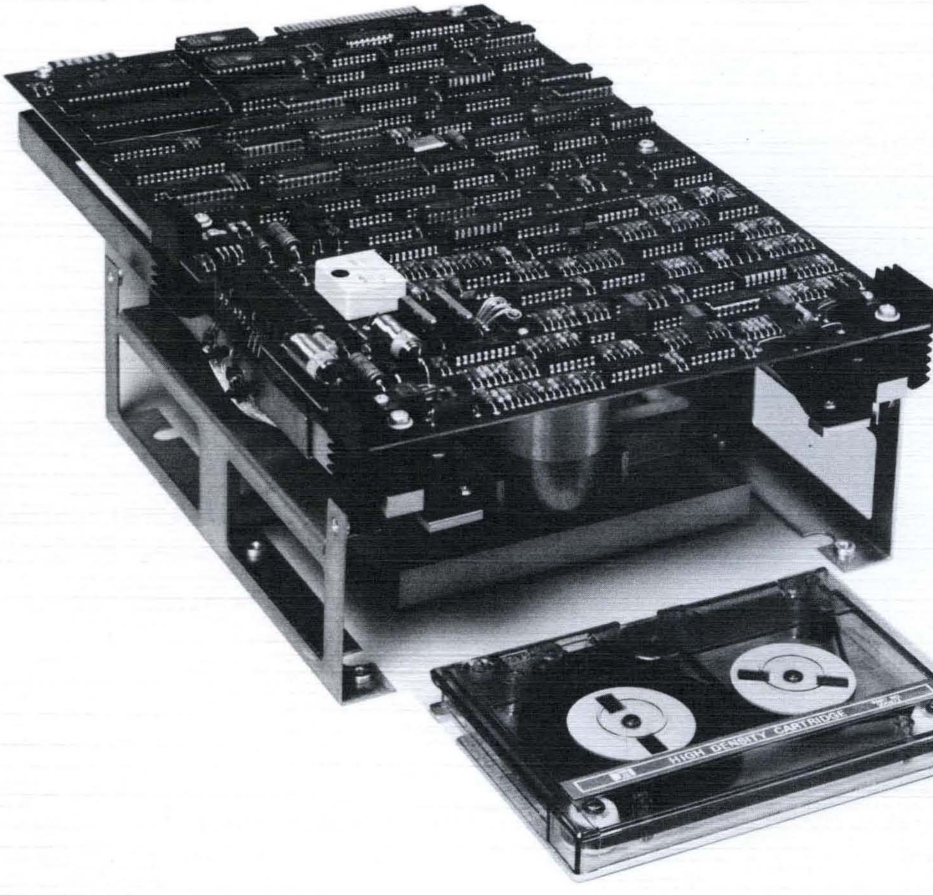
STREAMER

MANUAL



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PREFACE

This instruction manual is designed to assist the new customer or potential new customer in the areas of application, installation, operation, and maintenance. The emphasis is on product performance from an operator's viewpoint. The new Streamer operator should read the entire manual over once and then return to Section 3, Operation. The operation section refers the reader to other areas in the manual for background information, as required.

DEI maintains a staff of technical support personnel dedicated to assisting the new Streamer user. The new customer should feel free to call on this technical staff at anytime.

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SECTION 1 DESCRIPTION

1.1 INTRODUCTION

The Streamer is configured as a high level, byte parallel, FIFO memory; there is no restriction on block size. The system's integrator need not be concerned with the art and physics of magnetic tape recording. All algorithms for the recording of data, the restoration of data, and the recovery from errors are contained within the Streamer. Data is sent to and from the Streamer with a simple asynchronous handshake. Capacity and tape speed of the Streamer models are specified in the following table:

CAPACITY (megabytes)	TAPE SPEED (inches per second)	MODEL
10 Mbytes	30 ips	7130
10 Mbytes	90 ips	7190
20 Mbytes	30 ips	7230
20 Mbytes	90 ips	7290

1.2 GENERAL DESCRIPTION

The Streamer is a reliable tape drive, designed to provide economical data back-up and program load functions for systems using Winchester disk drives. Streaming uses a continuous recording process offering several advantages over the conventional stop/start recording method as follows:

- o eliminates need for start/stop servo electronics, thus reducing power requirements and heat dissipation.
- o increases tape speed and data transfer rates.
- o eliminates large interblock gaps, thus increasing data volume that can be stored on tape.

The Streamer separates incoming data into blockettes, inserting an internal block address, sync, and error check character between each blockette. During the write mode, data is written without stopping the tape. The extra characters are stripped away during the read mode, returning the verified data, in original block format, to the host.

1.2.1 Cartridge Drive

The Streamer is designed to write and read streaming data onto cartridges built to ANSI Standard X3.55-1977 specifications. Two tracks are used in the 10 Mbyte models while the 20 Mbyte models use four tracks. In both versions, the even numbered tracks are recorded in the forward direction; odd numbered tracks in the reverse direction. Data formats are compatible (that is, either a 10 or 20 Mbyte drive can recover data recorded on the other, however, only the first two tracks of the 20 Mbyte unit can be recovered by a 10 Mbyte drive).

The Streamer encodes data before recording and decodes before transmission to the host. All overhead characters are added to the data within the drive and removed before outputting.

A universal mounting frame provides primary support for the components of the cartridge drive which consists of three major subassemblies:

- o motor/heat sink assembly
- o mechanical/head, flexcircuit assembly
- o PC board assembly

The PC board provides edge connectors for I/O signals and power. Figure 1-1 illustrates the location of major components and subassemblies within the mainframe.

In summary, the Streamer is a cartridge magnetic tape drive designed to provide low cost, removable media, and effective back-up for fixed disk systems. This back-up capability includes program load, archival storage, data interchange, and audit trail, in addition to the accommodation of restructured files.

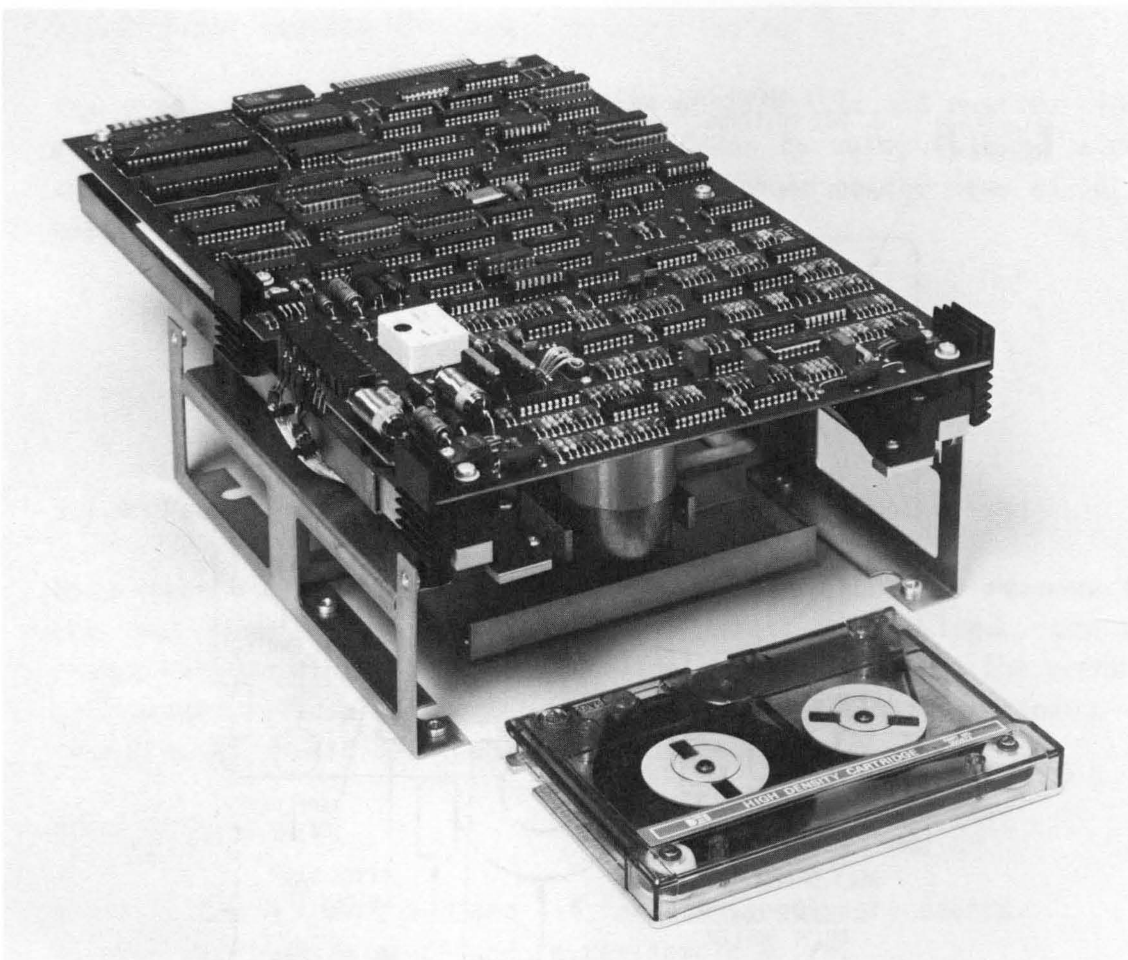


Figure 1-1 CARTRIDGE TAPE DRIVE

1.2.2 Tape Cartridge

The Streamer records and reproduces data on an ANSI compatible 1/4-inch tape cartridge. The tape is wound on two coplaner reels and is driven at a single point by the drive pulley as shown in Figure 1-2. Tape tension is maintained by a unique isoelastic band that contacts both reels. The cartridge contains both beginning-of-tape (BOT) and end-of-tape (EOT) optical sensing. When used with the Streamer cartridge drive, the cartridge provides protection of the data by enclosing the data bearing medium with 36 inches of tape in addition to the cartridge case. The position of components within the tape cartridge are shown in Figure 1-2.

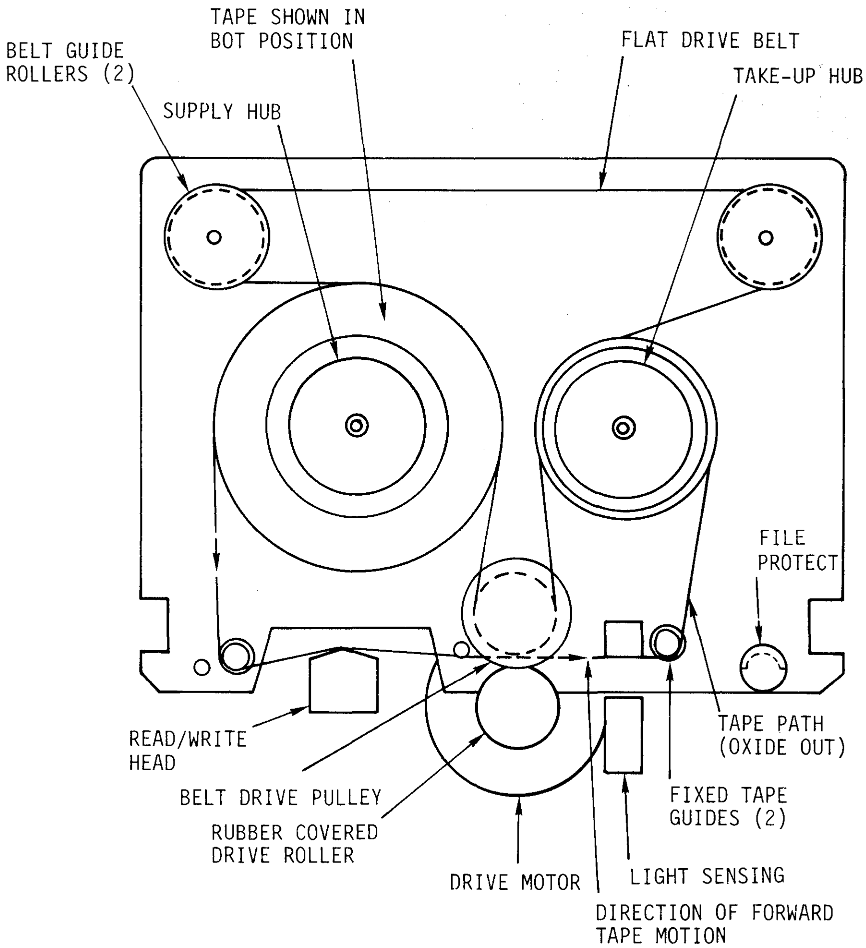


Figure 1-2 TAPE CARTRIDGE

1.2.3 Data Transmission

To sustain streaming operation, the host must be capable of supplying data rates equal to or greater than:

- o 128 kbytes per second (7.8 μs per byte) for 90 ips models
- o 43 kbytes per second (23 μs per byte) for 30 ips models

For brief periods, burst data transmission is allowed where process time equals 2.2 μs per byte. Transfer rates are valid only when the host conforms to timing specifications of the data transfer control signals.

1.2.4 Data Reliability, Interchangeability

Incorrect or marginal data is rewritten without stopping the streaming operation. The Streamer achieves this by first mechanically cleaning the tape with a sapphire tape cleaner. Then, to assure data integrity, written data is immediately read. Three (3) write thresholds are available for the controller during the read-after-write process. The written data is verified, byte-by-byte, with the input data. During the write process, a one's intensive GCR code is used. This creates a data bandwidth separated from the drive flutter components. This code is not sensitive to bit patterns and therefore provides greatest data recovery potential from media dropouts. The hard error rate is less than or equal to one (1) in 10^{10}.

Data written previously and now being read could be affected during media storage. However, the Streamer incorporates a CRCC technique and use of an error algorithm to solve this problem. The algorithm incorporates tape cleaning, retensioning, and threshold adjustment, as required.

The Streamer's mechanical design secures the cartridge to a rigid cast reference plane. This approach assures that data written by one drive can successfully be read on another.

The magnetic head is secured to a rigid cast frame. For the 20 Mbyte model, the head is moved and held against two precise surfaces in Jo Block configuration. This simple classic design holds the head position within 0.0005 inches.

A precise control of the cartridge position with respect to the head is very important. All generic mountings of the Streamer are torque -isolated. This eliminates local distortion of the mounting structures.

1.3 SPECIFICATION SUMMARY

Four (4) models of DEI Streamer Cartridge Tape Drives are available. Table 1-1, Specification Summary, describes parameters relative to particular model numbers.

PARAMETER	MODEL 7190	7290	7130	7230
Number of Recorded Tracks	2	4	2	4
Capacity, Formatted (Mbytes)	10	20	10	20
Speed, Read/Write Maximum	90 inches/s		30 inches/s	
Burst Transfer Rate				
Write Mode	210 kbytes/s		210 kbytes/s	
Read Mode	290 kbytes/s		290 kbytes/s	
Minimum Long-Term Transfer				
Rate: Write Mode	128 kbytes/s		43 kbytes/s	
Read Mode	100 kbytes/s		30 kbytes/s	
Nominal Average Transfer Rate	90 kbytes/s		30 kbytes/s	
Instantaneous Transfer Rate for two (2) bytes	2.2 μs/byte		2.2 μs/byte	

Table 1-1 SPECIFICATION SUMMARY

The Streamer will typically consume data at the Nominal Average Transfer Rate. However, to guarantee a streaming situation, the host must be capable of the Minimum Long-term Transfer Rate.

Exceeding the Maximum Burst Transfer Rate will cause the Streamer to implement the write underflow or read overflow algorithm which includes tape stoppage and repositioning.

Performance specifications common to all Streamer drive models follow:

Recording Form......................	Serpentine
Recording Code......................	GCR
Head Format.........................	Read-While-Write with erase
Recording Density...................	7600 bits/inch (Host Data)
Reliability (data):	
Soft Error Rate..................	$\leq$ 1 Error in 10^8 bits
Hard Error Rate..................	$\leq$ 1 Error in 10^{10} bits
Servo Voltage....................	24 VDC ± 15%
Other Voltage....................	4.85 to 5.25 VDC
Dissipation:	
Typical..........................	50 watts
Maximum..........................	90 watts
Width x Height x Depth..............	8.55 X 4.62 x 14.25 inches
Weight..............................	5 pounds
Mounting	8 inch Standard Diskette
Operating Temperature...............	+5° to +45° C
Storage Temperature.................	-30° to +60° C
Relative Humidity...................	20 to 80% RH
Altitude............................	-200 to 15,000 feet
Vibration Limits	0.1g, 3-300 Hz
Shock Limit.........................	3 g's, 20 ms impulse on Z-axis
Mean Time Between Failures*.........	> 3500 hours
* Excludes head and motor life	
Capstan Motor Assembly Life.........	> 2500 hours
Head Life...........................	> 1250 hours
Mean Time to Repair.................	< 0.5 hours

SECTION 2 INSTALLATION

2.1 MOUNTING

The Streamer's universal standard 8-inch frame permits side or bottom mounting of the drive. It can be mounted in most any orientation without affecting its performance; however, the following two operating positions are not recommended:

- the drive mounted such that the oxide surface of the tape is below the tape cleaner (tape material removed by the cleaner can fall back onto the tape surface resulting in loss of data)
- the drive mounted where the cartridge is inserted with the base plate up

Overall drive dimensions, including the universal mounting frame, are shown in Figure 2-1. Mounting holes are compatible with 8/32 inch bolts. See Figure 2-2, Universal Frame, for additional mounting information.

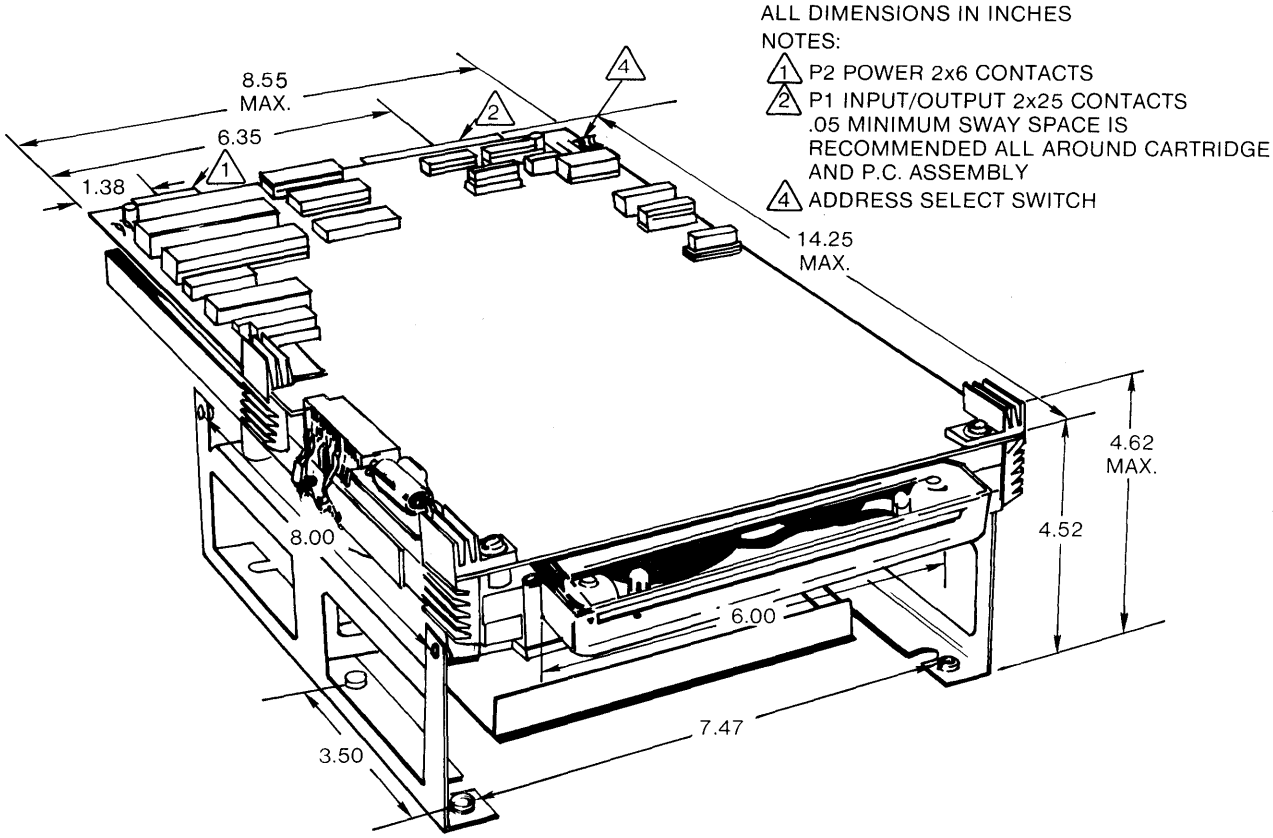


Figure 2-1 DRIVE DIMENSIONS

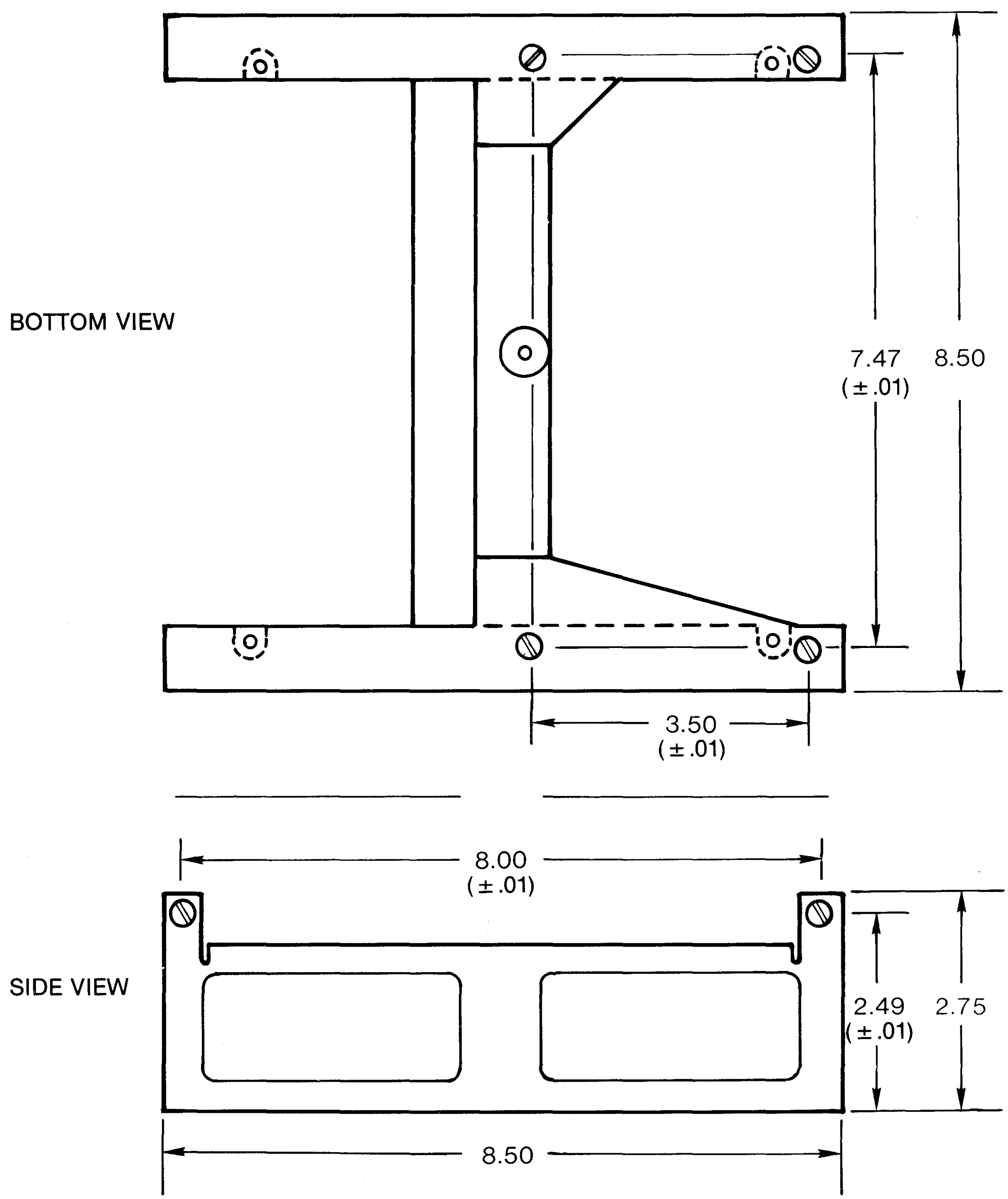


Figure 2-2 UNIVERSAL FRAME

2.2 INPUT POWER CONNECTION

Power is supplied to the Streamer through the card-edge connector (P2) on the PC board (see Figure 2-3 for location). Power connector board details are shown in Figure 2-3. The mating connector is a 12-pin edge-type connector, Winchester P/N 8BDJ6-S005G (or equivalent) with AWG #20 conductor wires. If the key (between pins 4 and 5) is not used, the mating connector can be installed in either position.

