REVISIONS

SYM	DESCRIPTION	BY	DATE	APPROVED
A	PILOT RELEASE PER CR/O 0227		5/17/82	N Howell
B	PRODUCTION RELEASE PER CR/O 0260 A	JB	7/22/82	N.A.TIPPLE
C	CHANGED PER CR/O 0287	JB	8/3/82	N.A.TIPPLE
D	CHANGED PER CR/O 0299	JB	8/17/82	N.A.TIPPLE
E	CHANGED PER CR/O 0329	JB	10/7/82	N.A.TIPPLE

NOTES UNLESS SPECIFIED

1 TOLERANCES
.XX ANGULAR
.XXX 0°30'
2 REMOVE ALL BURRS
3 BREAK ALL SHARP EDGES .010 APPROX.
4 MACH SURFACES 125✓ OR BETTER
5 DIM ARE IN INCHES
6 ( ) DIM ARE IN MILLIMETERS

DRAWN	JB	
CHECK		
APPR	N Howell	5/17/82
RELEASE		

ARCHIVE

MATERIAL:

FINISH:

MODEL NO.

TITLE

CARTRIDGE TAPE DRIVE
INTELLIGENT
PRODUCT DESCRIPTION

SIZE	DWG NO.	REV.
A	20092-007	E

SCALE | DO NOT SCALE DWG | SHEET 1 OF 74

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FIGURES

1.0 GENERAL INTRODUCTION

The Archive Intelligent Cartridge Tape Drive provides a user with a low cost, high performance mass storage device. The MODEL 9020I provides 90 ips tape speed and 20 Megabytes of user data storage. The MODEL 3020I provides 30 ips tape speed and 20 Megabytes of user data storage. The Intelligent Drive consists of two components, the Archive Streaming Cartridge Tape Controller and up to four Archive Streaming Basic Cartridge Tape Drives. The Basic Tape Drive has been designed specifically for a tape streaming environment at a recording density of 8000 bits per inch. The tape controller has been designed to complement the state-of-the-art design of the basic drive by incorporating a micro-computer to relieve the host CPU of the overhead functions associated with tape formatting, tape error processing, file mark processing and tape positioning. This high degree of intelligence is provided to minimize the engineering hardware and software efforts required to interface Archive Cartridge Tape Drives to a host CPU. Archive Cartridge Tape Drives equipped with the Archive Controller are called Intelligent Drives.

This document outlines the specifications for the Intelligent Drive. Since the Intelligent Drive operates exclusively in a streaming tape mode, a general description of tape streaming is appropriate before presenting the controller details. The advantages of tape streaming can best be seen when it is compared to conventional tape operation.

In conventional tape systems the recorded data is blocked into records which can be individually accessed and updated. To preserve the update feature for each record, the tape system must start and stop between records. This requirement necessitates the incorporation of fairly long inter-record gaps. The length of these gaps must be considered in the tradeoffs of tape utilization, tape speed, tape drive start and stop times, and tape drive complexity. Conventional tape systems are efficient, cost effective, computer peripherals which provide sequential access to small individual blocks of data. However, because of the long inter-record gaps, their tape utilization efficiency is typically low. Tape utilization efficiency is the ratio of data record length to data record length plus gap length. In tape cartridge systems, utilization efficiency can vary from less than 20% to almost 80%, but at 80% the record length is on the order of 4 Kilobytes and the advantages of short individual records are lost. Also, the tape system data through-put rate is proportional to the tape utilization efficiency.

A STREAMING TAPE SYSTEM PROVIDES MAXIMUM TAPE UTILIZATION AND HIGH THROUGH-PUT RATE FOR THOSE APPLICATIONS WHICH DO NOT REQUIRE THE TAPE SYSTEM TO UPDATE INDIVIDUAL RECORDS.

One obvious application is backup for Winchester disks. To achieve maximum tape utilization and data through-put rate, a Streaming Tape System incorporates very short inter-record gaps and constant high speed tape motion. The Streaming Tape System cannot update individual records which eliminates the inter-record start/stop requirement.

Therefore, the usual penalty of increased cost to increase the storage and performance is somewhat eliminated. When applied to the conventional 1/4 inch tape cartridge, streaming techniques will approach 100% tape utilization thereby providing a very low cost per bit for storage. By eliminating high performance start/stop requirements the tape can be moved in a cost effective manner at 90 IPS providing a system through-put of 20 megabytes in a little over four minutes. The low cost per bit for offline storage, the high data through-put rate and the minimum system cost make streaming cartridge tape systems an attractive backup device for Winchester disks and an attractive storage device for large volumes of data.

2.0 REFERENCE DOCUMENTS

ANSI X3.55-1977
ANSI X3.54-1976
ARCHIVE 20004-007

3.0 PRODUCT DESCRIPTION

This PRODUCT DESCRIPTION is applicable to the following INTELLIGENT CARTRIDGE TAPE DRIVES:

MODEL NUMBER	PART NUMBER
3020I	20038-011, -014
9020I	20036-011, -014

3.1 INTELLIGENT CARTRIDGE TAPE DRIVE

The ARCHIVE INTELLLIGENT CARTRIDGE TAPE DRIVE provides a user with the ability to take advantage of the cost savings associated with a streaming cartridge tape system without the usual delays associated with a full engineering program to develop a controller and software. The MODEL 9020I and MODEL 3020I Intelligent Cartridge Tape Drives consist of two components, the Archive Streaming Cartridge Tape Controller and up to four MODEL 9020B or MODEL 3020B Archive Streaming Tape Drives. Each Tape Drive is equipped with an 8" floppy disk mount to simplify integration into systems. The controller is attached to the 8" floppy disk mount behind the first drive.

