I/O channel register.
WFP	DATA	0,HALTS	PSDW – return to await printer interrupt.
RETRY	DATA	0,STARTIO1	PSDW – try printer operation again.
AIOK	DATA	0,TDVIO	PSDW – proceed on printer interrupt.
COMM1	EQU	$	Command doubleword address.
	DATA	X'01'	Order byte.
LINE	RES	66	Reserve for print message.