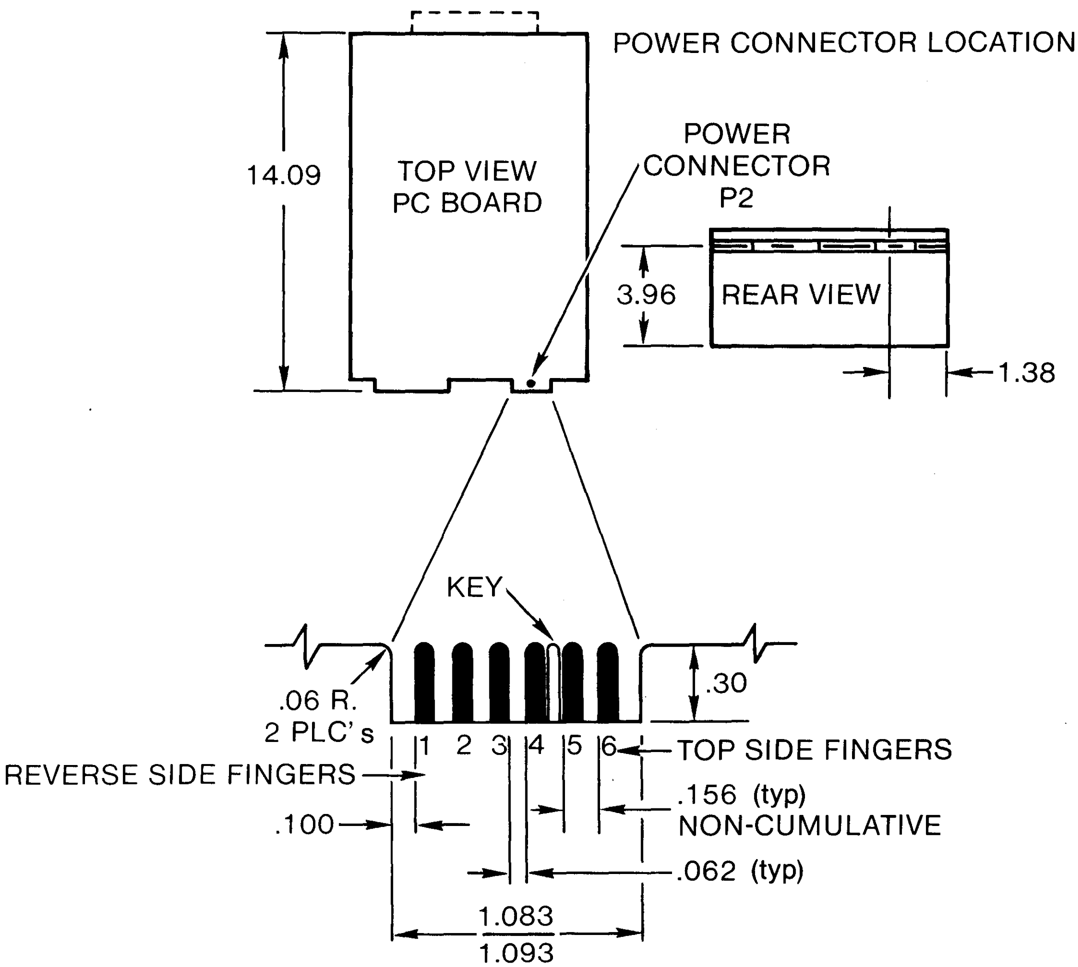


Figure 2-3 POWER CONNECTOR BOARD DETAIL

2.3 POWER SUPPLY REQUIREMENTS

The voltages and currents required to operate the Streamer are shown in Table 2-1 along with the applicable pin numbers of the P2 power connector.

PIN NUMBER	PIN NAME	VOLTAGE (VDC) MIN	VOLTAGE (VDC) MAX	CURRENT (AMPS) MIN	CURRENT (AMPS) TYP	CURRENT (AMPS) MAX	COMMENTS AND REFERENCE NOTES
4,C	V5+	4.85	5.25	2.8	3.0	3.6	+5 VDC, Ripple $\leq$ 2% inclusive of tolerances (see notes 3 and 4)
1,2,B	LCOM						Logic Common, logic current return (see note 1)
3,D	V24+	20.4	27.6	0.2	1.0	2.6	+24VDC (see notes 2, 3 and 4)
5,E,F	SCOM						Servo Common, servo current return (see note 1)
A,6	CCOM						Chassis Common, drive return to power supply (see note 1)

NOTES:
1. MUST BE TIED TOGETHER AND TO GROUND AT ONE POINT IN POWER SUPPLY.
2. Maximum current requirements are for period $\leq$ 300 ms A defective cartridge can extend the maximum current periods
3. All voltages measured at drive power connector with drive in operation

Table 2-1 STREAMER POWER SUPPLY REQUIREMENTS

2.3.1 Power Transients

Power transients must not exceed the limits specified for the power requirements in Table 2-1. To avoid spurious input commands during power-on or power-off sequencing, the host must provide a fail-safe method of maintaining the drive in a non-operative state. Power to the drive should not be turned on or off with a cartridge installed in the useable recording area. Failure to observe this precaution may destroy previously recorded data. If the drive shares a common power supply with a disk, the system designer must be aware that large disk current surges could affect drive data integrity.

2.4 SIGNAL CONNECTIONS

2.4.1 Input/Output Signal Connector

Input/output signals interface with the Streamer through the edge connector (P1) on the PC board. Connector pin locations are shown in Figure 2-4. Maximum cable length from the connector is 25 feet (8 meters). The mating connector is a 50-pin edge-type 3M P/N 3415-001 or equivalent.

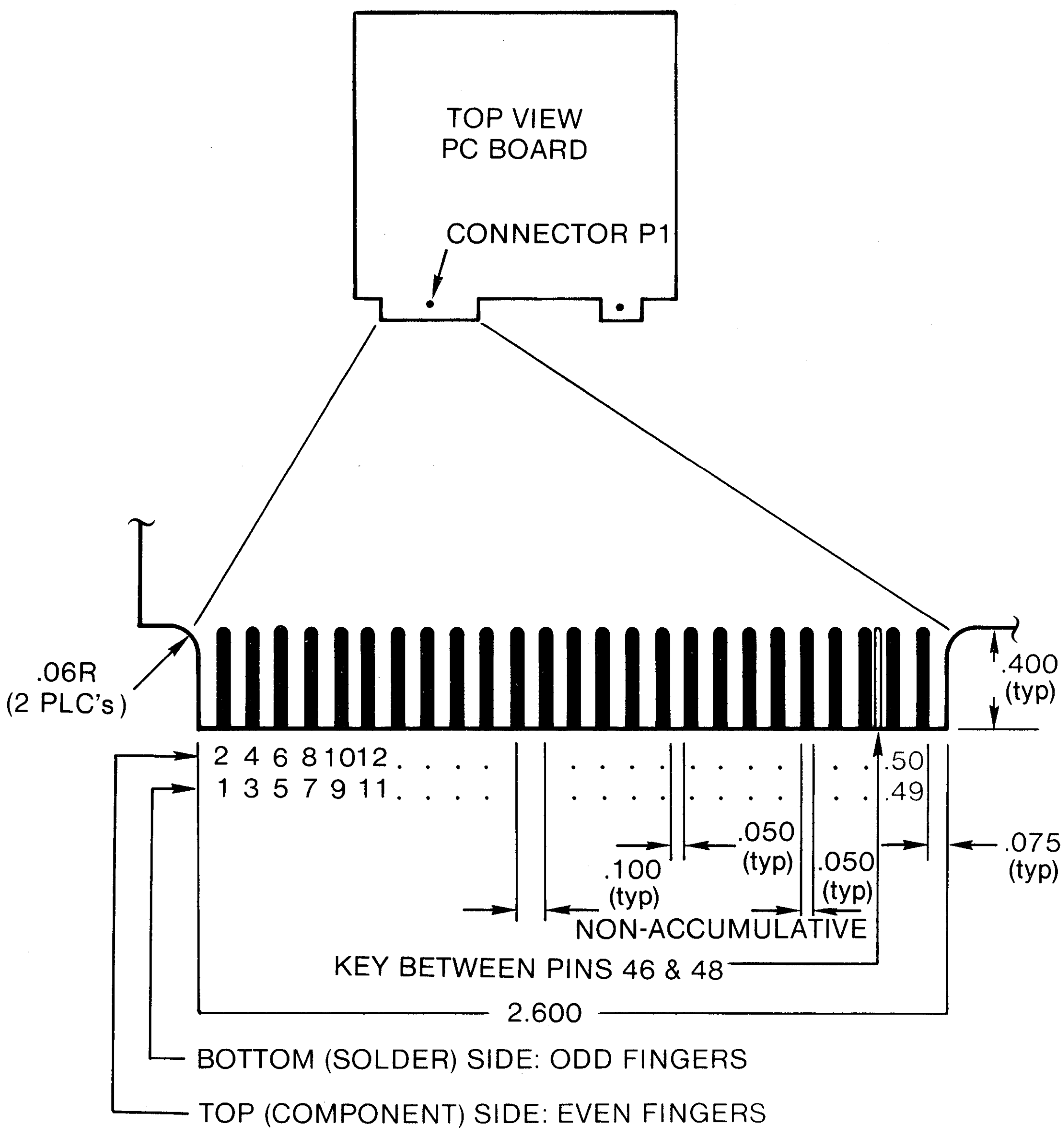


Figure 2-4 INPUT/OUTPUT CONNECTOR BOARD DETAIL

2.5 SIGNAL LINE TERMINATION

Input, output and data signal lines should be terminated as shown in Figure 2-5. Terminations shown are for 100 to 132 ohm cables.

2.6 MULTIPLE DRIVE APPLICATIONS

It is possible to connect up to four drives on a common bus cable. Proper line termination should be made at the last drive in the daisy chain only. All other line terminator IC's and discrete resistors used for line terminations should be removed.

2.7 CARTRIDGE LOADING, UNLOADING

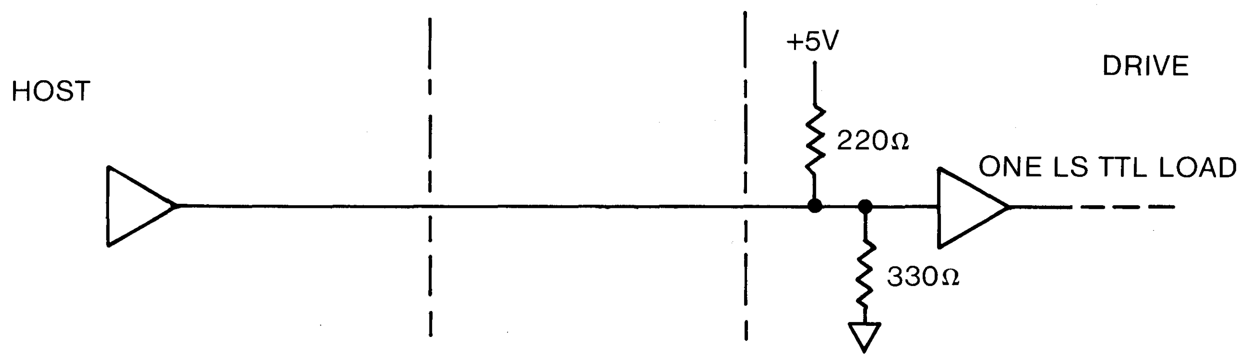
The cartridge is installed into the drive by positioning the cartridge at the drive entry opening and sliding forward until the cartridge is fully engaged. The pressure is released as the drive guides the cartridge into operating position. Loading and unloading mechanisms position the cartridge relative to the recording head to prevent damage to the cartridge.

The cartridge is removed from the drive simply by pulling it directly out from the drive housing.

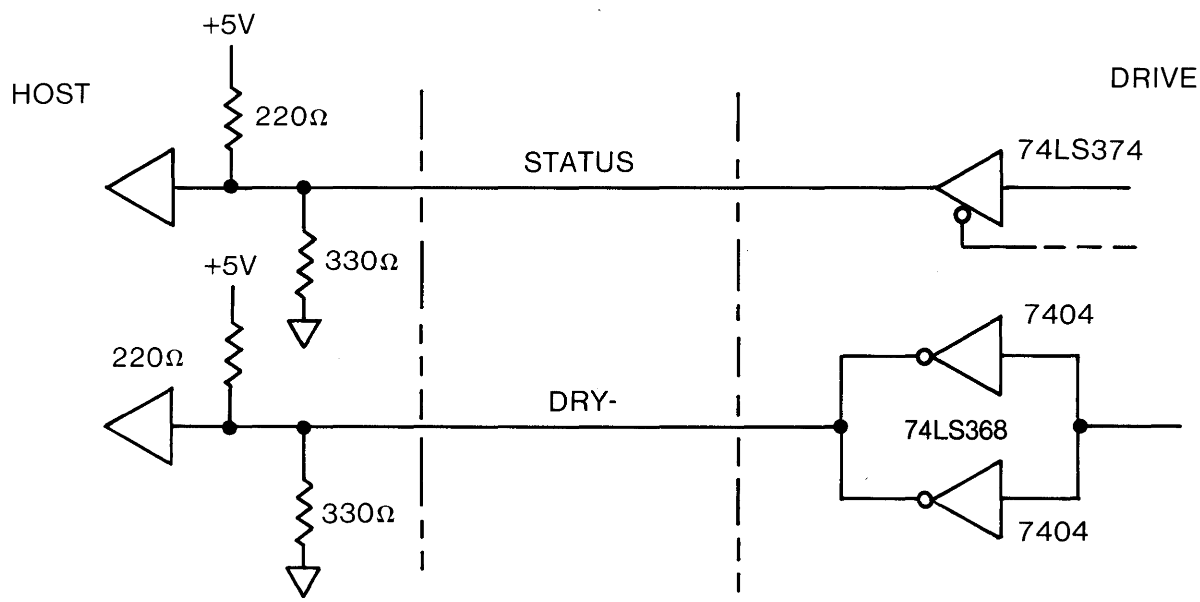
2.8 TEMPERATURE, COOLING

In general, no forced air cooling is required. The Drive can dissipate up to 90 watts under worst case (typical value: 50 watts), therefore sufficient free air flow is required to prevent the local ambient temperature from rising above 113°F (45°C) under operating conditions, otherwise forced cooling to achieve the operating temperature requirements should be supplied.

INPUT SIGNAL CONFIGURATION



OUTPUT SIGNAL CONFIGURATION



DATA SIGNAL CONFIGURATION

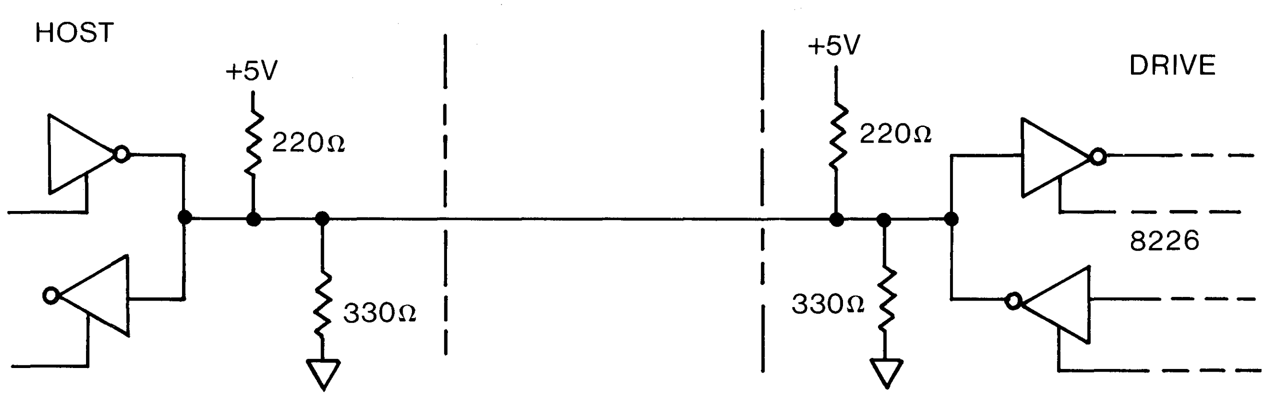


Figure 2-5 HOST, DRIVE INTERCONNECTION

SECTION 3 OPERATION

3.1 GENERAL OPERATION CONCEPTS

The communication interface, consisting of 23 I/O lines, between the drive and host are identified in Figure 3-1. Three types of communication exists:

- o commands from the host
- o status from the drive
- o data interface

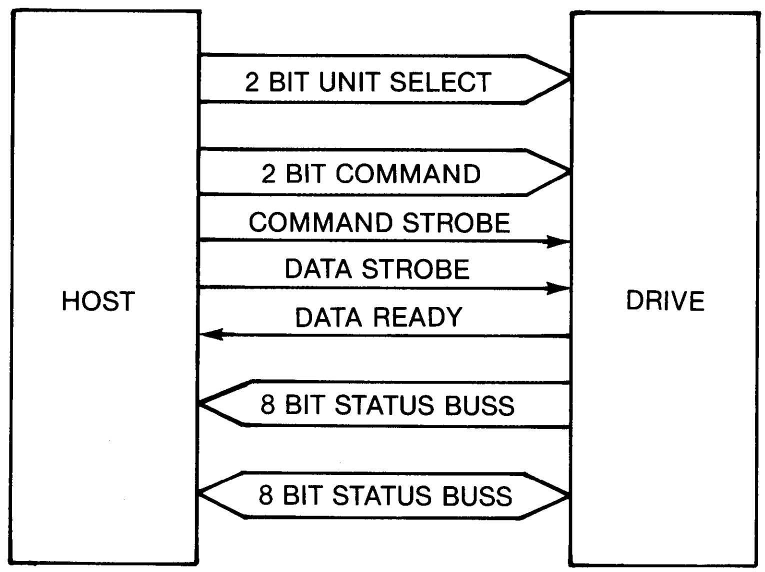


Figure 3-1 DRIVE HOST INTERFACE

The Streamer's microprocessor independently controls all real-time tape handling functions such as tape motion control, tape hole sensing, and tape positioning. The only commands required from the host are write, write tape mark, read, and reset.

Status information is continuously available to the host. Each of the eight lines represent a particular operation mode.

Data interface between the Streamer and host is just as simple. The eight-bit parallel data interface appears to the host as a FIFO memory unit, requiring no block-length restrictions. A pair of handshake lines between the Streamer and host ensures reliable data transfer.

3.1.1 Cartridge Operation

When properly engaged in the drive, the cartridge is securely held against a flat reference plane.

Writing new data on tape will require positioning the cartridge arrow in opposite direction from the SAFE position. After data is written on tape, the operator should secure written data by setting the arrow to the SAFE position. Refer to Figure 3-2 and inspect a cartridge for further information.

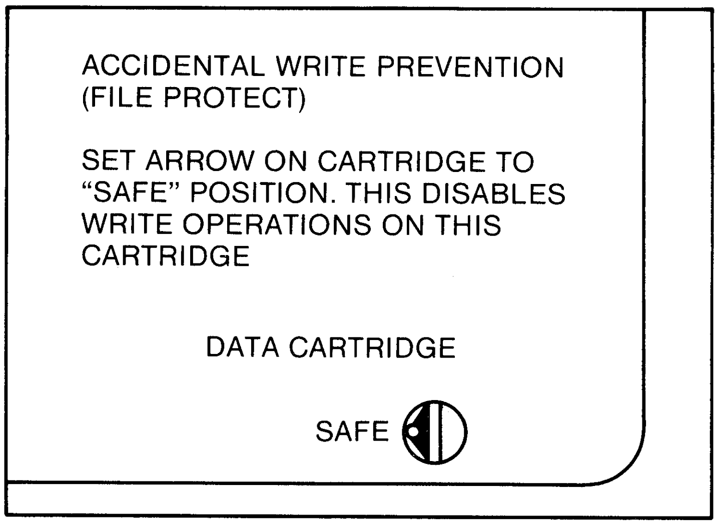


Figure 3-2 CARTRIDGE FILE PROTECTION

Write/and Erase current must pass through a micro-switch to the write head. The cartridge SAFE position does not allow the micro-switch to engage, thereby, protecting data on tape.

The SAFE position does not affect the Streamer READ operation, therefore, removing the cartridge from file storage and engaging into the drive will recall needed data.

3.1.2 Streaming Concept-Write Mode

Host data enters the drive buffer, byte-by-byte, as a result of handshake between the host Data Strobe (DSB) and the drive Data Ready (DRY). When the drive buffer is full, the drive interrupts by not issuing DRY. The controller now adds the block overhead characters and prepares the block for transfer via DMA Channel 1. Refer to Figure 3-3, Write Data Flow, below.

If DMA Channel 0 has started a byte-to-byte comparison on block N-1, the controller will access block N via DMA Channel 1 and send the block to the write circuitry. With DMA Channels 0,1 active, the drive issues DRY and data enters for construction of block N+1.

If DMA Channel 0 has not detected the start of block N-1, the controller looks for a rewritten block. If located, this block will be written in place of N. If a rewritten block is not located, the controller implements the write underflow routine.

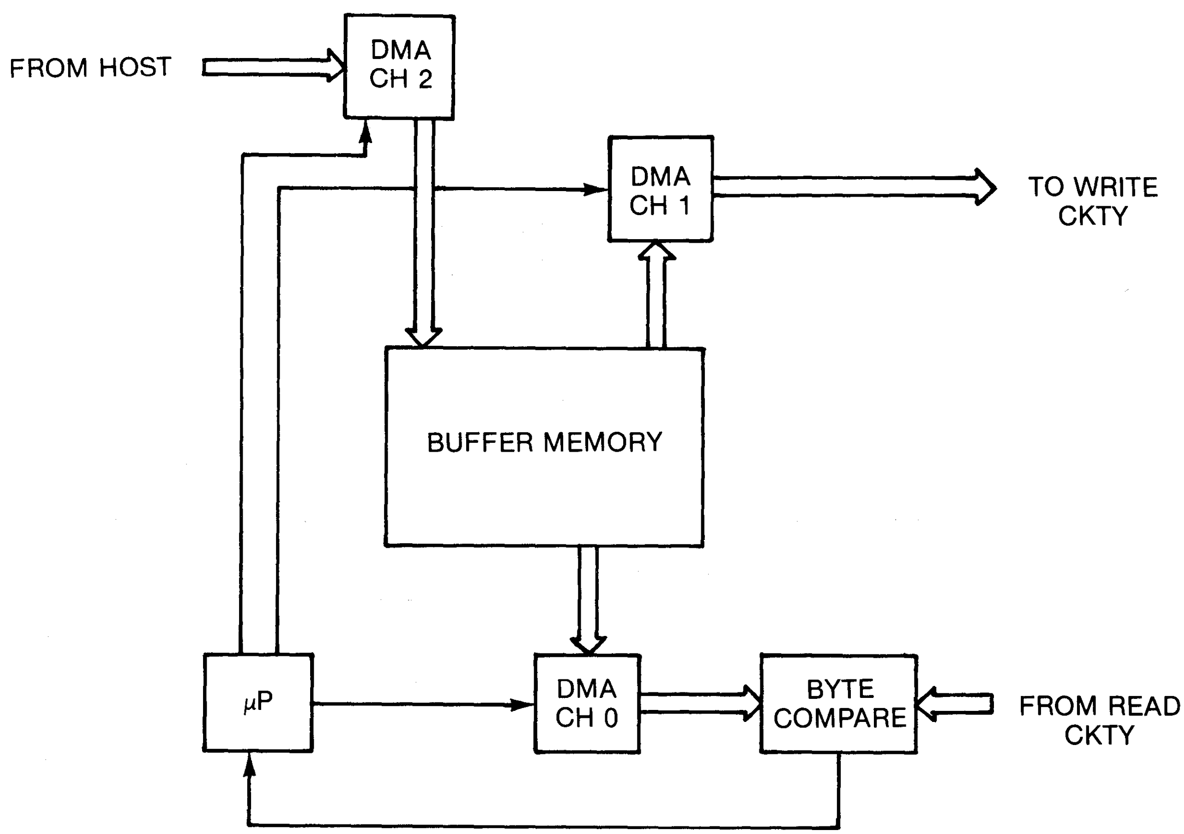


Figure 3-3 WRITE DATA FLOW

Streaming is a continuous write or read tape operation without write underflow or read overflow. Underflow will stop the tape motion, reposition the drive and continue only when the required data rate returns. Upon each underflow, the inter-block gap expands from the normal 0.35 inches to 0.70 inches. Table 3-1, Tape Capacity Reduction, indicates the loss of tape capacity as a function of small data record sizes. The table presumes a 90 ips drive with total capacity of 20 Mbytes.

Record Size (kbytes)	Tape Capacity Reduction (kbytes)
8	80
16	40
32	20
64	10
Streaming	0

Table 3-1 TAPE CAPACITY REDUCTION

Total transfer time is also affected. Table 3-2, Transfer Time illustrates approximate transfer times as a function of record size. The example presumes a 20 Mbyte, 90 ips, drive. Write operations are 2 minutes longer than read due to tape preconditioning. Tape preconditioning enhances data reliability.

Record Size (kbytes)	Transfer Time (Minutes)	
	Read	Write
8	55	57
16	29	31
32	17	19
64	10	12
Streaming	4	6

Table 3-2 TRANSFER TIME

3.1.3 Streaming Concept-Read Mode

Tape data flows through the drive FIFO buffer memory to the host via DMA Channels 0,2. The data moves, byte-by-byte, as the drive asserts DRY and the host acknowledges DSB. Refer to Figure 3-4, Read Data Flow, below.

As data enters memory, a CRC check is performed. When 952 bytes of data enter the FIFO, indicating a completed blockette, the controller interrupts the flow by delaying the next DRY. The controller then verifies the blockette number and looks for possible CRC, format, and overflow errors. If no problems are found, the controller issues DRY and the data continues, byte-by-byte, to the host.

If during interrupt, the controller finds a blockette number one (1) greater than expected or an error exists, the interrupt is delayed further while the tests are repeated. If the error repeats or a blockette number of two (2) greater than expected is discovered, the read error algorithm is activated.

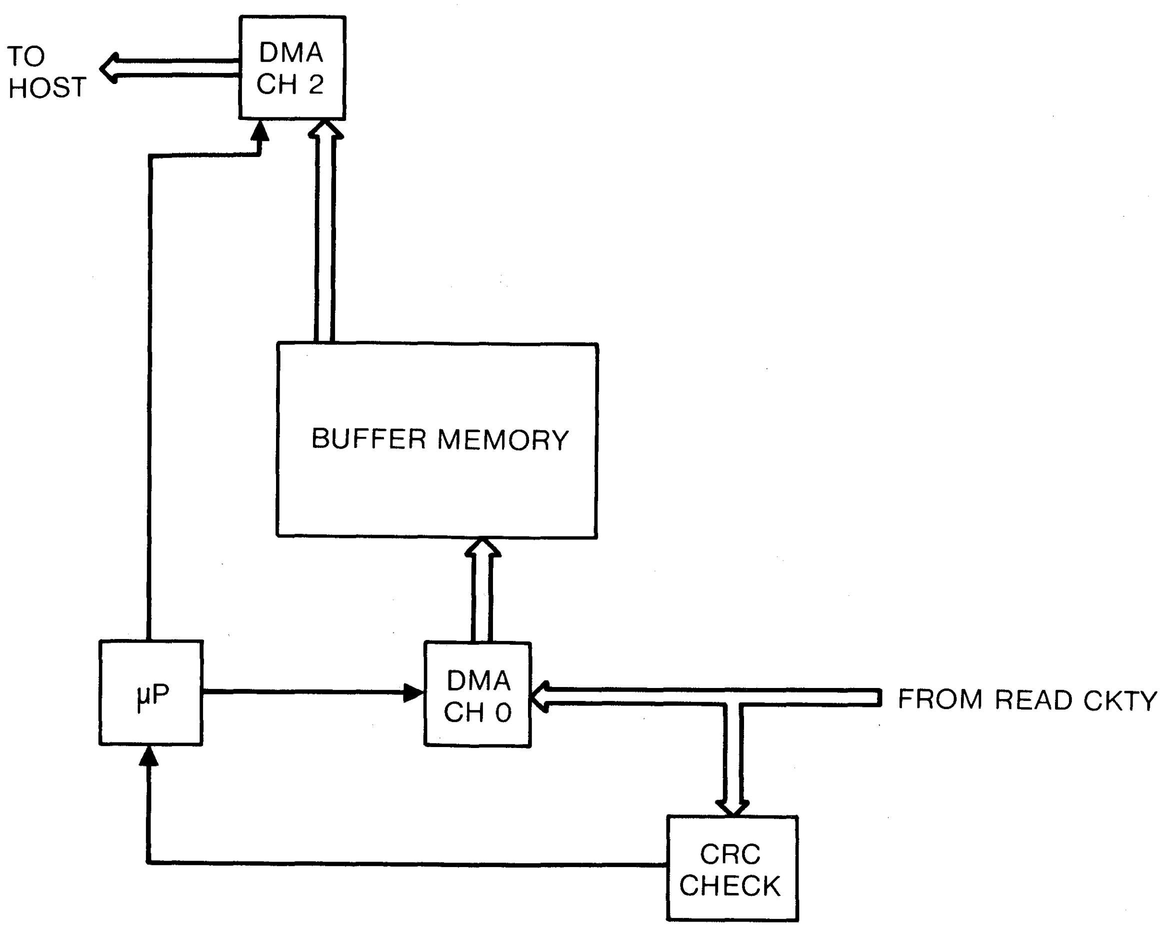


Figure 3-4 READ DATA FLOW

3.1.4 Data Underflow and Overflow

Data underflow and overflow are conditions in which the host is unable to maintain the Streamer's data rate. A write underflow occurs when the drive is ready to write another block of data, however, data is not available from the host. A read overflow occurs when the drive's buffers are filled with data read, another block is ready to be read, and the host is not ready to accept it.

When either a write underflow or a read overflow condition occurs, the drive must stop the tape, wait for the host to catch up, reposition the tape and start again. Since this process takes up to 1.2 seconds for a 90 ips drive and 0.8 seconds for a 30 ips drive, the host's time efficiency is reduced if streaming is not maintained.

In addition to loss of time, a write underflow condition results in loss of tape. Each time the write underflow repositioning is executed, the controller leaves a larger interblock gap on the tape.

As a result of these time and tape penalties, the Streamer attempts to keep the data buffers as full as possible during a write operation, and as empty as possible during a read operation. This keeps the drive streaming and reduces the chance of an underflow or overflow condition.

3.1.5 Host Adapter Hardware

A parallel input, output device such as the Intel 8255 is needed to handle twenty-three I/O lines. See Figure 3-1. The drive should be thought of as a hardware-driven device. Decoding circuitry is simple because each line is a separate function.

3.1.6 Software Driver

The software driver will require minimal effort as the drive is a hardware-driven device. The host communication is very fast requiring minimal host buss time-outs. Typical software loops utilized in the Programmed I/O Concept may be too slow for needed streaming data rates. Contact DEI, Application Engineering, for assistance in this area.

3.1.7 Disk Backup Considerations

The Streamer Cartridge Tape Drive can be a very effective disk backup device provided host data input rate becomes one of the major interface design considerations. This section covers the disk parameters that affect Streamer performance. The main objective is to prevent or at least minimize a data underflow condition to the Streamer.

A first look at a typical disk specification leaves the impression that the output data transfer rate is more than sufficient to support a streaming situation. A further look at Access Time, Latency Time and applications utilizing disk interleave and file management will temper the initial impression. Even in the disk Mirroring Mode, the interface designer must face data flow interruptions which potentially cause the Streamer to underflow.

A typical situation will find an interface designer working with a known disk, CPU, and application criteria. He should be aware of the general system concept relative to data movement. DMA and PIO concepts sharply differ. The DMA concept can handle a fast data stream, whereas, the PIO concept may require significant data buffering to meet the streaming needs. With all the interface parameters in perspective, the system designer can select an appropriate Streamer model. DEI Streamer Models come in 30 or 90 inches per second speeds. Contrary to popular belief, the 30 ips models, inputting data at slower rates, could provide the minimum disk backup time. This occurs when compared to a 90 ips model experiencing multiple underflow conditions causing the drive to constantly reposition.

In summary, when selecting a Streamer model the system designer must define and understand the following:

1. The particular disk, CPU.
2. The application - Mirroring, File Management, Disk Interleave.
3. The data transfer concept - PIO or DMA.

The discussion will now concentrate on understanding disk parameters. The objective is to define the actual Streamer input data rate.

A typical disk will rotate at 3600 rpm or 17 ms per revolution. Moving the disk head to a data track is known as Access Time. Access Time is typically the revolution time or, in this case, 17 ms. Being on track does not mean the data sector is immediately available. The maximum time to locate the needed data sector would again be one revolution or, in this case, another 17 ms. This time is called Latency Time.

In general, provided the application calls for removing data in a concentric track sequence, it appears the maximum data interruption would be 34 ms. As will be seen later, the actual maximum data interruption will exceed 34 ms. It also should be noted that the Access Time discussed above is for moving to the next adjacent track. If, as in the File Management Application, the disk head must access data several tracks away, the Access Time will greatly increase and consequent data flow will further be interrupted.

The Streamer interfaces to the disk output sector buffer - not the disk. Data loaded on disk is combined with overhead characters such as Error Correcting Characters, Header bytes, and Sync bytes. When passed through the sector buffer circuitry, these overhead characters are removed. Removal of these characters takes time. In general, a typical disk is 80 percent utilized for data - the remaining 20 percent for overhead characters. To the Streamer, this means sequential sectors on the same disk track will arrive with time interruptions. If a sector by sector handshake is part of a PIO concept, these time interruptions could be extended.

Data flow to the Streamer is interrupted by many sources; Access Time, Latency Time, and now sector-to-sector time. Additionally, as mentioned earlier, the type of application can have a large impact. The system designer must predict how much actual data will be released to the Streamer over some extended time frame. Then, considering all the interruptions, an average data transfer rate can be predicted. From this information the Streamer model can be selected.

Mirroring Mode essentially transfers sequential disk sectors track by track. This application minimizes the data flow interruptions. File Management typically seeks out particular data sectors on different tracks, sequences the information, and inputs data to the Streamer. This application causes significant data flow interruptions.

Disk interleave is used to improve data integrity recorded on disk. Disk interleave automatically places what was sequential data into sectors that could be one-half of a disk revolution away. When this data scheme is released to the Streamer, significant data interruptions occur while the disk head seeks each sector.

Knowledge of disk data interleave and how it is defined is very important. Definitions vary. IBM Interleave Factor 2 means that a 32 Sector disk will have 16 sectors separating data entered in sequence. This definition comes from dividing the total sector number by the interleave factor. IBM Interleave Factor 2 will add one-half of one disk revolution time to each sequential sector transfer.

The Shugart Associates SA1000 is presented as an example of disk parameters and how they interrelate.

Data Transfer Rate.. 543 kbytes/s

Acces Time, maximum (Full Stroke).............................. 150 ms

Access Time, average... 70 ms

Access Time, maximum (track-to-track)........................... 19 ms

Latency Time, maximum.. 19.2 ms

Latency Time, average... 9.6 ms

Bytes Per Track.. 10,400

Average Transfer Rate* .... 217 kbytes/s

Transfer Rate, Mirroring Mode.................... 200 kbytes/s, approx.

Transfer Rate, File Management Mode............... 40 kbytes/s, approx.

Interleave Factor 2 - Divide above transfer rates by 2.

*Average Transfer Rate results by taking a full track of data (10,400 bytes) and dividing it by the Latency Time plus Access Time plus Revolution Time and then reducing the quotient by 20% to allow for stripping of overhead characters.

From a practical standpoint, buffering is needed between the disk and Streamer. The system designer must determine buffer capacity. Buffering must have the capacity to assure streaming during disk data flow interruptions.

The DEI 90 ips Streamer can occasionally consume up to 140 kbytes/s of data. The greatest disk delay for the SA1000 would be the summation of the Full Stroke Access Time plus the maximum Latency Time or a total of 169 ms. To assure streaming during this rare event, 23,660 bytes (140 kbytes/s times 169 ms) of buffering would be needed.

The DEI 90 ips Streamer typically consumes 90 kbytes/s of data. A typical disk delay would approximate the maximum track-to-track access time plus the maximum Latency Time or 40 ms total. To assure streaming during this typical situation would require 3600 bytes of buffering. When using the DMA approach, 4 kbytes of buffering would, therefore, only cause a very occasional drive stutter. Buffering needs are also affected by software timing loops when using the PIO concept.

Another aspect of disk backup sometimes overlooked is that of CPU Bus Priority. During the streaming process, the drive requires top bus priority. The host, therefore, must be fast enough to process it's own needs without interrupting the Streamer. For this reason, backup is often accomplished in off-line mode.

It is apparent that significant study or knowledge is required to assure a streaming backup situation. One of the first considerations is understanding the CPU scheme of data transfer. Is the scheme PIO, DMA, or a combination concept? Next, the application is very important - Mirroring Mode, or File Management? Will the disk need to be interleaved? Then comes the careful study of disk parameters. The decision on buffer capacity is next. Should the buffer reside in the CPU or disk controller? And finally, the selection of the Streamer Model to minimize stutter operation and minimize the backup time for a given record length is necessary.

By reducing the number of data flow interruptions, the total disk backup time will be minimized. Figure 3-5 illustrates backup time as a function of tape speed and data record length.

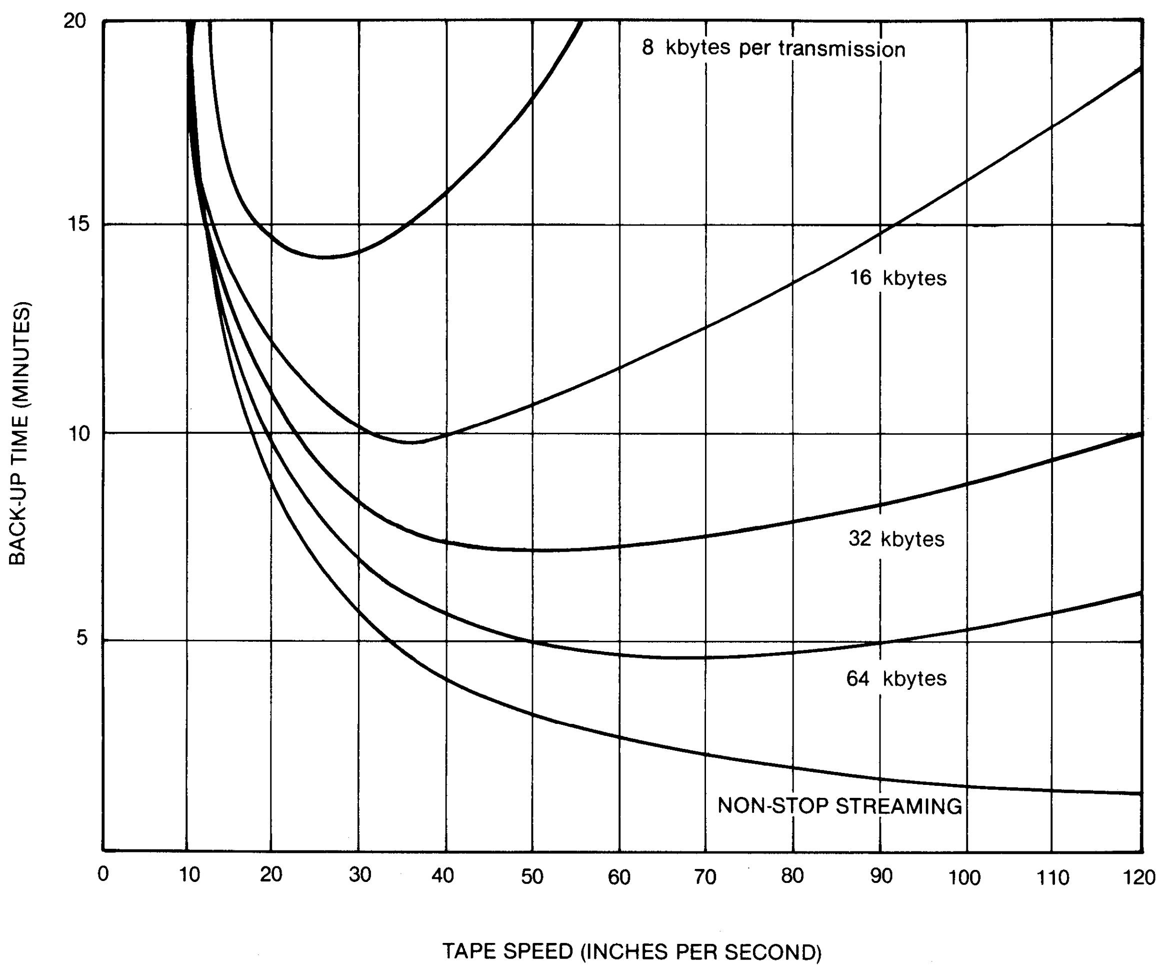


Figure 3-5: BACKUP TIME FOR 10 MBYTES OF DISK DATA VS TAPE SPEED AND DATA RECORD LENGTH

Note that a 90 ips Streamer will backup 64 kbyte record lengths in 5 minutes. Following the curve to the left, it is apparent that a 30 ips Streamer would not have been the best choice from this standpoint. If data record lengths are 16 kbytes, a 90 ips Streamer would add 5 minutes to the backup time over the properly chosen 30 ips Streamer. If 16 kbyte record lengths are required, a non-streaming drive could be considered. And finally, for 8 kbyte record lengths, the non-streaming drive is the best choice.

3.2 OPERATION DETAILS

This section elaborates on the operation concepts covered in Section 3.1. A step-by-step operation sequence is covered at the end of this section.

3.2.1 Input/Output Signal Descriptions

PIN	SIGNAL	FROM	COMMENTS
1	CSB	CONTROLLER	CONTROL STROBE
3	US1	CONTROLLER	UNIT SELECT
5	US0	CONTROLLER	UNIT SELECT
7	CB0	CONTROLLER	COMMAND BIT
9	CB1	CONTROLLER	COMMAND BIT
11	SLD	DRIVE	SELECTED
13	TMD	DRIVE	TAPE MARK DETECTED
15	ERF	DRIVE	ERROR FLAG
17	PRE/EOD	DRIVE	PRECONDITIONING/END OF DATA
19	ROM	DRIVE	READ ONLY MEMORY
21	EOM	DRIVE	END OF MEMORY
23	URY	DRIVE	UNIT READY
25	DIE	DRIVE	DATA IN ERROR
27	DA0	BIDIRECTIONAL	DATA BIT (LSB)
29	DA1	"	DATA BIT
31	DA2	"	DATA BIT
33	DA3	"	DATA BIT
35	DA4	"	DATA BIT
37	DA5	"	DATA BIT
39	DA6	"	DATA BIT
41	DA7	"	DATA BIT (MSB)
43	-	"	NOT USED
45	DSB	CONTROLLER	DATA STROBE
47	DRY	DRIVE	DATA READY
49	-		NOT USED

Table 3-3 INTERFACE CONNECTOR PIN ASSIGNMENTS

<table>
<tr><th>PIN</th><th>MNEMONIC</th><th>SIGNAL NAME</th><th colspan="5">DESCRIPTION</th></tr>
<tr><td>1
2</td><td>CSB-
CSBR</td><td>COMMAND
STROBE</td><td colspan="5">An input which causes the state of the input control signals to be executed by the drive.</td></tr>
<tr><td rowspan="4">3
4
5
6</td><td rowspan="4">US1
US1R
USO
USOR</td><td rowspan="4">UNIT SELECT
BIT 0
BIT 1</td><td colspan="5">Two inputs which will allow the host system to select between four (4) drives on a common buss. Each drive is equipped with two address switches allowing for selection of any unit address. See Figure 2.1 for location. The switch nomenclature and address are shown below:</td></tr>
<tr><td colspan="5">SWITCH ADDRESS</td></tr>
<tr><td></td><td>SW1</td><td>SWO</td><td>US1</td><td>USO-</td></tr>
<tr><td>1
2
3
4</td><td>ON
ON
ON
OFF</td><td>OFF
ON
ON
OFF</td><td>H
L
L
H</td><td>L
H
L
H</td></tr>
<tr><td rowspan="5">7
8

9
10</td><td rowspan="5">CBO
CBOR

CB1
CB1R</td><td rowspan="5">COMMAND
BIT 0

COMMAND
BIT 1</td><td>CB1-</td><td>CBO</td><td>SIGNAL NAME</td><td colspan="2">DESCRIPTION</td></tr>
<tr><td>H</td><td>H</td><td>Read</td><td colspan="2">Read mode command</td></tr>
<tr><td>H</td><td>L</td><td>Write-Data</td><td colspan="2">Write data mode command, only if drive is not in read only state.</td></tr>
<tr><td>L</td><td>H</td><td>Reset</td><td colspan="2">Reset command which caused the drive to return to beginning of memory.</td></tr>
<tr><td>L</td><td>L</td><td>Write-Mark</td><td colspan="2">Write a tape mark command which causes the drive to write a tape mark and signal success by setting TMD true when complete. Drive must not be in read only state. See Figure 3-18 for timing.</td></tr>
<tr><td>11
12</td><td>SLD-
SLDR</td><td>SELECTED</td><td colspan="5">A status output which indicates that the drive has been selected by the host system.</td></tr>
</table>

Table 3-4 INPUT/OUTPUT SIGNALS AND PIN ASSIGNMENTS
(Sheet 1 of 3)

PIN	MNEMONIC	SIGNAL NAME	DESCRIPTION
13 14	TMD- TMDR	TAPE MARK DETECTED	A status output which indicated a tape mark has been read.
15 16	ERF- ERFR	ERROR FLAG	A status output which indicates that the error correction algorithm is being used. The signal does not necessarily remain true for the entire duration of the algorithm. ERF will be asserted for 80 microsecond, minimum.
17 18	PRE/EOD- EODR	PRECONDITIONING/ END OF DATA	A status output which indicates that the drive is preconditioning tape or has seen the end of the recorded data.
19 20	ROM ROMR	READ ONLY MEMORY	A status output which indicates the cartridge installed can only be read (set by means of the SAFE plug in the cartridge).
21 22	EOM- EOMR	END OF MEMORY	A status output which indicates that less than 952 bytes of storage space remains in the memory during a write operation, and that the end of memory has been reached in a restore operation.
23 24	URY- URYR	UNIT READY	A status output which indicates that drive power has been applied, a cartridge has been installed, and the drive is ready to accept commands.
25 26	DIE- DIER	DATA IN ERROR	A status output which indicates the data being sent from the drive has not been recovered correctly but is being transmitted. This signal will remain true during all of the error data transmission. In the write mode, the signal indicates the data cannot be recorded within proper error correction tolerances and the write operation has been aborted. The cartridge is to be replaced to restore normal operation.

Table 3-4 INPUT/OUTPUT SIGNALS AND PIN ASSIGNMENTS
(Sheet 2 of 3)

PIN	MNEMONIC	SIGNAL NAME	DESCRIPTION
27 28	DA0 DA0R	L.S.B	
29 30	DA1- DA1R		
31 32	DA2- DA2R		
33 34	DA3- DA3R	DATA	Eight bidirectional signals which are used to communicate data to or from the drive. In the Read mode these are outputs and in the Write mode, inputs. The level convention is '0' high and '1' is low.
35 36	DA4- DA4R		
37 38	DA5- DA5R		
39 40	DA6- DA6R		
41 42	DA7- DA7R	M.S.B	
43 44	M.N.E.C.		
45 46	DSB- DSBR	DATA STROBE	An input signal that indicates to the drive that the host has a byte of data ready for transmission (write mode) or that the host has accepted a byte of data (read mode). The first falling edge shall be a start signal to the drive in the write mode, the read mode shall commence as directed. For timing, See Figure's 3-15, 3-16, 3-17.
47 48	DRY- DRYR	DATA READY	An output signal that indicates the drive has accepted a byte of data (in write mode) or that the drive has a byte of data ready for transmission (read mode). For timing see Figures 3-15, 3-16, 3-17.
49 50	M.N.E.C.		

R = Denotes the respective return wire.
All other Pins = Make no external connections.
M.N.E.C. = Make No External Connection.

Table 3-4 INPUT/OUTPUT SIGNALS AND PIN ASSIGNMENTS
(Sheet 3 of 3)

3.2.2 Data Signal Parameters

All drive input, output and data signals (DA0 through DA7) conform to the requirements shown in Table 3-3. (All measurements made at the drive input/output connector).

PARAMETER	REQUIREMENT
True State (Low)	-0.5 to 0.8 VDC (noise inclusive)
False State (High)	2.2 to 5.2 VDC
Low Level Drive Input Current	$\leq$ -23 mA (typical)
Low Level Drive Output Current	$\geq$ +24 mA
Termination	Characteristic impedance is 132 ohms. A 220/330 ohm termination is installed on the host for all signals and also on the drive for input and data signals. (see Figure 2-4 for typical interconnections with the host).

Table 3-5 INPUT, OUTPUT AND DATA SIGNAL REQUIREMENTS

3.2.3 Signal Line Termination

Input, output and data signal lines are terminated as shown in Figure 2-4. These are the recommended signal terminations for 100 - 132 ohm cable. Daisy chain operation requires that all terminators be removed except the last drive in the chain.

3.2.4 Write Operation

Writing data to tape requires successful completion of the Power-Up Sequence followed by a host write command. The actual step by step Power-Up Sequence is covered in Section 3.2.9. The Write Command Sequence is covered in Section 3.2.10. Write Operation also relates to conditions present in the cartridge. Refer to Section 3.1.1 to understand how the write head current is asserted.

A continuous write operation requires that the host supply data at a minimum rate specified for the particular drive. If minimum data rates are not supplied, the drive will stop, reposition, and wait for new data. Interblock gaps are extended during each interruption (stutter) and both tape capacity and backup time suffer. Refer to Section 3.1.7 to assure optimum performance during a write operation.

After completion of the Power-Up sequence and the automatic two minute tape-retensioning routine, data can enter the drive from the host. Data block size is of no consequence as the drive input is configured as a FIFO memory. The drive data consumption varies inversely on how busy the microprocessor is with related activity such as structuring data block overhead characters and implementing an error recovery algorithm. Initially, the buffer memory will load very fast with up to a 2.2 microsecond per byte transfer rate. Then during the streaming operation, data consumption will vary between 4-7 microseconds per byte for the 90 ips drive.

The drive buffer memory is configured as a DMA-controlled byte parallel 2kx8 RAM. While in communication with the microprocessor, the DMA circuit uses three bidirectional channels into buffer memory. The three channels process data to and from the host, send write data to tape, and receive read data from tape.

Data arriving the buffer memory is segmented into blocks, overhead characters are added, and the combination is readied for encoding. Upon microprocessor command, the byte parallel data block passes through a eight-to-four bit conversion and a four-by-five GCR recording code is generated. A one's intensive GCR code is used because it's data bandwidth is separated from the drive flutter bandwidth. This code has a low sensitivity to bit patterns and therefore a greater recovery potential from media dropouts.

Data now moves in a steady serial stream to the write head. A flux reversal at the Write Head indicates a one. Zeros do not cause a flux reversal. As data is recorded on tape, a byte to byte comparison is made with the Read Head. The objective of read after write is to evaluate media performance. If written data is not verified, the block will be rewritten up to eight times before the write process is aborted. During the rewrite process, the Streamer firmware incorporates the choice of three (3) write thresholds. The algorithm is automatic and transparent to the user. Data is not released from the write FIFO until verified, however, data block N+1 is written before data block N is fully verified. This procedure is implemented for maximum tape capacity.

At 90 ips, the drive requires approximately 11 ms to write one block to tape. The Write to Read Head gap represents an approximate 3.3 ms delay at 90 ips, therefore, about 30% of data block N is yet to be verified when the writing of data block N+1 starts. If an error is detected in data block N before data block N+1 is written, data block N will be rewritten. If an error is detected in data block N after data block N+1 starts writing, N+1 will be written and verified followed by data block N being rewritten and verified. The latter situation results in data blocks existing out of sequence on tape. Because each block is numbered, the microprocessor can later identify and ignore redundant blocks. Section 4.6.1 and Figure 4-4, Write Mode Error Rewrites, provides additional information on rewritten data blocks.

A write underflow can occur when the drive is ready for data, however, no data is available from the host. To minimize this situation, the Streamer firmware will keep the FIFO memory as full as possible with data. The underflow routine repositions the drive and the controller leaves a large interblock gap on the tape. Streaming will result in interblock gaps between .027 and .035 inches, whereas, an underflow will leave an approximate .070 inch interblock gap.

Data is written between Load Point (LP) and Early Warning (EW) tape holes. Upon encountering the logical EW on the last track, the drive will typically write one more full block of data. If EW is encountered while a block is being transferred from the host, this block along with one other block will be written. The host then issues a reset command and the drive rewinds to BOT.

3.2.5 Read Operation

Reading data from tape previously recorded requires successful completion of the Power-Up Sequence followed by a host read command. The actual step by step Power-Up Sequence is covered in Section 3.2.9. The Read Command Sequence is covered in Section 3.2.11. Read operation is also affected by conditions present in the cartridge. A discussion relative to assurance that the write current is disabled is covered in Section 3.1.1 It is recommended that the host successfully read the ROM status line. ROM in the true state assures the cartridge is in the SAFE mode.

Continuous read operation requires that the host be capable of receiving the required data rate specified for the particular drive. Streaming requires top host bus priority, therefore, the host must be fast enough to manage its own needs without interrupting the Streamer. If the required data rate is not supplied, the drive will stop, reposition and, wait for new data. Interblock gaps are extended during each interruption, therefore, tape capacity is reduced. Continuous streaming operation will be interrupted if the host cannot accept at least 100 kbytes per second - 90 ips or 30 kbytes per second - 30 ips.

Having completed the requirements stated in paragraph 1 above, the host must assert the Read Command Bit and Command Strobe. The drive will acknowledge and the drive will start streaming. Additional details can be found in Section 3.2.11, Read Commands Sequence, Flowchart.

Data blocks exiting from tape first enter the data separator. This section separates the overhead characters, performs a five-by-four GCR decoding, and a four-to-eight bit conversion. This process prepares byte parallel data for loading into the drive FIFO memory and, upon controller command, transmitted to the host.

The FIFO memory is a DMA-controlled 2kx8 RAM. The RAM capacity is sufficient to retain block overhead characters now separated from the blocks. Before data block transfer to the host, the controller evaluates the overhead characters, byte by byte, for integrity. The block check character is analyzed and a search is made for possible format error or block overflow. The block number is also evaluated relative to block numbers previously processed. The reason for evaluation of the overhead characters is to implement the error recovery algorithm, as required.

Upon successful evaluation of the overhead characters, the block is loaded into the FIFO being readied for transmittal to the host. Then, upon controller command, the data block moves to the host. Since overhead characters for this particular block are no longer needed, they are erased from RAM in preparation for the next overhead character. Handshake communication between the host and drive is required for each transfer. Section 3.2.11, Read Command Sequence, Flowchart, details the step-by-step handshake.

Evaluation disapproval of overhead characters means additional processing activity will be needed before transmittal to the host. In general, two types of activity can occur. First, data blocks rewritten during the write operation can be out of sequence. These blocks must be found, manipulated into correct order, and transmitted to the host without redundancy. Second, data blocks that appear to be missing will require a search for duplicates and possible use of the read recovery algorithm. Most rewritten data blocks are marginally accepted during the write operation. However, they are recoverable during the read process. The reason for successful recovery is due to the use of lower thresholds during the read operation.

The read error algorithm is used when rewritten blocks are not recoverable and duplicate data blocks cannot be found. A Cyclic Redundancy Check Character (CRCC) technique is used to evaluate the data block. If the data block fails the CRCC test, the controller looks for a rewrite of the data block by processing subsequent data blocks - each time keeping track of block numbers. If a data block with a block number two (2) greater than the block in question is encountered, the read error recovery algorithm is asserted. The algorithm sequence follows:

1. The block is reread twice at the nominal read threshold.

2. The threshold is lowered and the block is again read.

3. The threshold is raised to a higher than normal level and the block is again read.

4. If the block is not recovered, the tape is retensioned. The controller moves the tape to logical EW setting an error flag status; then back to logical LP; and once again forward to the data block. Here the block is read again at nominal read thresholds.

5. If the block is still in error, the Data In Error (DIE) host status line is asserted and fill data is transmitted to the host. The DIE signal is active throughout the transmission of the dummy block. The controller always transmits a full block using fill characters.

Should any step of the above procedure correctly read a data block, the algorithm is immediately abandoned for the normal read operation.

Read buffer overflow ocurs when the host is not able to maintain the data rate being transmitted from the drive. When overflow occurs, the drive ramps down to a stop, ramps up in reverse, runs for several milliseconds, and ramps down again to a stop. If, at this time, the host has not emptied all data from the buffer memory, the Streamer waits until it does so. When it has, the drive ramps up again going forward, searches for the point where the overflow occurred and continues normal operation. The host system designer should assure that the host keep the Streamer buffer memory as empty as possible during read operation.

Read termination typically results when the Preconditioning/End of Data (PRE/EOD) signal is transmited to the host. This status is asserted when the drive encounters four (4) inches of blank tape. A minimum of ten (10) inches of blank tape is present before EOT tape holes. At this time, the drive ramps down to a stop and waits for either a Reset or Write command. Reset asserts the end of the read operation, whereas a Write command indicates use of the append operation sequence. Refer to Section 3.2.7 for detailed discussion on append operation. Read termination can also occur anytime the host issues a reset command.

3.2.6 Tape Mark

A tape mark may be written anytime during the write mode. To preserve tape capacity, one bit of the block header is reserved for the tape mark. When the tape mark is asserted, the block in process becomes a partial block with filler bits inserted, as required. Additionally, an approximate one (1) second delay interrupts the streaming process while the drive repositions and automatically returns to write data mode. The host is advised that a tape mark has been written via the drive Tape Mark Detected (TMD) status output. This status output is typically available to the host thirty (30) ms after the tape mark is written.

Writing a tape mark, in general, requires that the host disable the Data Strobe (DSB), set the proper Command Bits, assert the Command Strobe (CSB), and wait for the Tape Mark Detected (TMD) status signal. A tape mark is not automatically written upon termination of the Write Operation. The step by step timing requirements when writing a tape mark are covered in Section 3.2.12. An understanding of the Tape Mark Bit and its relationship to the block header is covered in Section 4.4, Tape Data Record Format.

The detection of a tape mark during read mode does not automatically stop the drive. The host can, however, stop the read process upon reaching a particular tape mark. Normal handshake operation continues until a tape mark is detected.

In the read mode, the TMD status signal may become true anytime during the processing of a block containing a tape mark. The pulse width of TMD varies inversely with the number of data bytes within the block. For example, if the data block is near full capacity, the TMD width would be very narrow. Minimum width would approximate 400 microsecond, 90 ips and 1.2 ms, 30 ips. Maximum width would approximate 10 ms, 90 ips and 30 ms, 30 ips. When a block contains data, TMD will be asserted within 140 microsecond after the last data byte is transferred to the host. If a block contains no data, the TMD will be asserted within 1.0 ms of the time at which a transfer would have occurred had data been present.

During the TMD signal detection, the drive disables the Data Ready (DRY) signal indicating to the host that no valid data is available. When the TMD signal returns to a false state, the drive sets the DRY true once again and normal read operation continues. The host may choose not to accept the data.

If the host has been accepting a data transfer rate greater than or equal to 100 kbytes per second, the drive will continue the read operation without a repositioning interruption. The host system designer should assure that the host keep the Streamer buffer memory as empty as possible during read operation.

3.2.7 Append Operation

The Streamer will allow new data to be appended to existing tape data. To perform this function, the cartridge must enable Write Operation. See Section 3.1.1 for further information, if required.

To perform the Append Operation, the host sets the appropriate Command Bit for Read Operation, issues the Command Strobe (CSB), and waits for the PRE/EOD status signal. When PRE/EOD is reached, the host sets the appropriate Command Bit for Write Operation and issues the Command Strobe (CSB). The new data can be appended up to End of Memory (EOM).

When the Streamer is in the Read Mode and PRE/EOD is reached, the drive will automatically stop. When the drive starts again appending new data, an expanded gap of approximately 0.07 inches will exist. Figure 3-6 illustrates a detailed flowchart of the Streamer Append Operation. The flowchart assumes successful completion of the Power-Up Sequence as covered in Section 3.2.9.

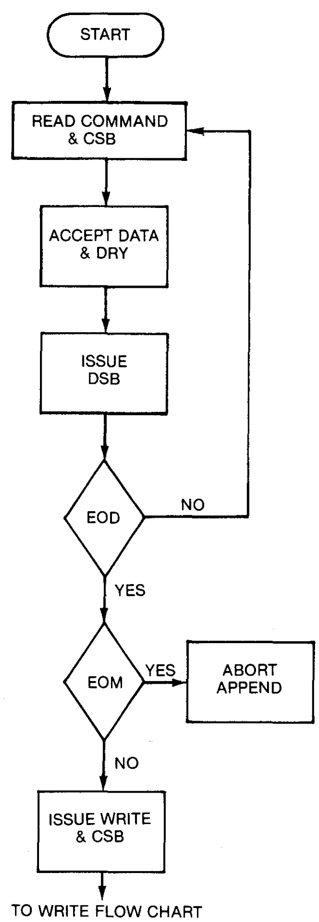


Figure 3-6 APPEND FLOW CHART

3.2.8 Repositioning Operation

The Streamer drive will stop and reset tape adjusting to a write underflow or a read overflow condition. Each time the repositioning routine is executed, the controller leaves an interblock gap of approximately 0.07 inches. Figure 3-7 illustrates the repositioning cycle.

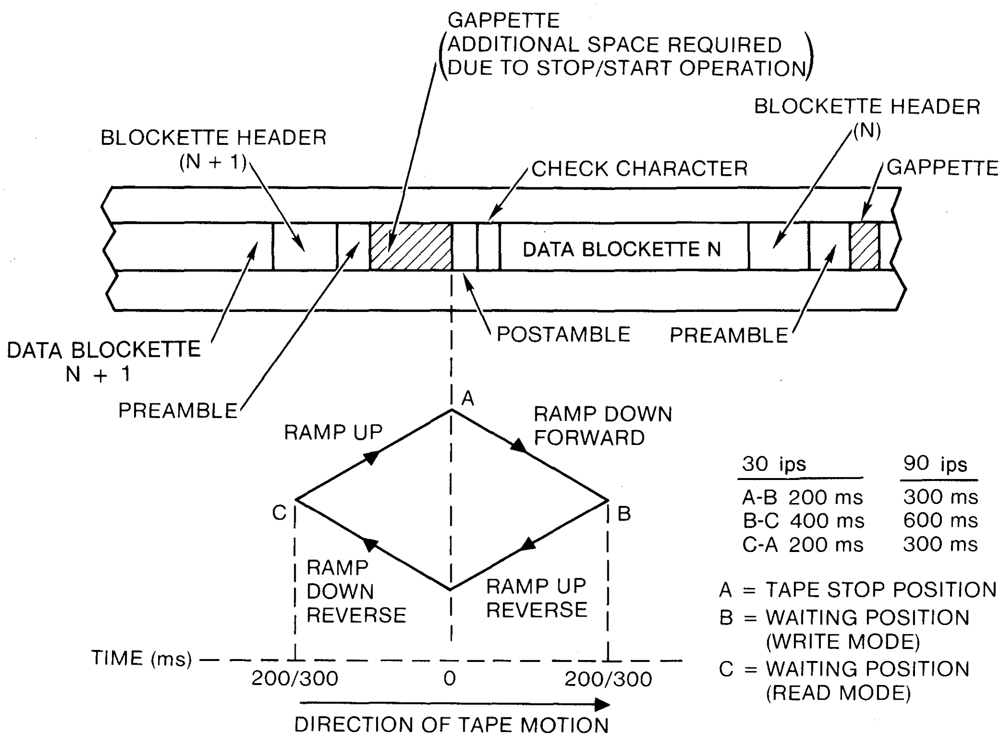


Figure 3-7 REPOSITIONING CYCLE

Ramp times vary from drive to drive and are typically less than those stated above. Ramp times are also affected by variations in cartridge tape tension. The host system designer should assure data transfer rates are sufficient to minimize repositioning cycles. Repositioning reduces tape capacity and increases the data processing time.

3.2.9 Power-Up Command Sequence, Flowchart

This section describes the event sequence that take place prior to the host selection of a particular command such as Write or Read. A flow chart, Figure 3-8, provides additional details. The host and drive interact as follows:

1. Having applied power, the drive first performs a check sum test. The controller, RAM, EPROM's, and DMA activity is verified for proper operation. This test is completed within one second.

2. With an Unsafe cartridge, the drive next performs a write test several times between BOT and LP. This test is completed within 10 seconds. If the cartridge is in the Safe position, this test will be preempted and the drive will move immediately to BOT.

3. The host is now allowed to select the drive. A discussion relative to drive selection and the required address switching is covered in Table 3-2. Setting of two (2) bits is required (US0, US1). Physical location of the address switches is shown in Figure 2-1. Selection of the drive does not require a host Command Strobe (CSB).

4. The host can now perform a status interrupt to assure the following:

    a. Selected (SLD) and Unit Ready (URY) for a cartridge in the Safe position or

    b. SLD, URY, and Read Only Memory (ROM) for a cartridge in the Unsafe position.

5. The host can now assert the particular command desired.

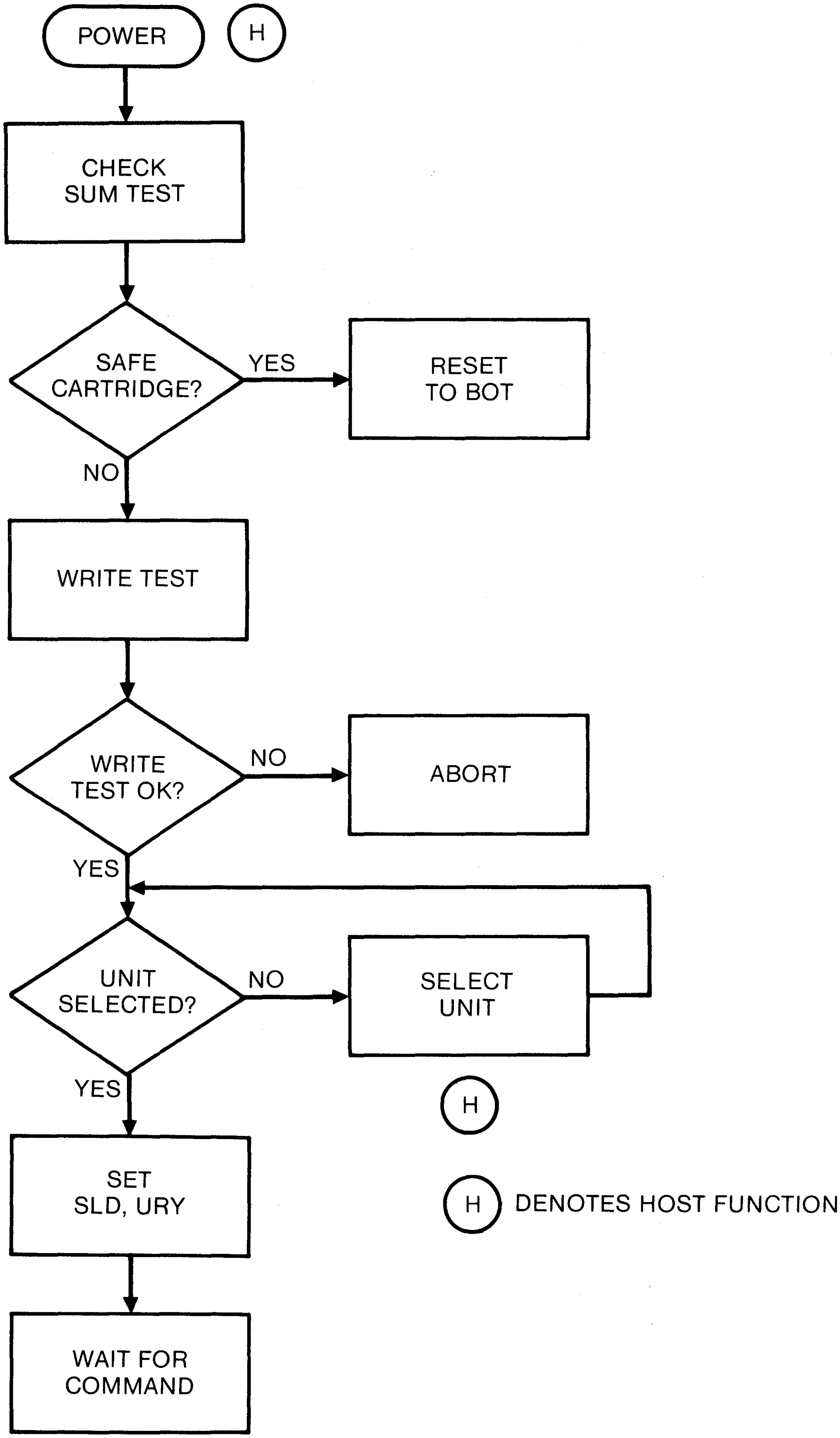


Figure 3-8 POWER-UP SEQUENCE FLOWCHART

3.2.10 Write Command Sequence, Flowchart

The Power-Up Sequence, Section 3.2.9, should be reviewed prior to studying this section. Figure 3-9, Write Operation Flowchart, can be reviewed in conjunction with this discussion. Before asserting the Write Command Sequence, the following conditions are necessary:

1. Cartridge must be in the Unsafe position.

2. Drive must have passed the Write test between BOT and LP.

3. The drive must be Selected (SLD).

4. Drive should be ready, that is, URY status asserted.

5. ROM status should not be asserted.

6. The drive should be waiting at BOT.

Providing the above conditions are met, the following two sequential events take place:

1. The host first sets the appropriate Command Bit (CB0, CB1) for Write and asserts the Command Strobe (CSB).

2. The drive now automatically performs a two (2) minute tape cartridge preconditioning routine. Tape will move from BOT to EOT and back to BOT.

During preconditioning, the tape is erased, retensioned, cleaned, and speed monitored. SLD, URY, and PRE status remain asserted. No data will be accepted and the drive will only react to a host reset command. Both the 90 ips and 30 ips drives are preconditioned at 90 ips.

With the preconditioning complete and the drive waiting at BOT, the following illustrates a continuation at the drive/host interaction. Times specified are for the 90 ips drive. Times are proportionally lengthened for the 30 ips drive.

1. The host sets the data bits (DA0-DA7) and asserts the Data Strobe (DSB). Upon receipt of each byte, the drive will assert Data Ready (DRY). This process continues, byte by byte, until drive buffer memory is filled. Approximately 4-7 microseconds per byte is needed during the streaming process.

2. As the host loads the drive buffer memory, the drive speed ramps up from BOT. Just after passing the LP tape hole, the controller assures that proper tape speed exists and, thereby, starts writing data to tape. The approximate time used between BOT and tape data written is 700 ms for a 90 ips drive and 1.3 seconds for the 30 ips drive. The drive will continue writing data in track sequence of 0,1. For a 20 Mbyte drive, the head moves and data continues on track 2,3.

3. The drive controller segments data into 952 byte blockettes, adds the needed overhead characters, and sends the blockette on for additional processing prior to being written on tape. The data block typically spends 11 ms in buffer memory. Providing EOM is not asserted, the host can continue the handshake as discussed in step 1 above. The host must fill the empty buffer within 7.1 ms to assure streaming operation.

4. Several conditions will stop the write process as follows:

    a. The tape fills to EW. Upon encountering EW, the drive will typically write one more full block of data. The host then issues a reset and the drive rewinds to BOT.

    b. The host stops sending data. This causes the drive to go into the write underflow routine. In this case, the drive will reposition and wait at some mid point of the cartridge.

    c. Data In Error (DIE) status asserted. This indicates that the Write process has been aborted, usually because of defective media.

    d. An arbitrary reset command from the host.

    e. An illegal read command from the host.

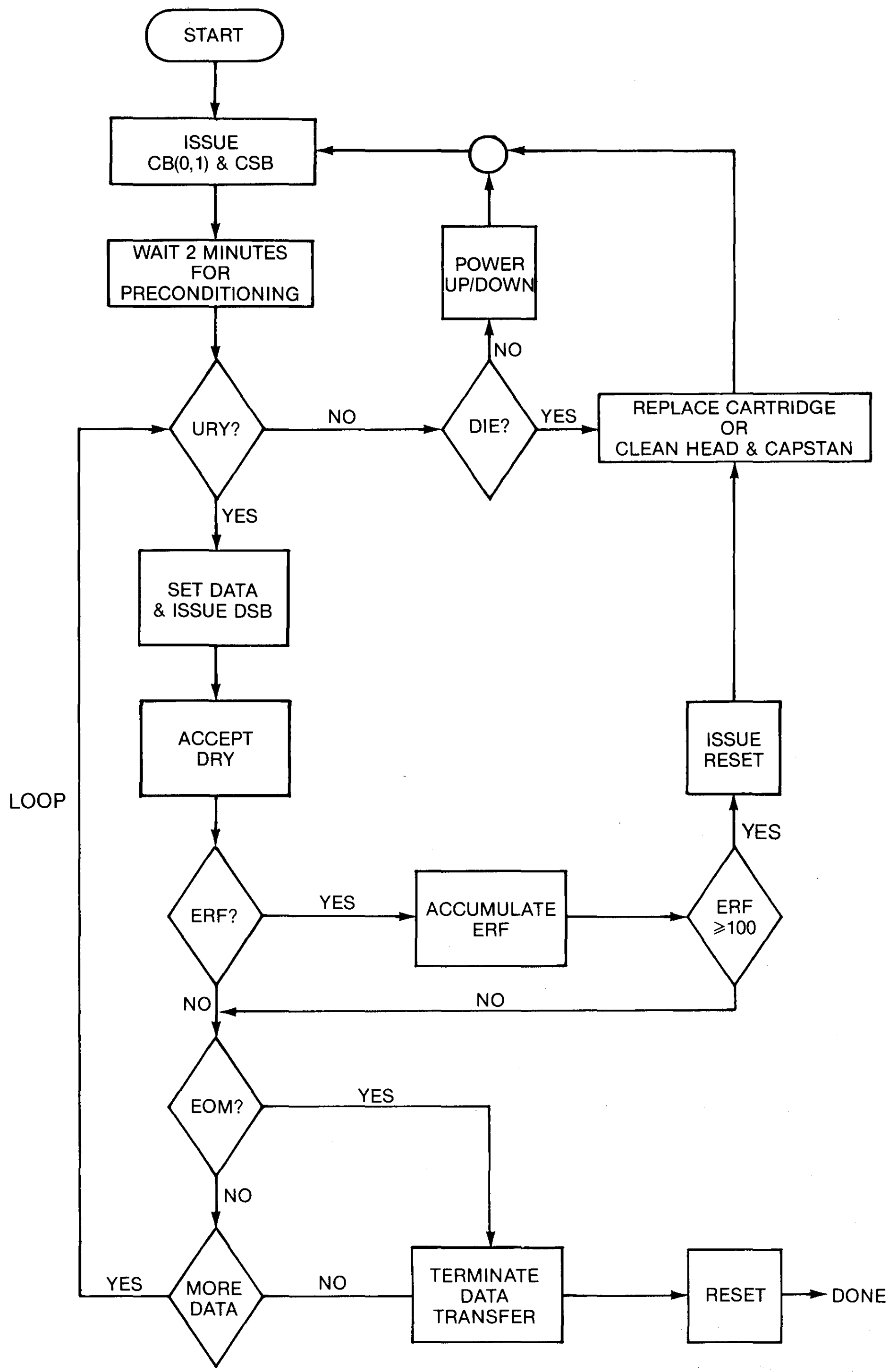


Figure 3-9 WRITE OPERATION FLOWCHART

3.2.11 Read Commands Sequence, Flowchart

The Power-Up Sequence, Section 3.2.9, should be reviewed prior to studying this section. Figure 3-10, Read Operation Flowchart, can be reviewed following this discussion. Before asserting the Read Command Sequence, the following conditions are necessary:

1. Drive Selected (SLD) asserted.

2. Unit Ready (URY) asserted.

3. Drive at BOT.

4. Read-Only-Memory (ROM) assertion is recommended.

Provided the above conditions 1 through 3 are met, the following sequenced events take place:

1. Host sets the appropriate Read Command Bit (CB0, CB1) and asserts the Command Strobe (CSB).

2. The drive ramps up in speed from BOT. Just after passing LP, the controller assures that proper speed exists and then asserts Data Ready (DRY). The time consummed between BOT and assertion of DRY is typically 300 ms - 90 ips drive and 100 ms - 30 ips drive.

3. The host then acknowledges DRY and asserts Data Strobe (DSB).

Prior to transmission of each byte, the drive will assert DRY. Additionally, the host will acknowledge DRY and assert DSB.

To assure a read streaming situation, the host's maximum process time per byte must be 10 microseconds for a 90 ips drive and 30 microseconds for 30 ips drive. The host should rapidly acknowledge DRY and assert DSB to prevent a read overflow. If the drive buffer memory overflows with tape data, the drive will reposition and wait for the host assertion of DSB.

During the read streaming process, the byte to byte time interval of DRY will vary. The reason for this is that the drive controller must manipulate rewritten blocks into proper sequence and ignore redundant blocks. Also, blocks that appear to be missing will require a search for duplicates or a need to activate the read error recovery algorithm. A discussion regarding rewritten blocks and the read error recovery algorithm is covered in Section 3.2.5, Read Operation.

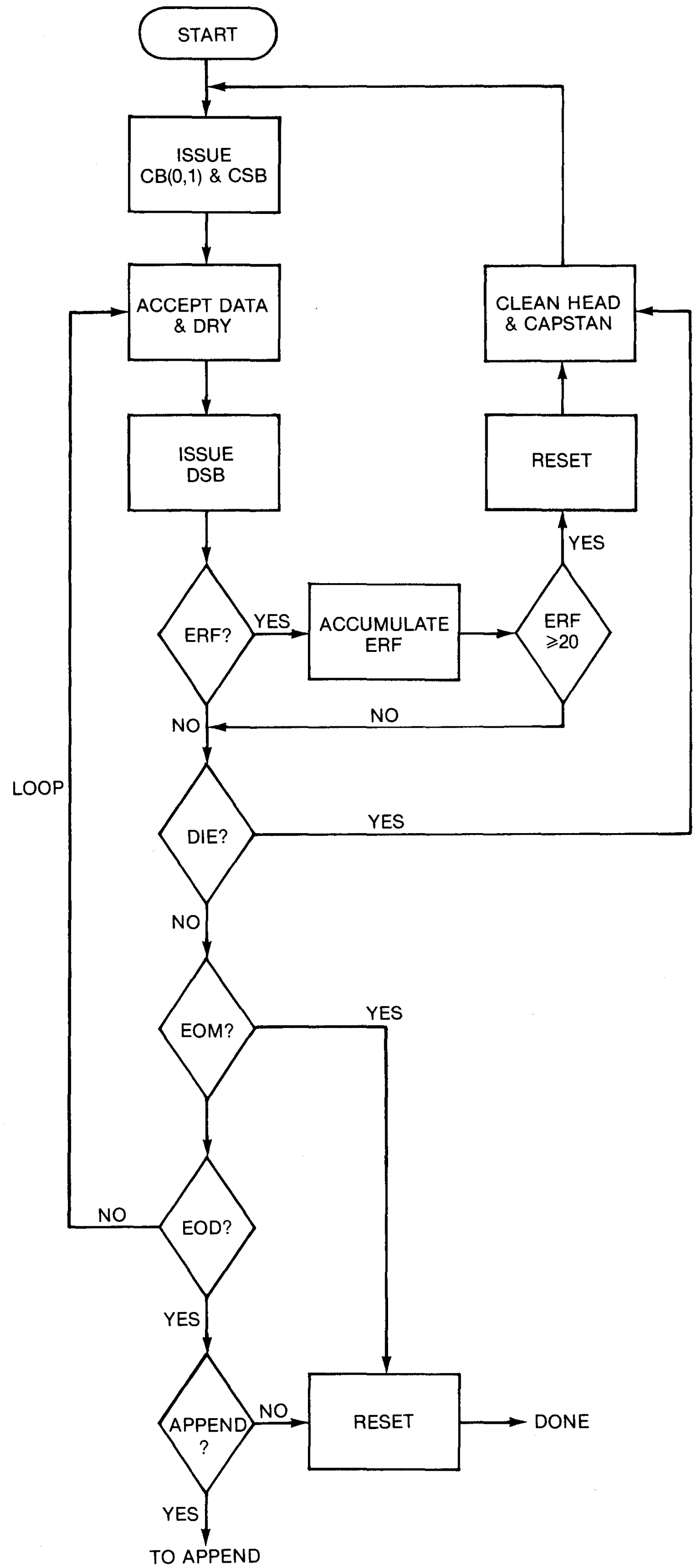


Figure 3-10 READ OPERATION FLOWCHART

Read termination results when the host issues a reset after acknowledging End-of-Memory (EOM) status. In the Read Mode, PRE/EOD is asserted simultaneous with EOM. If the host does not act on EOM, the drive will stop and wait for the next host command.

Having reached PRE/EOD, the host could assert a Write command rather than a reset. This procedure would implement the Append Operation. If this was the intent, the cartridge would have to be in the Unsafe mode. Normally data would be read from a Safe Cartridge.

3.2.12 Tape Mark Command Sequence

The only necessary condition preceding a tape mark command is that the drive be in the Write mode. The host must disable the Data Strobe (DSB) and allow approximately one (1) second to pass while the drive records the tape mark, repositions, and returns to continue the Write process.

Only one tape mark can be written per block because the tape mark is actually an assertion of one bit in the data block header. Upon asserting the tape mark for block N, the data that would normally remain in block N is held and reserved for block N+1. Block N becomes a partial block containing only data preceding the tape mark.

The required sequence of events follow:

1. Host disables DSB for 120 ms.

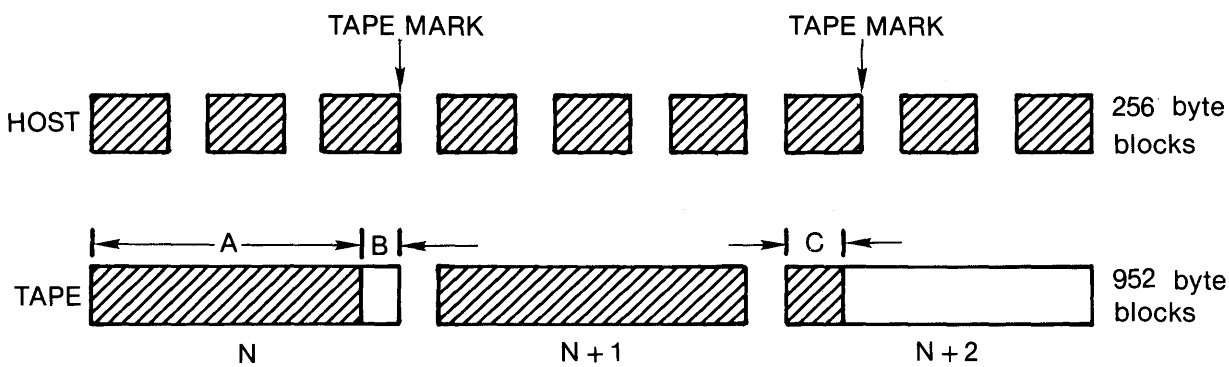
2. Host asserts Command Bit (CB0, CB1) for tape mark and asserts Command Strobe (CSB).

3. Host waits approximately 30 ms and looks for Tape Mark Detected (TMD) status assertion. The pulse width of TMD will approximate 165 microseconds.

4. Upon detection of TMD, the host must wait 335 microseconds before the drive will issue DRY.

5. The host must wait an additional one (1) second before expecting the next DRY while the drive repositions and returns to the Write mode.

The advantage of utilizing the data block header for tape mark is that it preserves tape capacity. An excessive use of tape marks will reduce this advantage because each block containing a tape mark becomes a partial block and each tape mark means an interblock gap of approximately 0.07 inches rather than 0.035 inches. Figure 3-11, Tape Mark Management, illustrates this effect. Note that for 1792 bytes recorded, a 1064 byte capacity was given up for tape marks. Since two (2) interblock gaps were expanded, an additional 65 bytes make a total of 1129 bytes given up. Additional information regarding tape mark operation can be found in Section 3.2.6.



Tape N Block		Tape N+2 Block	
A:	byte count = 768	C:	byte count = 72
B:	fill bytes = 184	D:	fill bytes = 880

Figure 3-11 TAPE MARK MANAGEMENT

3.2.13 Reset Command Sequence

A reset command will terminate read or write operation by disabling Unit Ready (URY) and rewinding the drive to BOT. During initial Power -Up, reset is automatic.

The normal sequence for a reset command follows:

1. Host discontinues the handshake.

2. Host waits one (1) second while the drive ramps down and stops.

3. Host sets the Command Bit (CB0, CB1) for reset and asserts Command Strobe (CSB).

4. Drive disables URY.

5. Drive moves forward sixty (60) inches and then moves to BOT.

6. Drive asserts URY and waits for next host command.

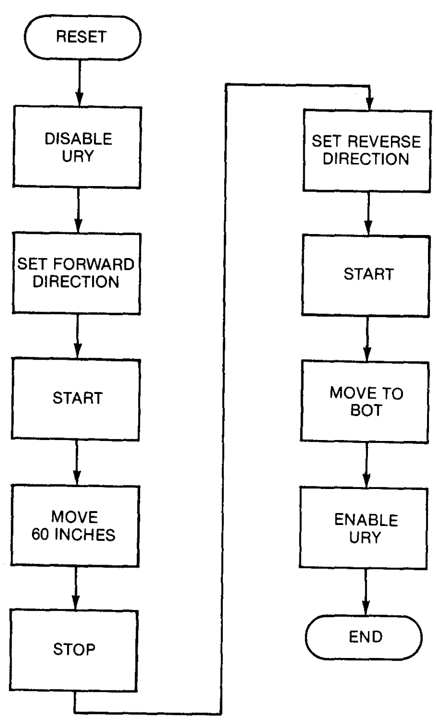
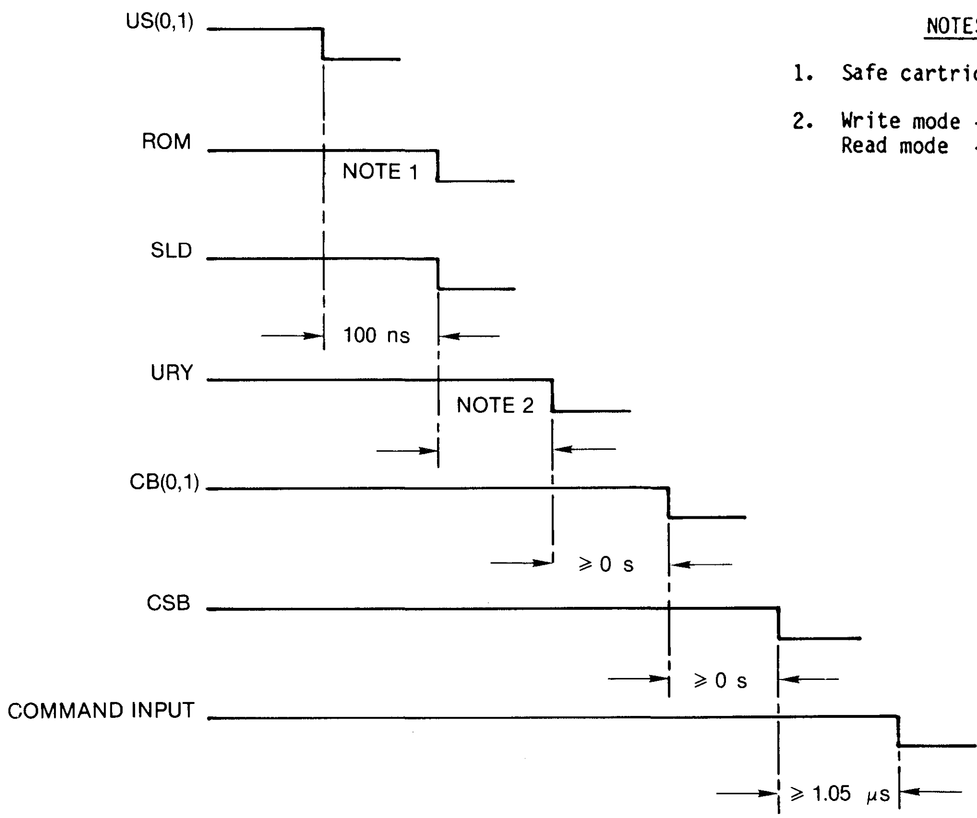


Figure 3-12 RESET OPERATION FLOWCHART

3.2.14 Interface Timing Diagrams

Timing diagrams are illustrated for initial Power-Up, Write, Read, and Write Tape Mark. It is recommended that the system designer fully read the operation section prior to analyzing the timing diagrams. Sections 3.2.9 through 3.2.13 provide additional information regarding the particular mode of operation.

Figure 3-13 illustrates the Power-Up Command, Status Timing. Note that URY is always delayed upon initial power-up to perform a self-test.

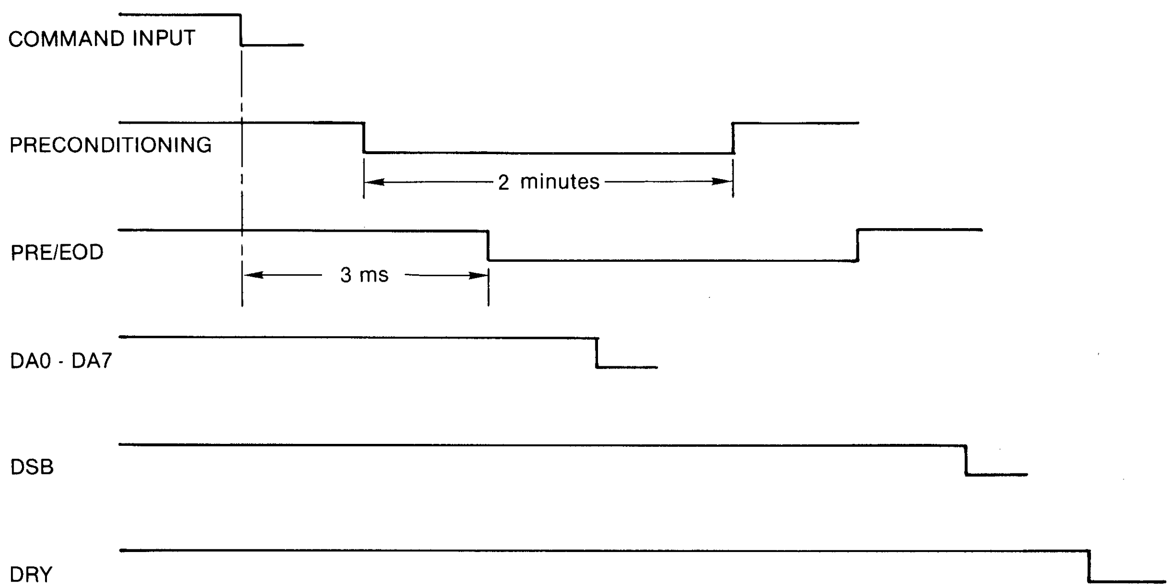


NOTES

1. Safe cartridge only.
2. Write mode - 10 seconds.
   Read mode - 5 seconds.

Figure 3-13 POWER-UP COMMAND, STATUS TIMING

Figure 3-14, Initial Write Timing, shows relative timing prior to the write handshake process. This figure prepares the reader for Figure 3-15, Write Handshake Timing. The only requirement for much of the timing is $\geq$ 0 seconds. Review the notes below.



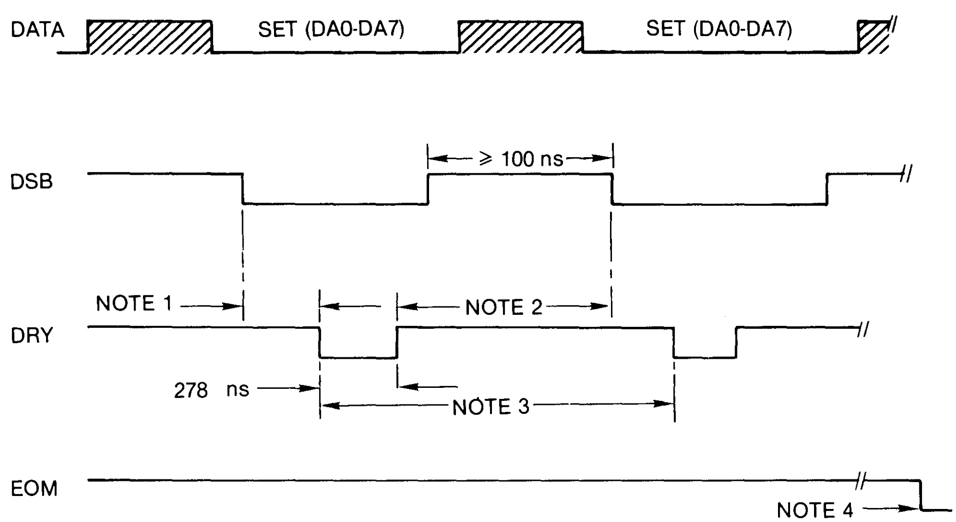
NOTE

The following times are required to be $\geq$ 0:

- Command Input assertion to preconditioning.
- Preconditioning inhibit to PRE/EOD inhibit.
- PRE/EOD assertion to set (DA0-DA7).
- Set (DA0-DA7) to DSB assertion.
- PRE/EOD inhibit to DSB assertion.

Figure 3-14 INITIAL WRITE TIMING

Figure 3-15, Write Handshake Timing, greatly differs between the 90 ips and 30 ips drive. Refer to the notes below.



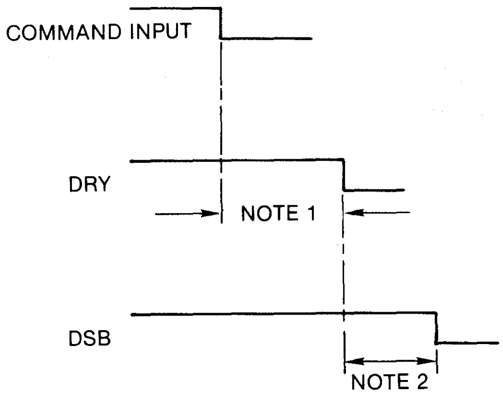
<u>NOTES</u>

1. Time $\leq$ 11.5 μs, 90 ips; $\leq$ 34.5 μs, 30 ips.
2. Time $\leq$ 7 μs, 90 ips; $\leq$ 24 μs, 30 ips.
3. Time $\geq$ 2.1 μs, 90 ips; $\geq$ 6.3 μs, 30 ips.
4. After detection of early warning tape hole, EOM will be asserted within 11.5 μs, 90 ips and 34.5 μs, 30 ips.
5. Following times are required to be $\geq$ 0:

   - Set (DAO-DA7) to DSB assertion.
   - DSB inhibit to total data transfer.
   - DRY inhibit to DSB inhibit.
   - DSB assertion to DRY assertion.

Figure 3-15 WRITE HANDSHAKE TIMING

Read initial and handshake timing are covered in Figures 3-16, 3-17.

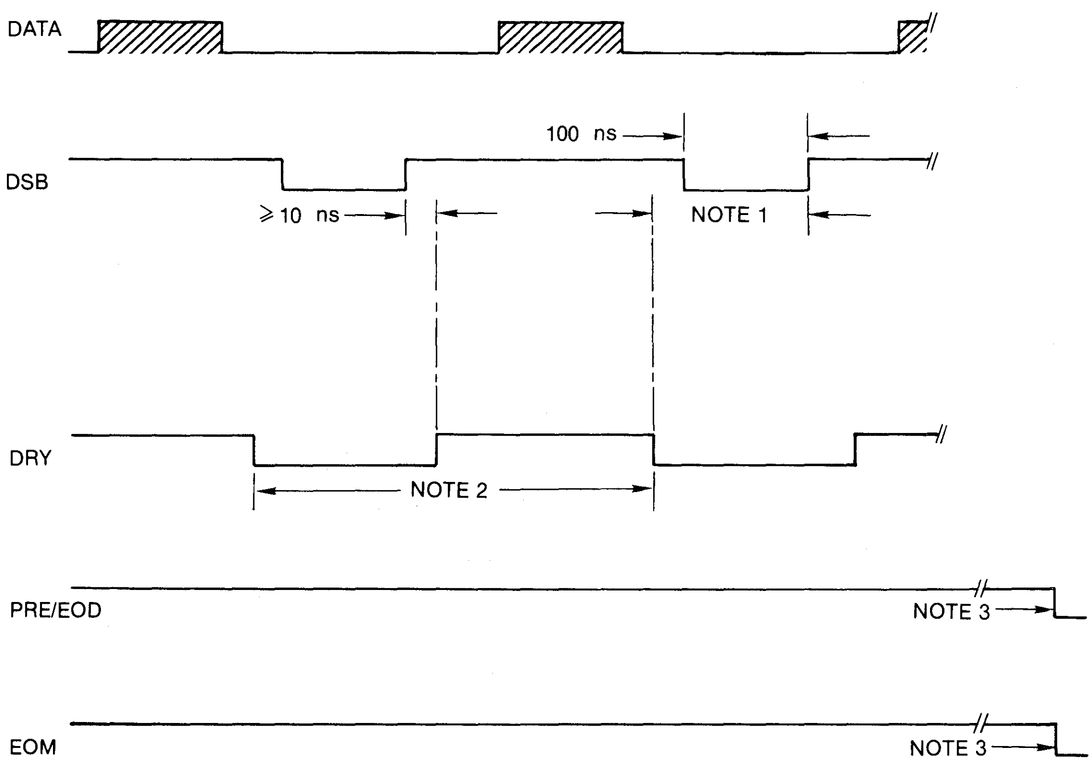


NOTES

1. Time $\leq$ 300 ms, 90 ips; $\leq$ 100 ms, 30 ips.

2. Time will be $\geq$ 0.

Figure 3-16 INITIAL READ TIMING



NOTES

1. Time $\leq$ 6 μs, 90 ips; $\leq$ 26 μs, 30 ips.

2. Time $\geq$ 2.1 μs , 90 ips; $\geq$ 6.3 μs, 30 ips.

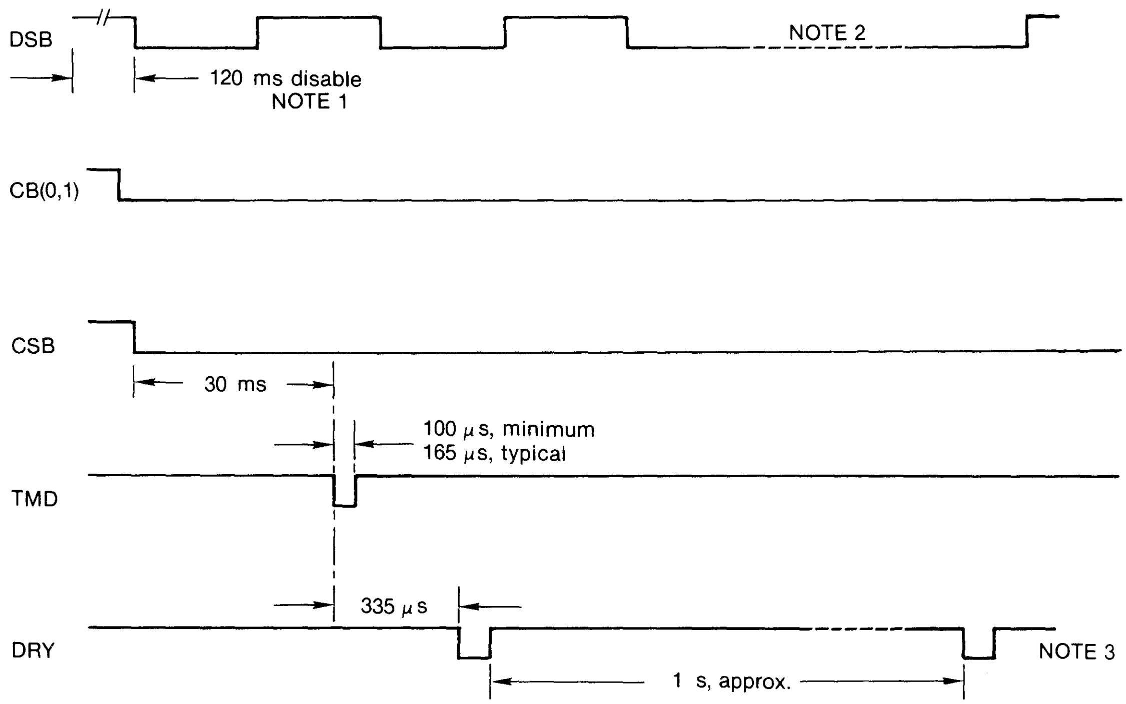
3. PRE/EOD and EOM will be asserted $\leq$ 3.5 ms, 90 ips, and $\leq$ 35 ms, 30 ips after last $\overline{DRY}$ assertion.

4. Following times required to be $\geq$ 0:

   - DRY inhibit to total data transfer.
   - Set (DA0-DA7) to DRY assertion.
   - DRY assertion to DSB assertion.

Figure 3-17 READ HANDSHAKE TIMING

Figure 3-18, Write Tape Mark Timing, is illustrated below. Section 3.2.6, Tape Mark, and Section 3.2.12, Tape Mark Command Sequence, should be reviewed prior to analyzing the timing sequence.



NOTES

1. During the write mode handshake, DSB is disabled for 120 ms.

2. After TMD, host must wait 335 μs before drive will acknowledge previous DSB. Drive will not acknowledge any subsequent DSB until drive has repositioned. Time required approximates 1 second.

3. Handshake continues for data subsequent to the tape mark, however, this data is now part of the next block.

Figure 3-18 WRITE MARK TIMING

SECTION 4 THEORY OF OPERATION

4.1 GENERAL CONCEPT

The Streamer is a microprocessor controlled, 1/4 inch, Cartridge Tape Drive. Data is sent to and from the Streamer with a simple asynchronous handshake. During Write Operation, host data is first placed into buffer memory. Then upon command, it is encoded and placed on tape. During Read Operation, data is removed from tape, decoded, and sent to the host. In addition to controlling data flow, the microprocessor controls tape movement, and the head position, as required.

4.2 DATA HANDLING

The Streamer input is configured as byte parallel, FIFO memory with no restriction on block size. Host data of any block size enters two 952 byte buffers. Fifteen bytes of overhead characters are added for identification and syncronization. Buffer memory is configured as a DMA-controlled 2kx8 RAM. While in communication with the microprocessor, the DMA circuit uses three bidirectional channels into buffer memory to perform the following:

a. Transfer of data to or from the host.
b. Sending write data to the encoder circuit.
c. Receiving read data from the decoder.

In general, a particular block of data is selected within buffer memory, and upon microprocessor command is transferred to an input or output device. Refer to Figure 4-1 for the Streamer Block Diagram.

The encoder/decoder circuitry uses a proprietary concept to assure data integrity. An eight-to-four bit conversion and a four-by-five GCR recording code generation takes place in the encoder section. Conversely, the decoder section separates overhead characters, a five-by-four GCR decoding takes place, and a four-to-eight bit conversion is accomplished.

The host interface circuitry is comprised of two four-bit, parallel, bidirectional bus driver/receivers. Both write and read data latches are used to speed data transfer on the bus.

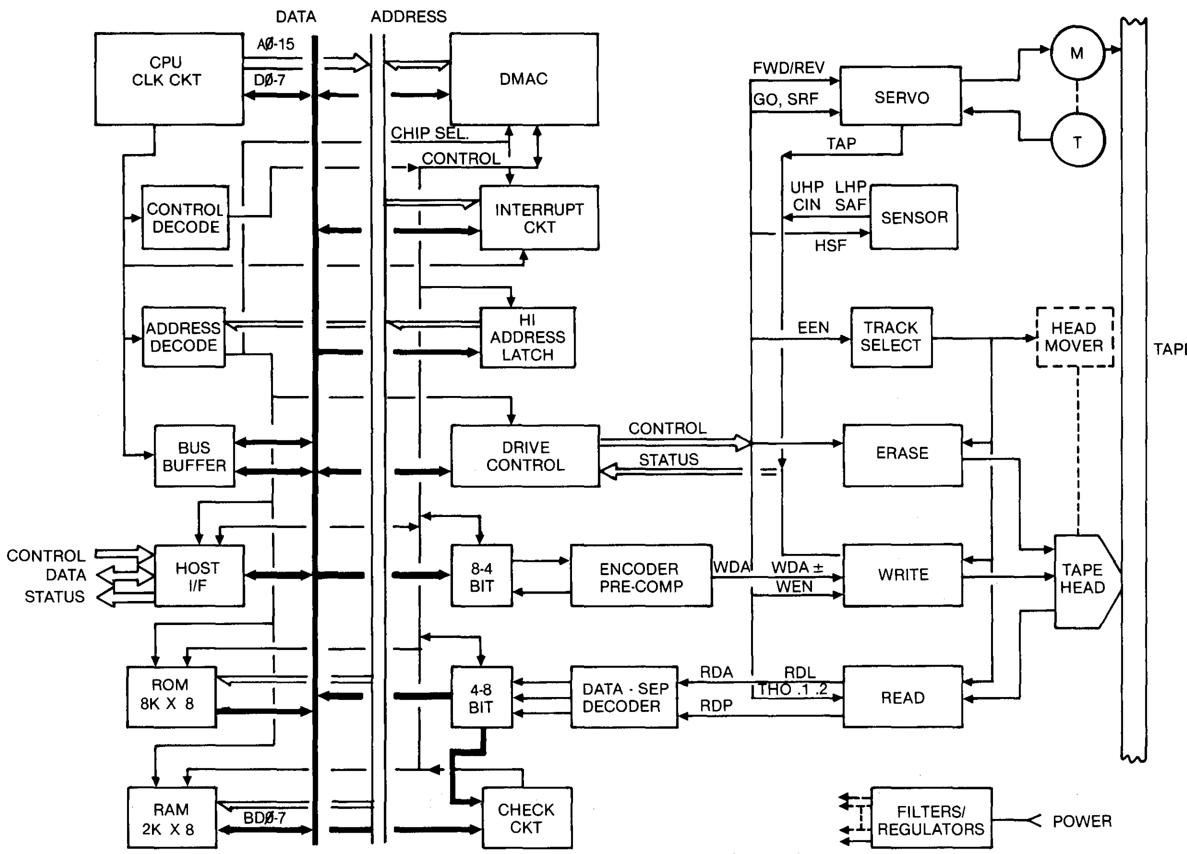


Figure 4-1 STREAMER BLOCK DIAGRAM

4.3 TAPE POSITION CONTROL

Tape drive functions are implemented by EPROMs in conjunction with the microprocessor. Also contained within the EPROMs are self-diagnostic programs to assure proper drive operation. For example, during a power-up cycle, the check sum test is performed on EPROMs and RAM. In addition, a write test is performed if the cartridge is in the unsafe position. The speed of the tape is monitored with a tachometer circuit looking for possible capstan speed drag caused by a defective cartridge.

The tape drive circuitry consists of capstan servo and motor control, tape hole, file protect, cartridge-in-place sensors, head selection, read, write, and erase circuits.

4.4 TAPE DATA RECORD FORMAT

Data to the drive from the host interface is blocked into 952-byte blockettes. Additional data-block overhead characters are added for synchronization and identification as shown in Figure 4-2. Although they are not found in the four by five GCR data array, characters that reside in the preamble and the postamble can readily be distinguished from data. The 32-bit preamble is encoded into 40 bits and appears on the tape as 11111,11111,.....11111,00111. The 24-bit postamble is encoded into 30 bits and appears on the tape as 11100,11111,11111,.....11111. The characters 00111 and 11100 are referred to as Mark 1 and Mark 2, respectively. The blockette header is added to implement the error evaluation algorithm.

The header is comprised of 6 bytes and is coded as follows:

- byte 1 is assigned a blockette number.
- byte 2 is a continuation of assigned blockette number.
- byte 3 is the previous blockette number.
- byte 4 is a continuation of previous blockette number.
- bytes 5 and 6 are combined and used as follows:
  - bits 0 - 10 form the blockette byte count.
  - bits 11 - 13 are the sequential count of re-write operations.
  - bits 14 is the tape mark bit.
  - bit 15 is a partial blockette flag (PBF).

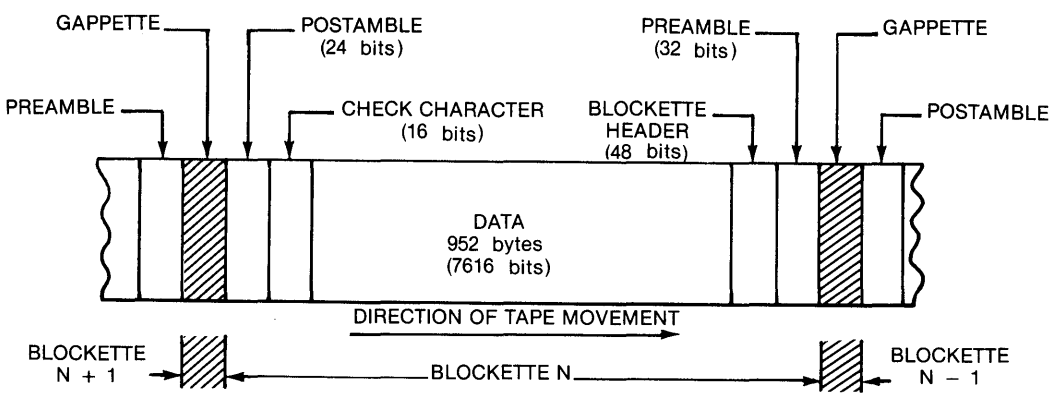


Figure 4-2 DATA FORMAT

The first blockette received from the host is assigned a blockette number of one. Successive blockettes are numbered in sequence. Making the previous blockette number a part of the current blockette's header assures that the error algorithm operates on the proper blockette.

A partial blockette is indicated in the per byte count portion of the blockette header. A count of less than 952 causes a partial blockette (PBF) equal to one. A full blockette indicates a PBF of zero.

4.5 RECORDING CODE

Data is converted to a self-clocking, four-by-five, GCR code in conformance to the American National Standard Institue X3.54-1976. The code is written on tape in an NRZ-M format. Ones are indicated by a flux reversal in the middle of the bit cell. Zeros do not have the flux reversal. Three of the unused record values (11100, 11111, and 00111) are used for synchronization. The others are not used, except that the default state of 00000 is used between blocks. The data values, record values, and recorded waveform of the GCR code are shown in Figure 4-3.

DATA VALUES	RECORD VALUES
1 2 3 4	1 2 3 4 5
0 0 0 0	1 1 0 0 1
0 0 0 1	1 1 0 1 1
0 0 1 0	1 0 0 1 0
0 0 1 1	1 0 0 1 1
0 1 0 0	1 1 1 0 1
0 1 0 1	1 0 1 0 1
0 1 1 0	1 0 1 1 0
0 1 1 1	1 0 1 1 1
1 0 0 0	1 1 0 1 0
1 0 0 1	0 1 0 0 1
1 0 1 0	0 1 0 1 0
1 0 1 1	0 1 0 1 1
1 1 0 0	1 1 1 1 0
1 1 0 1	0 1 1 0 1
1 1 1 0	0 1 1 1 0
1 1 1 1	0 1 1 1 1

RECORDED WAVEFORM

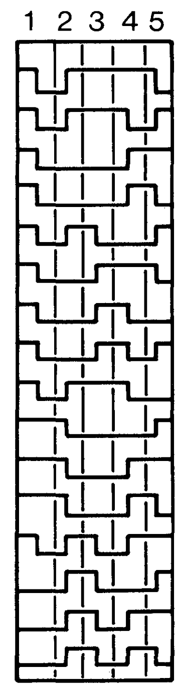


Figure 4-3 GCR CODE

4.6 ERROR RECOVERY

4.6.1 Write Error Recovery

During a Write Operation, the drive does a read-while-write check for data integrity. If the data is verified, new host data can enter buffer memory. If a write error is detected, the data will be re-written and another verification attempt will take place. When data is written incorrectly, an error flag, indicating a soft error, is transferred to the host. The data can be written a total of eight times before the error algorithm will abort.

4.6.1 Write Error Recovery (Continued)

Two examples of a write error recovery are shown in Figure 4-4. Case 1 shows a read-while-write error detected before the write gap. The blockette that contains the error (N+1) is immediately re-written. Case 2 shows a read-while-write error detected after the write gap. The next blockette (N+2) is being written from the buffer. Blockette N+1 is subsequently rewritten after blockette N+2.

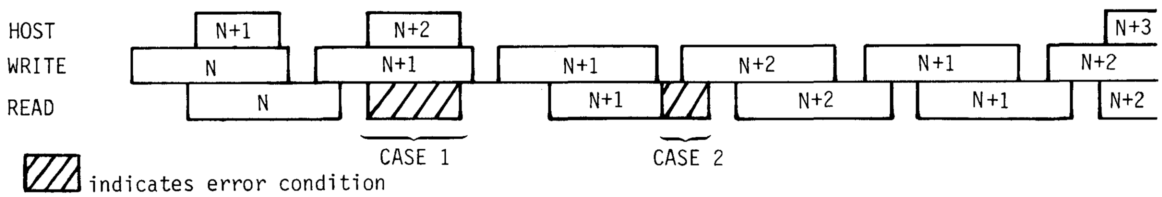


Figure 4-4 WRITE MODE ERROR REWRITES

4.6.2 Read Error Recovery

Read data is checked as it is placed into the buffer memory by a hardware network that uses a cyclic redundancy check character (CRCC) technique. When all bytes of data, blockette ID, and check characters are clocked, the result should be equal to zero. If not, the controller begins to look for a re-write of the blockette. If a blockette with a number equal to plus 2 is encountered, a reread is performed.

A reread is a second or subsequent read attempt on a blockette of data. To perform a reread, the controller first stops the tape. Then, it ramps up the tape in the opposite direction. When the tape is at normal speed, it runs for several milliseconds before stopping. The controller then starts the tape in the forward direction and begins to look for the target data blockette. If the blockette is correct when it is read, the Read Operation continues. If not, the blockette is re-read again.

The controller adheres to a specific algorithm for read error recovery. When a bad blockette is read correctly, the procedure is abandoned for normal read operation. The algorithm works in the following manner:

a. The blockette rereads twice at the nominal read threshold.
b. The threshold is lowered to a lower value and the blockette is reread again.

c. The threshold is raised to a higher than normal level in an attempt to re-establish phase margin which may have been lost at the lower thresholds.

d. Another reread attempt is made. If it fails, the tape is retensioned. The controller moves the tape to logical EW; then back to logical LP; and once again forward to the data blockette. Then, the blockette is read again at nominal read thresholds.

e. If the blockette is still in error, the Data In Error (DIE) host status line is asserted and dummy fill data is transmitted to the host. The DIE signal is active throughout the transmission of the dummy blockette.

4.7 CARTRIDGE TAPE DATA FORMAT

The drive is designed to write or read data in the streaming mode, using a serpentine recording method. Recording is accomplished by using two tracks for the 10 Mbyte drive and 4 tracks for the 20 Mbyte drive. The 10 Mbyte drive uses a fixed-position, two-track head and records data from beginning-of-tape to end-of-tape on track 0, and then from end-of-tape to beginning-of-tape on track 1. The 20 Mbyte drive uses a moveable, two-position, two-track head and records data on tracks 0 and 1 in the same way as in the 10 Mbyte drive. When tracks 2 and 3 are recorded, the head is moved to a second fixed stop position. figure 4-5 shows the 10 and 20 Mbyte track formats.

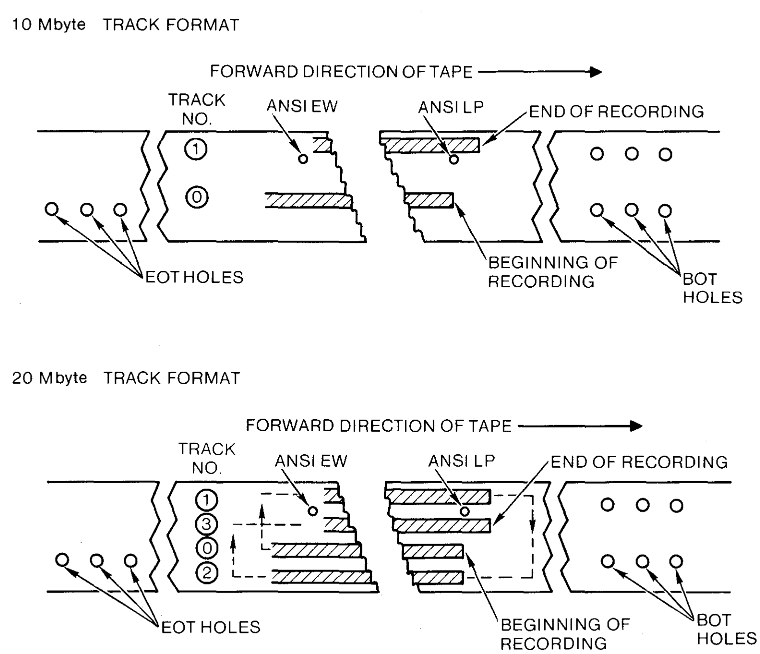
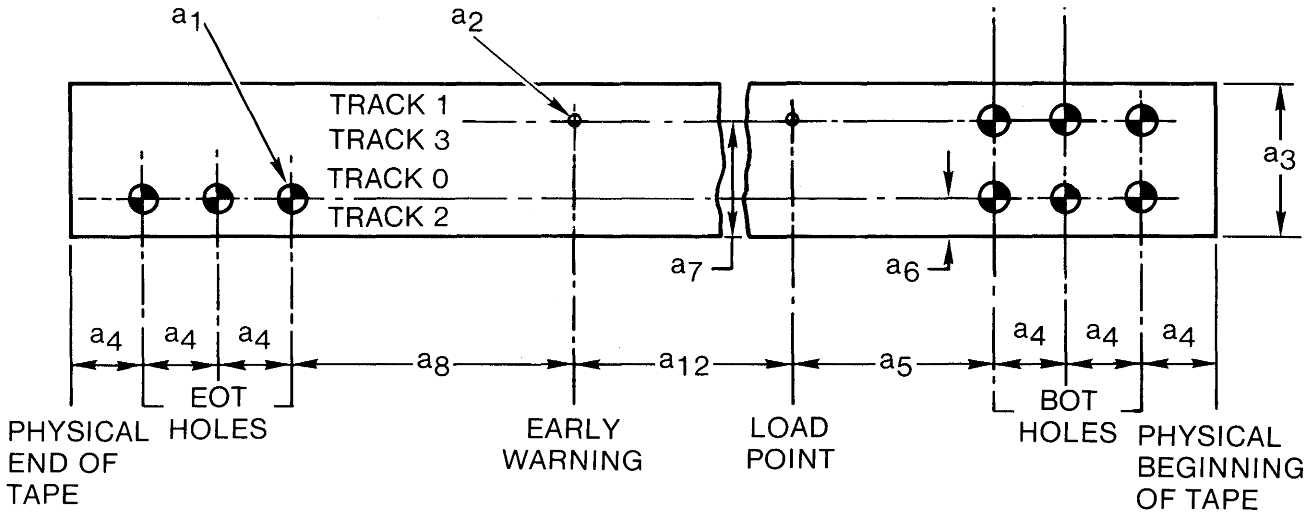


Figure 4-5 TRACK FORMATS

4.7.1 Physical Dimensions

Figure 4-6 shows the dimensions of the cartridge tape. The oxide side of the tape is shown.



DIMENSION	INCHES	MILLIMETERS
a_1	0.046 (± 0.002)*	1.17 (± 0.05)*
a_2	0.023 (± 0.002)†	0.58 (± 0.05)†
a_3	0.2470 (± 0.0010, –0.0015)	6.274 (+ 0.025, – 0.038)
a_4 (6x)	18 (± 3)	457 (± 76)
a_5	36 (± 3)	914 (± 76)
a_6	0.059 (± 0.002)	1.50 (± 0.05)
a_7	0.187 (± 0.002)	4.75 (± 0.05)
a_8	48 (± 3)	1219 (± 76)
	FEET	METERS
a_{12}	450 (+ 10, – 0)	137.2 (+ 3.0, – 0.0)

* Diameter (9 holes).
† Diameter (2 holes).
§ Maximum.

Figure 4-6 CARTRIDGE TAPE PHYSICAL DIMENSIONS

4.8 HEAD CONFIGURATION

The head used with the Streamer is a two-track, read-while-write serpentine magnetic tape head. The head contains separate read and write gaps for each track and an erase bar to erase the entire width of the tape in one pass. The read track is narrower than the write track to permit interchange of data between drives.

4.8 HEAD CONFIGURATION (Continued)

When the head is used with the 10 Mbyte drive, it is held in a fixed position. Recording is performed on tracks zero and one. The 20 Mbyte drive uses the same head with a digitally-controlled head positioner. It records data on tracks zero and one in the same manner as the 10 Mbyte drive; however, when tracks two and three are recorded, the head is moved to a second fixed stop position. This configuration permits a tape recorded on a 10 Mbyte drive to read on a 20 Mbyte drive and permits upward compatibility.

The gap distance between the read and write head is nominally 0.3 inches, which results in a read-after-write delay of 10 milliseconds for 30 ips models and 3.3 milliseconds for 90 ips models. The head configuration is shown in Figure 4-7.

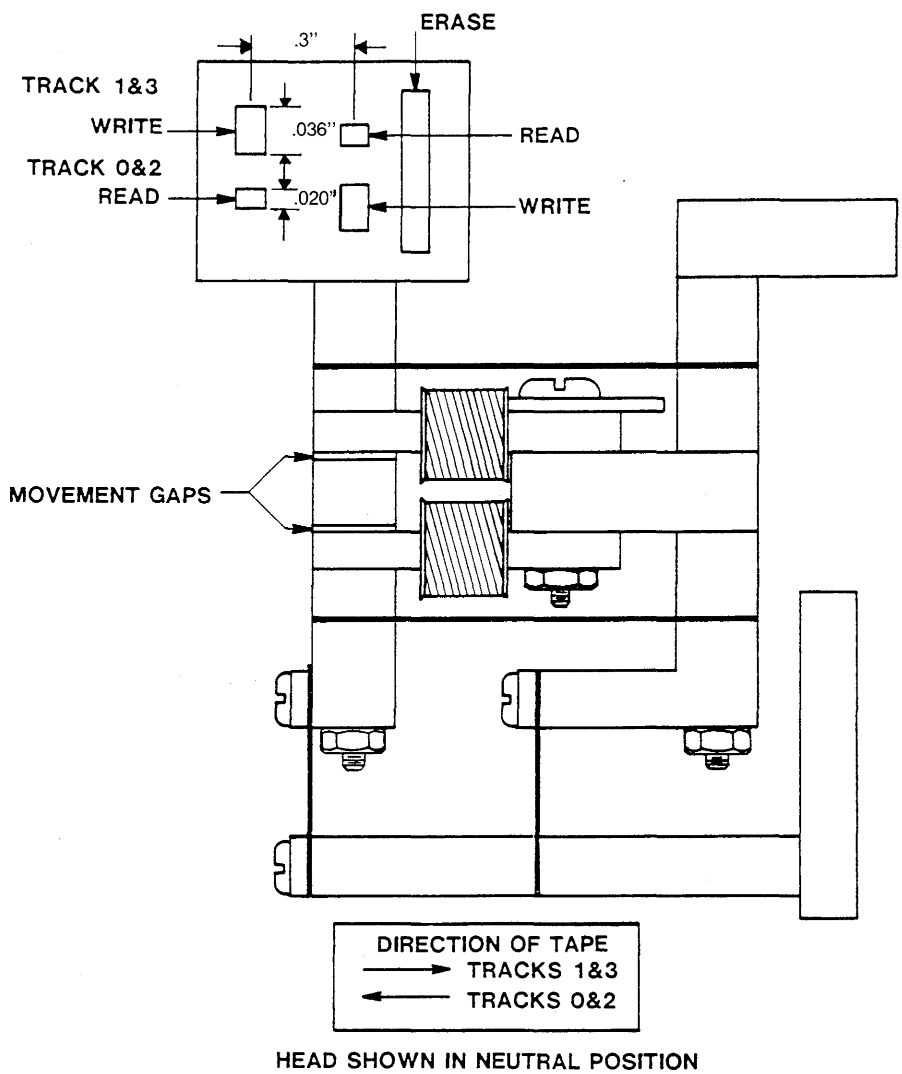


Figure 4-7 HEAD CONFIGURATION

4.9 REPOSITIONING

Repositioning is the stopping and resetting of the tape to adjust to a write underflow or read overflow condition. A write underflow occurs when the drive is ready to write another block of data but none is available from the host. A read overflow occurs when the drives's buffers are filled with data read from the tape and another block of data is ready to be read. When either of these conditions occur, the drive stops the tape, waits for the host to catch up, repositions the tape, and starts again. Each time this repositioning routine is executed, the controller leaves a large interblock gap on the tape. Figure 4-8 shows the repositioning cycle.

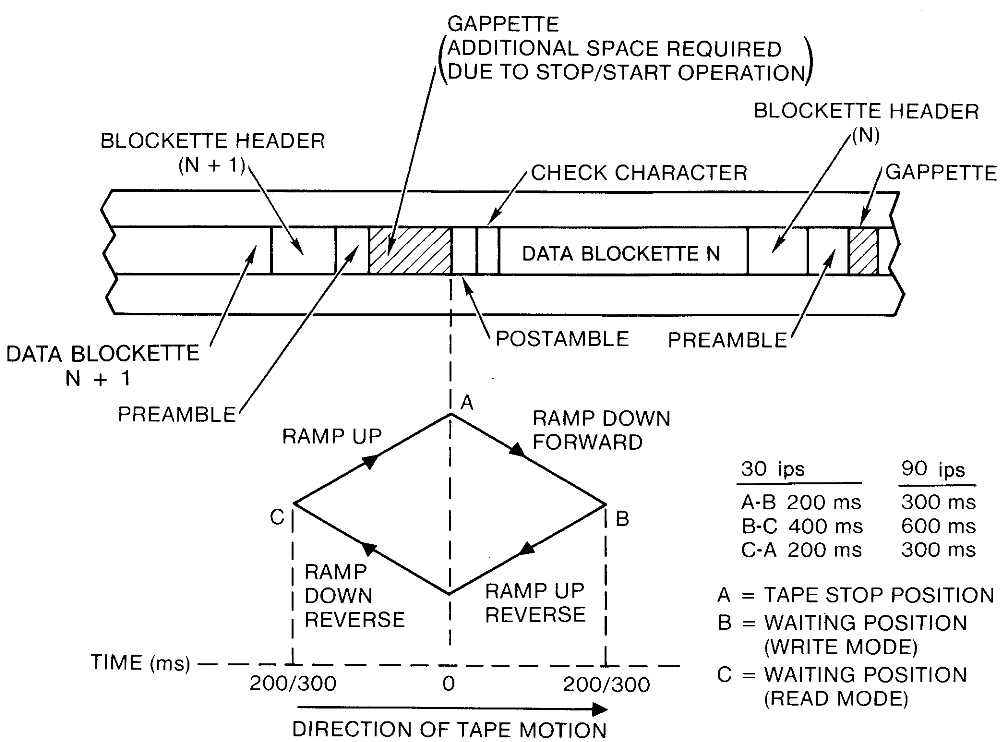


Figure 4-8 REPOSITIONING CYCLE

In summary, the Streamer should be thought as a rapidly controlled FIFO Memory implementing algorithms for the recording of data, the restoration of data, the recovery from errors, and self-diagnostics. Data is transferred to and from the host in byte parallel fashion with unrestricted block size. Configured with a host capable of providing and accepting required data rates, the Streamer will rapidly transfer data with minimal interblock gaps, thereby, maximizing storage capacity. An asynchronous handshake simplifies the timing for data transfer thereby simplifying the system integrator's task.

SECTION 5 MAINTENANCE

5.1 GENERAL

This section contains information on periodic maintenance, disassembly, and troubleshooting.

5.2 PERIODIC MAINTENANCE

5.2.1 Magnetic Head Cleaning

The magnetic head should be cleaned daily if the tape drive is in regular use. Dirty heads may cause data dropouts during read and write operations. Use a non-residue, non-corrosive cleaning agent, such as duPont Freon TF or isopropyl alcohol, and a cotton swab to clean the head assembly. Be sure to wipe up any excess and allow the heads to dry prior to operating the drive.

CAUTION

Spray-type head cleaners are not recommended because overspray may contaminate the motor bearings. Also, never clean the head with hard objects. This will result in permanent head damage.

5.2.2 Tape Cleaner Cleaning

(Refer to Figure 5-1) The tape cleaner removes loose tape oxide and other foreign material from the tape before it contacts the head. This foreign material accumulates in and around the tape cleaner and must be removed to ensure that the tape cleaner will continue to work effectively. The tape cleaner should be cleaned on the same schedule as the head.

5.2.2 Tape Cleaner Cleaning (Continued)

Compressed air or a soft brush may be used to remove the foreign material from the area around the tape cleaner and head assembly. Alternately, the tape cleaner can be cleaned using the same materials used to clean the magnetic head.

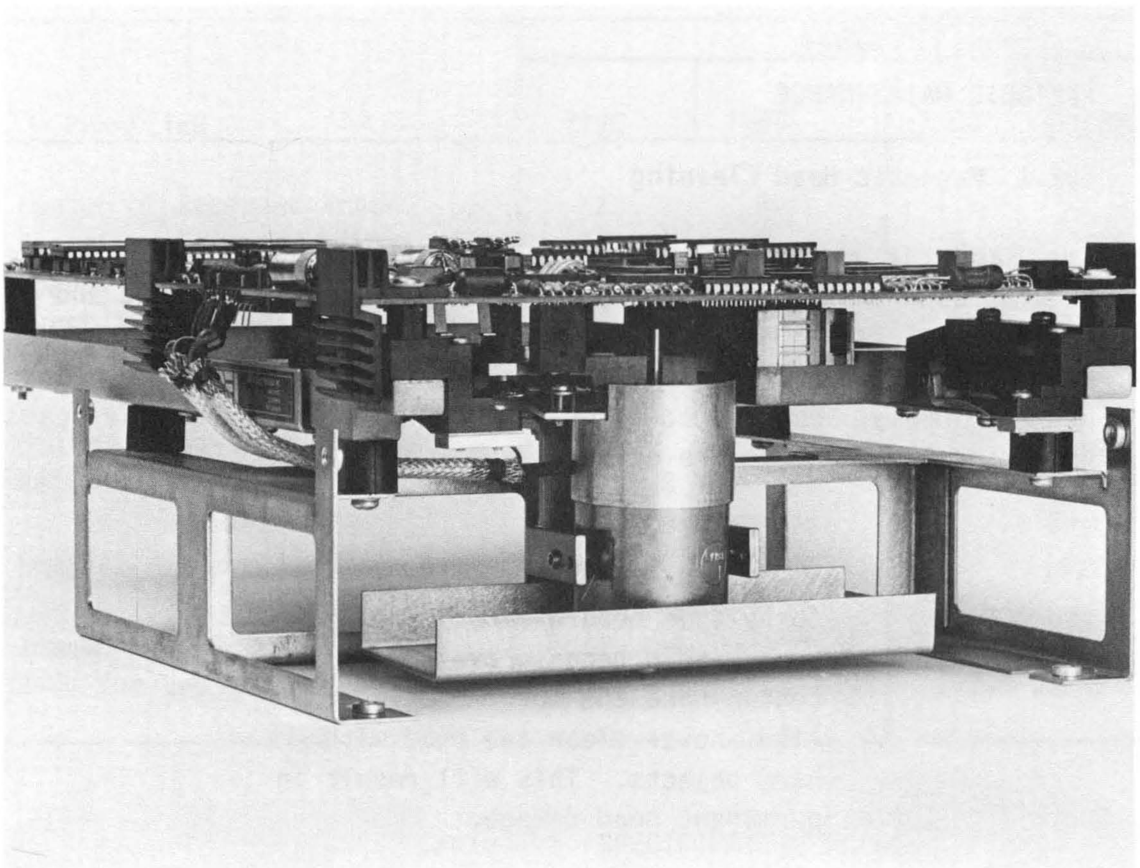


Figure 5-1 PARTS LOCATION

CAUTION

Do not allow hard objects to clean the tape cleaner! If the tape cleaner should become chipped, it could scratch the tape surface, resulting in lost data and/or permanent damage.

5.2.3 Motor Capstan Cleaning

The drive capstan is composed of hard polyurethane and must be cleaned after foreign material has built up. Clean by using isoropyl alcohol and a cotton swab. The cleaning schedule should be the same as for the head.

CAUTION
Be very careful not to permit cleaning solvent to contaminate the drive motor bearings.

5.2.4 Heat Sink, Circuit Board and Sensor Hole Cleaning

To prevent possible overheating, dust and dirt should be removed from the heat sink and drive assembly components as required. the time period between cleanings will vary widely, depending upon the operating environment. Use a soft brush and/or compressed air for cleaning. The sensor holes should be cleaned in the same manner.

5.3 DRIVE DISASSEMBLY

Refer to Figures 5-2, 5-3 and 5-4 for disassembly procedures.
Reverse disassembly procedure to reassemble drive.

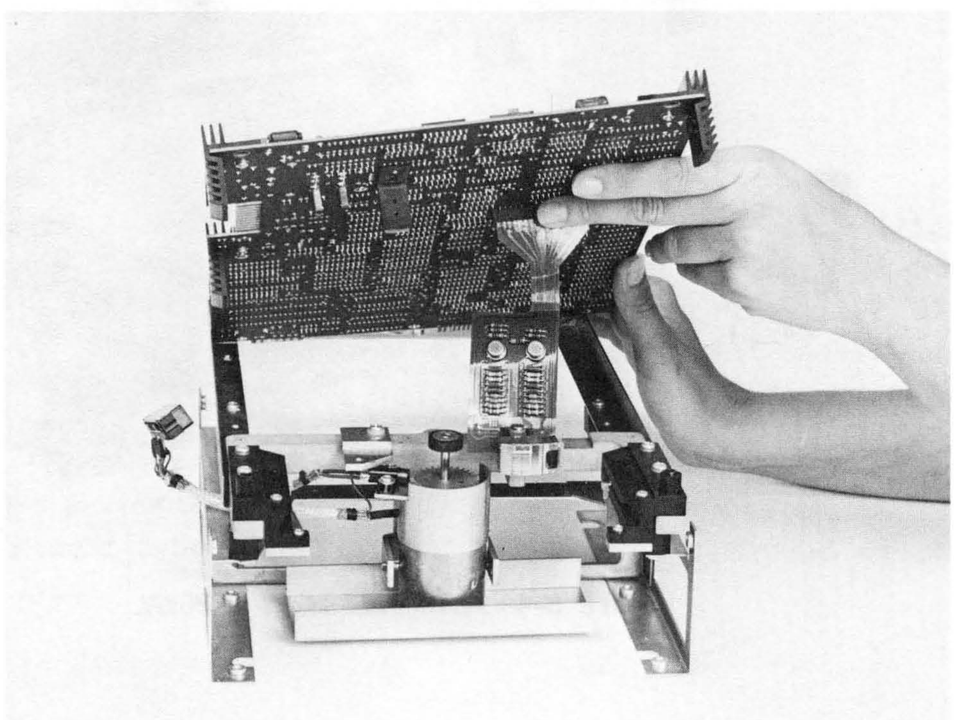


Figure 5-2 P.C. BOARD REMOVAL

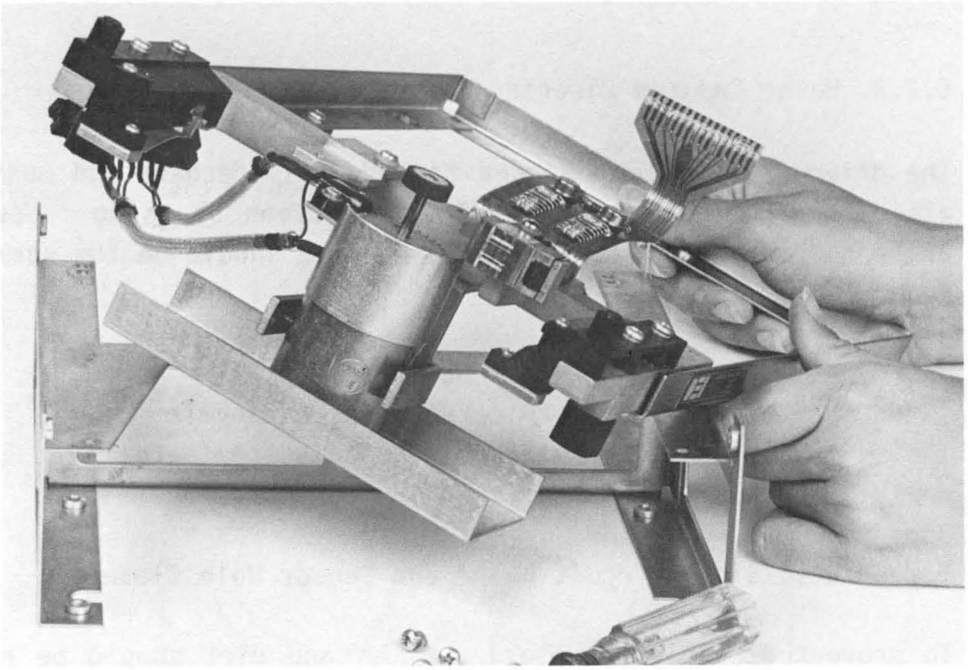


Figure 5-3 HEAD, MOTOR ASSEMBLY REMOVAL

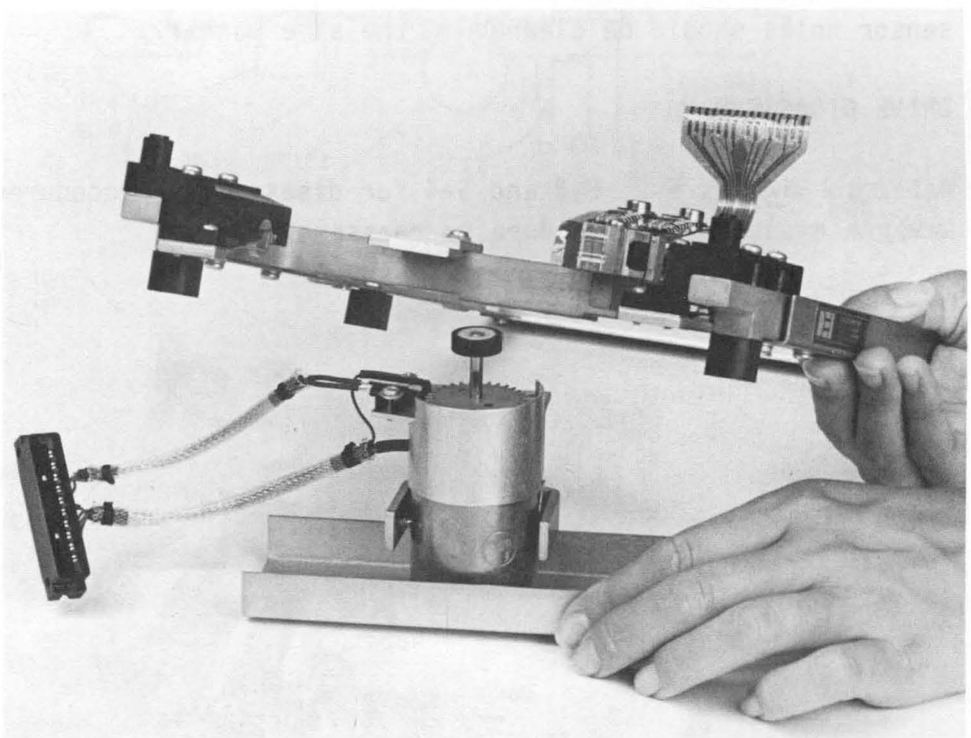


Figure 5-4 MOTOR ASSEMBLY REMOVAL

5.4 TROUBLESHOOTING

Troubleshooting information is categorized in the areas of Power, Tape Motion, and Data Malfunctions. A list of these malfunctions follows along with troubleshooting flowcharts, Section 5.4.3. The technician should review the list of symptoms below and then enter the flowcharts at the appropriate point.

Use of a Host Simulator is a good first level method of troubleshooting. Contact the DEI factory regarding available test fixtures.

NOTE

Calibration and adjustments are not methods of troubleshooting. The Streamer Series 7000, after receiving initial factory calibration, does not require periodic attention to calibration. Contact the DEI factory, San Diego, should you desire more information on calibration.

5.4.1 Symptom Review

A. Power Malfunction

1. External power supply + 24 VDC fuse blows or power supply current limits.
2. External power supply +5 VDC fuse blows or power supply current limits.

B. Tape Motion Malfunction

1. Drive will not run in any mode.
2. Drive runs only forward.
3. Drive runs only in reverse.
4. Motor turns but does not drive very high speeds.
5. Motor "runs away" into very high speeds.
6. Heat sink gets excessively hot without motion commands.

5.4.1 Sympton Review (Continued)

7. Inserting cartridge will not cause loading to BOT.
8. Motion causes excessive noise.
9. Ramp times are out of tolerance.
10. Motor runs at different speeds forward versus reverse.

C. Data Malfunction

1. Drive will not read, one track.
2. Drive will not read, all tracks.
3. Drive will not read or write.
4. Drive will not write or will read previously written tape.
5. Drive will not erase pervious information written.
6. Excessive errors in reading while writing, but not in read only.
7. Excessive errors in read only but not in read while write mode.
8. Excessive data errors in all modes.

5.4.2 Summary

In summary, the Maintenance Section allows a skilled technician to address a periodic maintenance routine and provides an introduction to troubleshooting. A serious detailed troubleshooting task will require use of a product schematic set. Customers providing their own maintenance service can inquire about receiving a schematic set. Upon signing of a Proprietary Data Agreement, this documentation will be sent.

A calibration procedure has not been included because the need for a periodic calibration is not required.

DEI Marketing staffs a group of Product Specialists to assist in operation, application engineering, and repair situations. Do not hesitate to call at anytime.

5.4.3 Troubleshooting Flowcharts

The following flowcharts should be used with the symptoms discussed in Section 5.4.1:

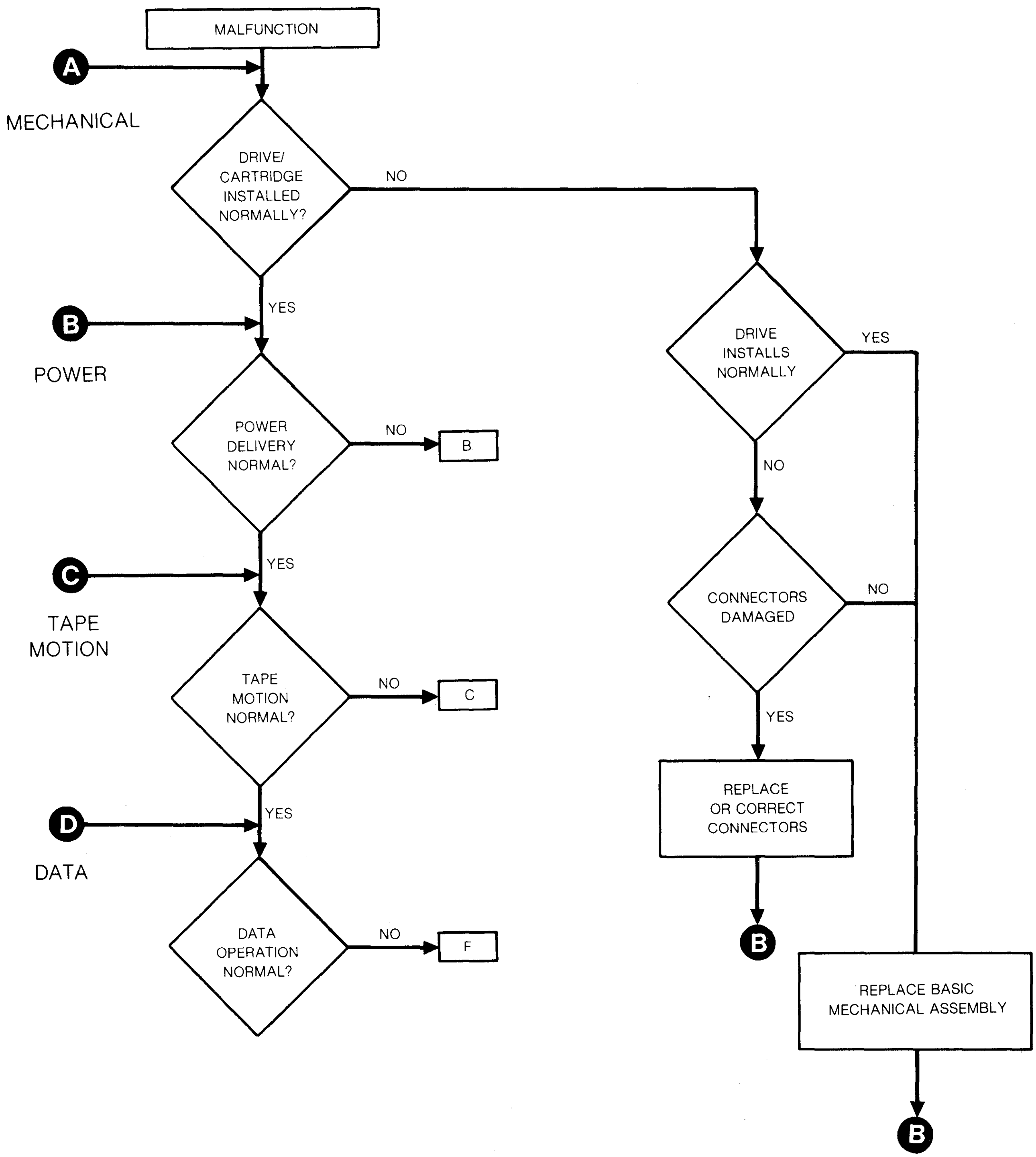
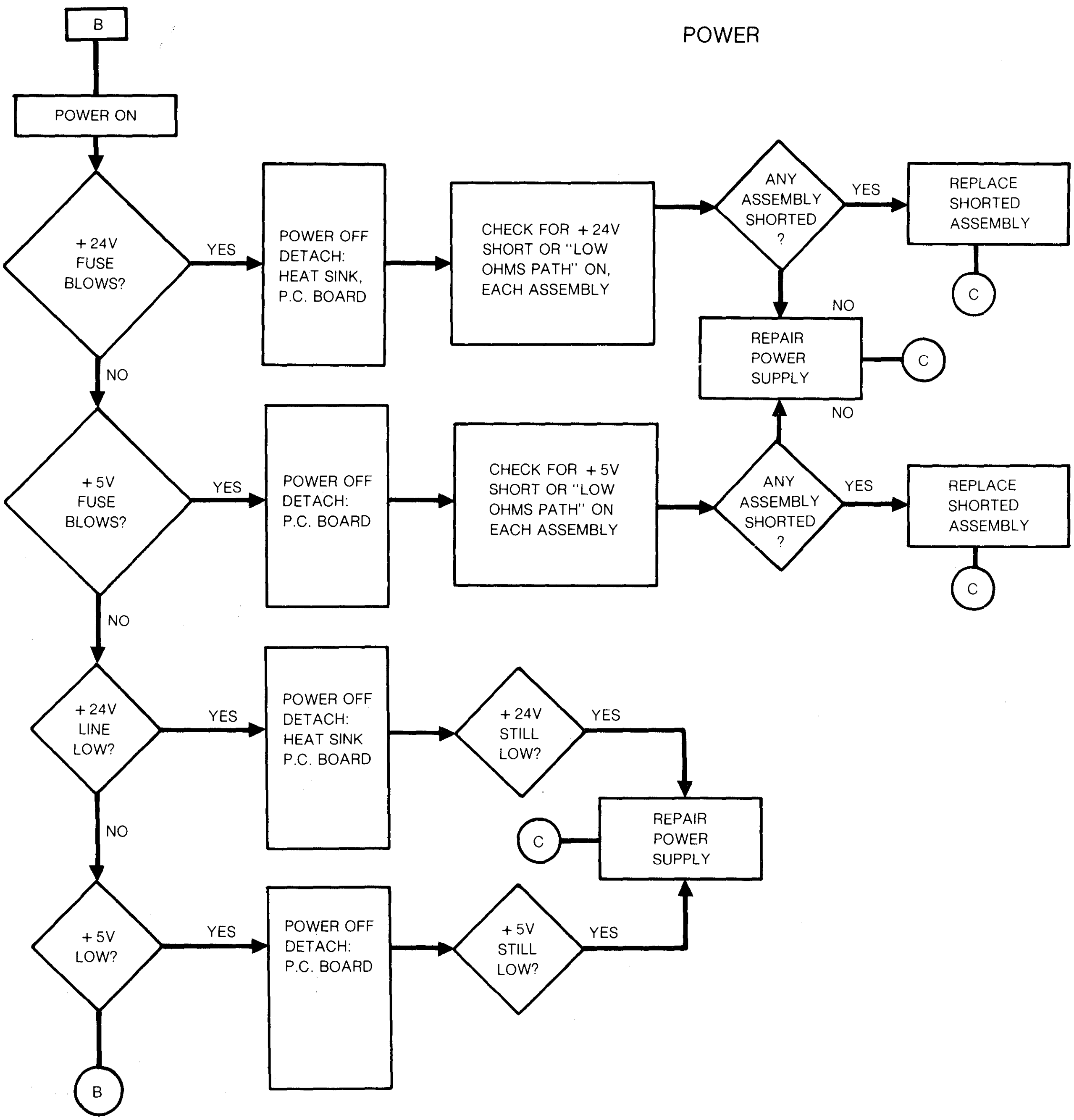


Figure 5-5 TROUBLESHOOTING FLOWCHART
(Sheet 1 of 6)



NOTE: TURN OFF POWER BEFORE RECONNECTING EACH ASSEMBLY.

Figure 5-5 TROUBLESHOOTING FLOWCHART
(Sheet 2 of 6)

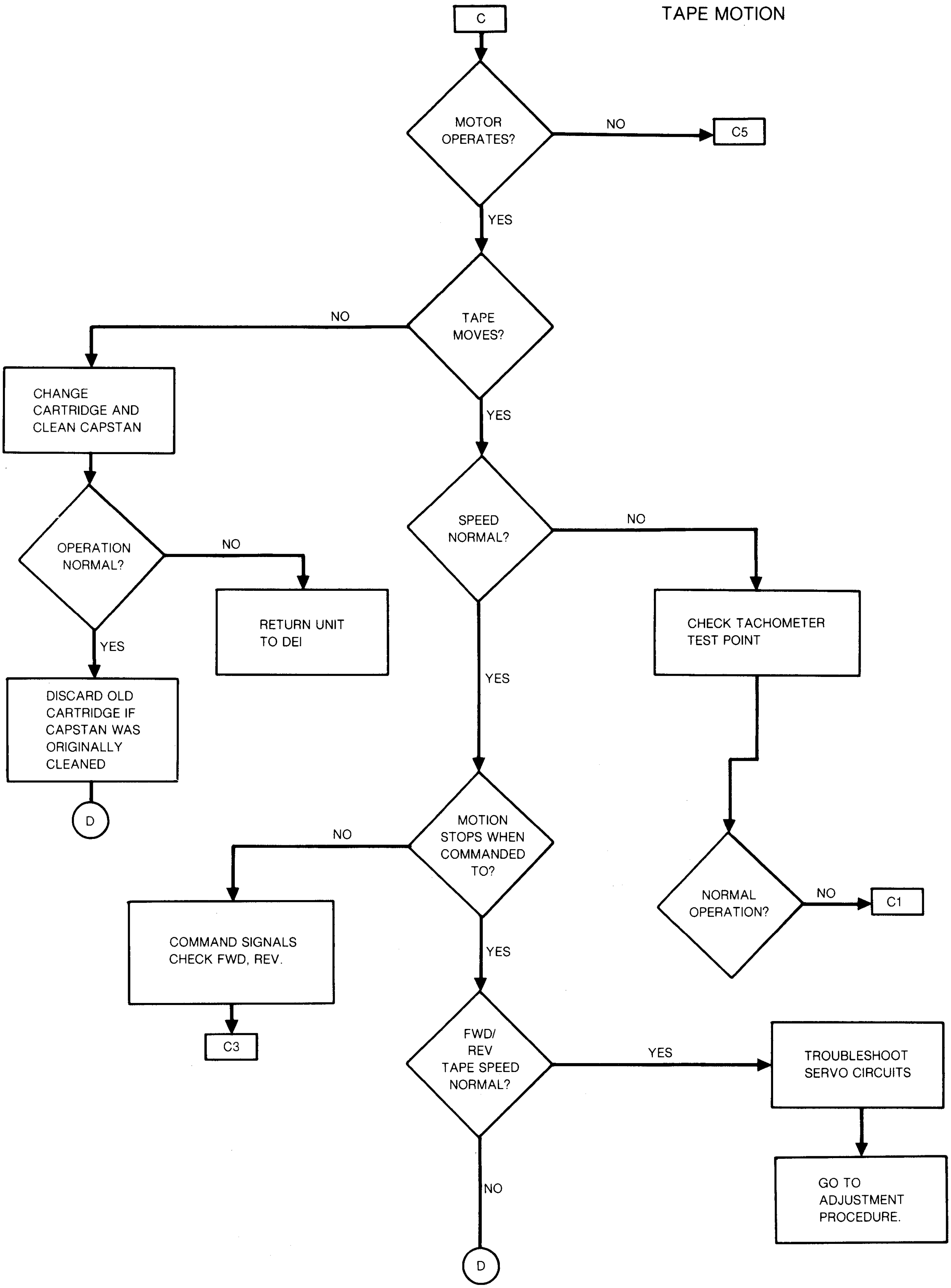


Figure 5-5 TROUBLESHOOTING FLOWCHART
(Sheet 3 of 6)

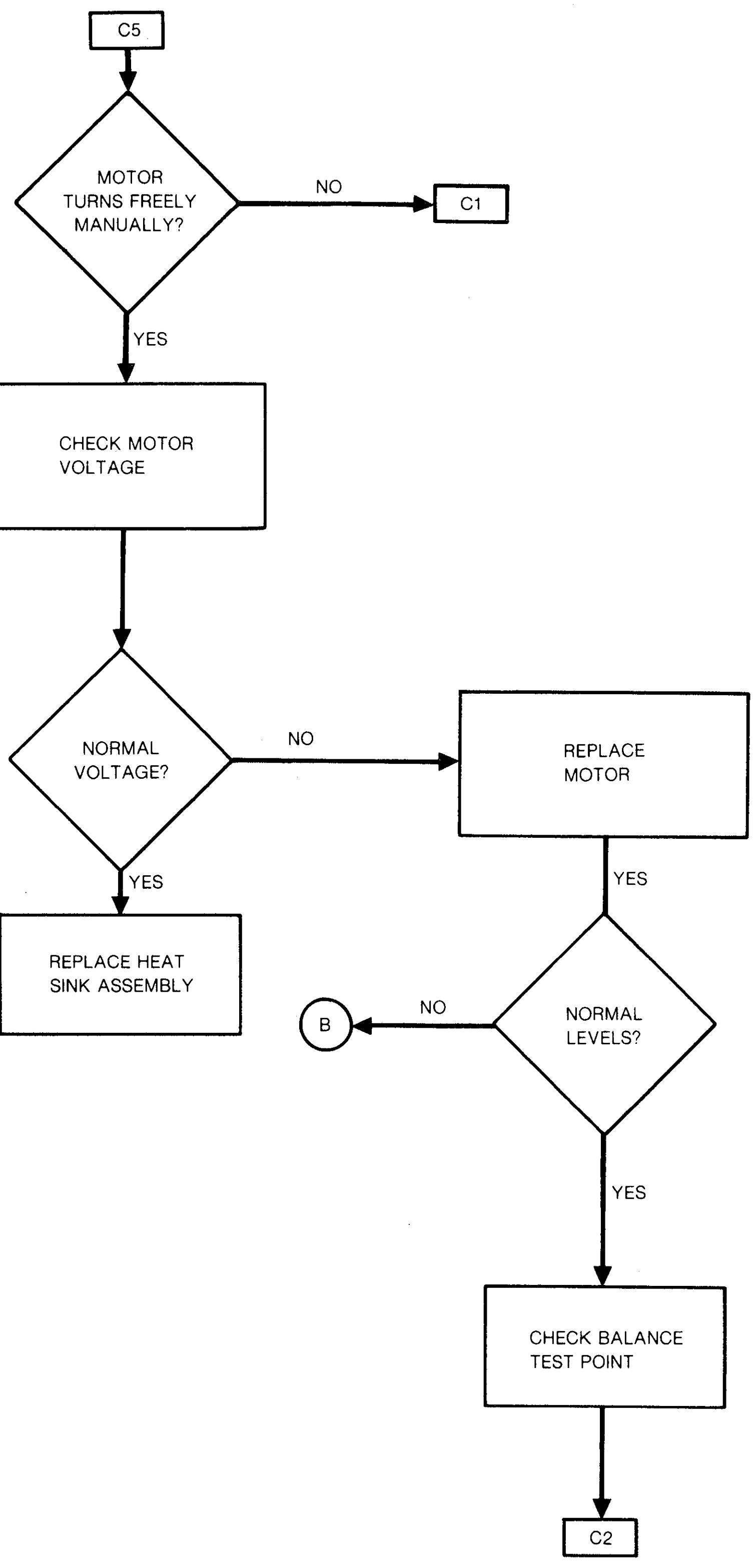


Figure 5-5 TROUBLESHOOTING FLOWCHART
(Sheet 4 of 6)

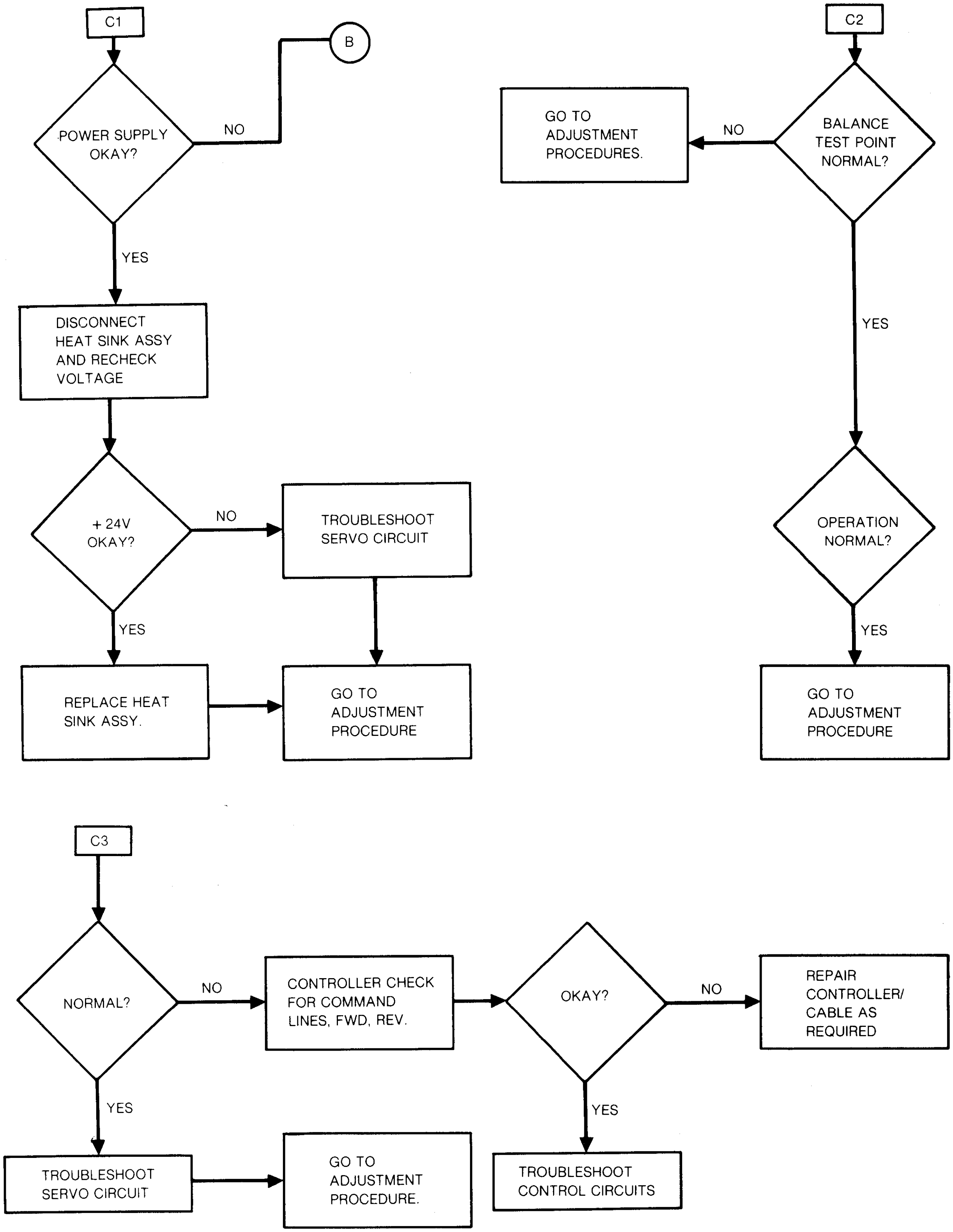


Figure 5-5 TROUBLESHOOTING FLOWCHART
(Sheet 5 of 6)

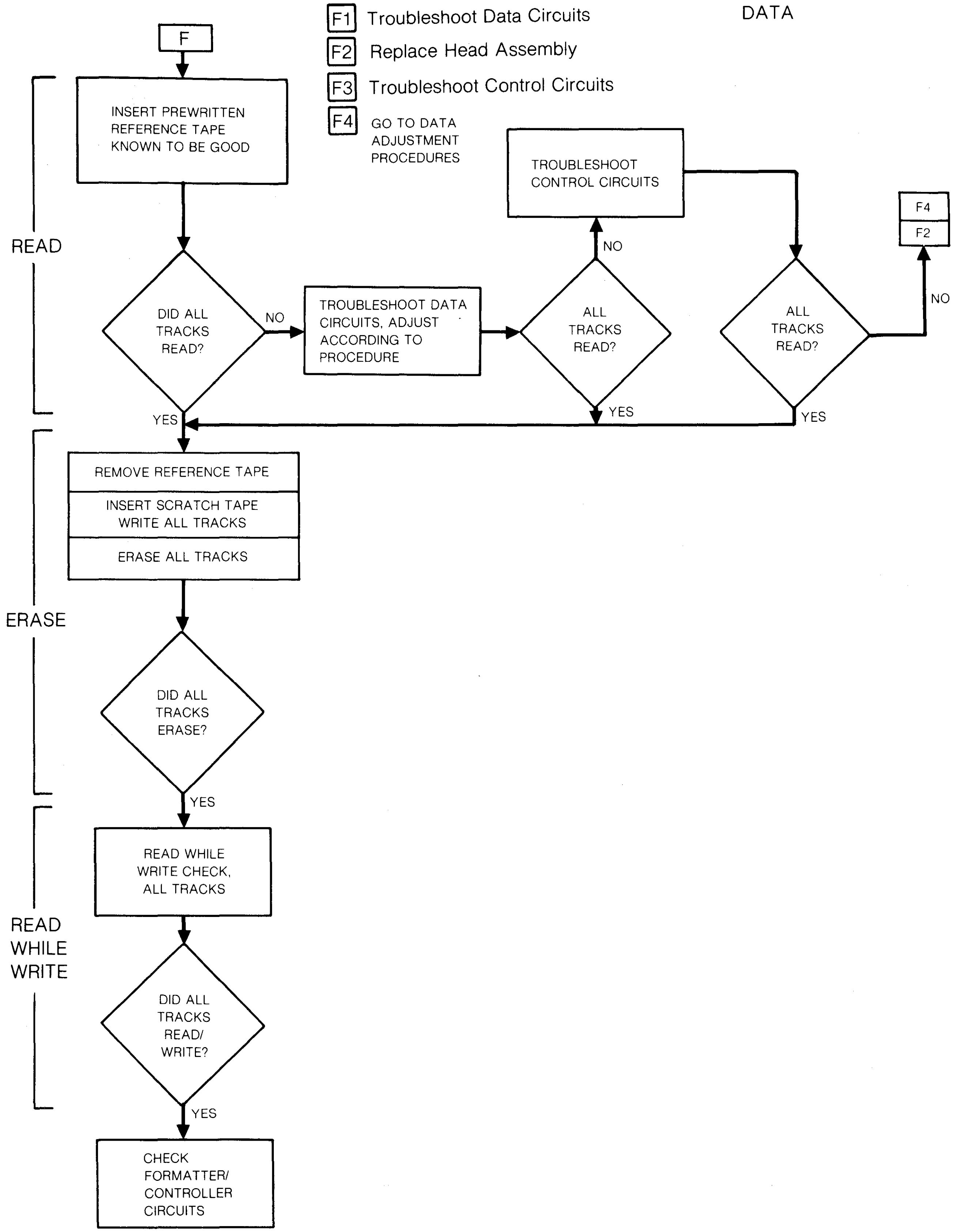


Figure 5-5 TROUBLESHOOTING FLOWCHART
(Sheet 6 of 6)

SECTION 6 PARTS LIST

6.1 GENERAL

Subassemblies manufactured by DEI are listed below by model number. Refer to Section 5.3 for pictorial views and disassembly method.

Components using the DEI 7000 Streamer Series are common to most local parts distributors. Special parts, not common to local distributors, have been assigned DEI part numbers. These parts must be ordered from the DEI factory.

6.2 DEI Manufactured Subassemblies

DESCRIPTION	MODEL			
	7190	7290	7130	7230
Printed Circuit Assembly	307072	307072	307071	307071
Mechanical Assembly w/Heads	307027	307059	307027	307059
Motor Assembly	307088	307088	307088	307088
Flex Circuit Assembly	307075	307075	307084	307084

6.3 Special Component Parts List

USAGE	PART NO.	USAGE	PART NO.
U21,	307911	U68	307699
U25	307912	U69	307697
U39, 41, 57, 63	307901	U52	307700
U40	307902	U75	307907
U45 (90 ips)	307910	U66	307908
U45 (30 ips)	307945	U76	307707
U50	307909	U77*	
U53	307903	U82*	
U54	307904		
U59	307979		
U64	307906		

* U77 and U82 P/N's subject to change, contact DEI technical support.