3.2 CONTROLLER

The controller contains independent read and write channels, three 512 byte buffer memories, a host interface, a drive interface and a micro-computer. The incorporation of the micro-computer into the controller makes the tape formatting, tape error processing, tape positioning and tape motion controls invisible to the host system. Additionally, the micro-computer statistical error data may be used to prevent progressive deterioration of the tape system due to bad tapes and marginal components.

Archive Streaming Cartridge Tape Drives supported by the controller product are the 90 and 30 ips versions with four tracks (MODEL 9020B and MODEL 3020B respectively). Drives attached to the controller shall be all of the same type. The controller will not support combinations of unlike drives.

The host interface hardware is designed for easy connection to a variety of microprocessors and system buses. It consists of two programmed I/O control lines, two programmed I/O status lines, two DMA control lines, an 8-bit bi-directional bus, a bus direction line and a controller reset line. The host software drivers can be designed with as few as three commands, Read, Write and Read Status. With this software configuration, a 20 Megabyte Intelligent Drive will appear as a 20 Megabyte FIFO in which data is blocked into 512 byte blocks.

For those applications that require a more conventional tape format, the Controller has a variety of commands which permit:

1. Drive Select
2. Read Status-
   including error statistics
3. Position Tape to BOT
4. Retension Tape-
   part of an error recovery procedure
   recommended by cartridge tape suppliers
5. Erase Tape
6. Write
7. Read-
   including transfer of blocks
   containing hard errors
8. Write File Mark
9. Read File Mark

The flexibility of this controller design permits the user to quickly interface the Archive Streaming Cartridge Tape Drives to this CPU for evaluation. At the completion of the evaluation, this same system can be software upgraded and integrated into his operating system with a minimum software effort.

3.3 BASIC DRIVE

The MODEL 9020B or MODEL 3020B drive contains a basic main frame on which is mounted the magnetic recording head, capstan drive motor, tape hole sensors, "cartridge in place" and "safe" sensing switches. The drive electronics is packaged on two printed circuit boards, one mounted above and one mounted below the installed tape cartridge. The drive may be equipped with an optional front panel.

3.4 TAPE FORMAT

Magnetic tape is a very cost-effective mass storage media. However, even the highest quality tapes are not error free. The errors are caused by small imperfections in the tape oxide coating. Sensitivity to these oxide imperfections is somewhat proportional to the recording density. A high quality tape controller must incorporate a recording scheme which provides almost complete immunity to these errors in order to achieve an acceptable level of data integrity. There are many design parameters for the tape cartridge drive such as tape drive mechanics, drive electronics and data separator which must be controlled. These parameters are beyond the scope of this document. However, one of the factors in controlling tape errors is the tape format. This section will deal with the tape format and discuss the design tradeoffs in selecting the format for the Archive Controller.

Tape utilization is a tradeoff of the user data record length to inter-record gap length. If tapes could be produced with no imperfections, very long block lengths would be advantageous for increasing tape utilization. However, errors caused by tape imperfections are better handled when shorter record lengths are used. Streaming tape systems, as do most other tape systems, use a read after write technique to verify the recorded data shortly after it is written. In a conventional tape system, when a read after write error is detected, the tape is stopped, backed up and rewritten. Forward creep, a feature of most conventional tape systems, causes the rewritten record to be displaced in the forward direction from the previous position of the record. The inter-record gap is thus lengthened by each successive application of back-up and rewrite until the oxide imperfection causing the error has been eliminated from the data record. With a streaming tape system, back-up and rewrite would significantly decrease the system through-put and is therefore not an appropriate scheme. In streaming systems the Block In Error (BIE) is simply rewritten and no read after write errors are detected. Therefore, short block lengths provide better tape utilization than long block lengths for streaming systems. Furthermore, the hardware data separator provides more reliable results when it is resynchronized between each short block of data. For these reasons (and others beyond the scope of this discussion), a data block length of 512 bytes is used in the Archive Streaming Tape Controller.

The Archive Tape Format contains a total of 528.5 bytes per block arranged into fields consisting of the following bytes:

13 bytes Gap
0.5 bytes Sync Mark
512 bytes User Data
1 byte Block Address
2 bytes CRC

The 13 bytes of gap provide a constant frequency data field for resynchronization of the data separator. The Sync Mark provides a means of determining the byte boundaries within the serial data stream from the tape. The User Data field is the user data. The Block Address byte is generated by the controller micro-computer and is part of the error processing scheme. When a block of data is detected with a read after write error, it is rewritten on the tape. On the read-back operation the address byte maintains the proper sequence of error free data blocks to the host. The final two bytes, the CRC, are a polynominal function of the data block. During the read-back operation this polynominal is regenerated and compared to the polynominal generated by the write data. If both polynominals match, the read-back data is the same as the data originally written onto the tape (i.e., no errors).

In summary, the data is recorded onto the tape in 528.5 byte blocks. Of these, 512 are user data and 16.5 are overhead bytes. This provides a tape utilization factor of 97% while providing data separator resynchronization and error checking every 528.5 bytes.

Another factor affecting the overall data integrity of the tape system is the recording code. The Archive Tape Controller uses a (0,2) run length limited code. This code was selected because it provides a uniquely identifiable gap field, because it provides a large data window for the data separator, and because it has been used successfully in high density tape recording. Run length limited recording codes are defined in section 5.1.

3.5 STORAGE MEDIA

Archive Intelligent Tape Drives use the Archive MODEL 09C 8000 BPI Data Cartridge (or equivalent) as the storage media. The MODEL 09C (Archive part number 20121-001) is a 450 feet long 1/4" wide tape cartridge that is described mechanically by ANSI standard X3.55-1977 and qualified for 8000 BPI operation by Archive.

4.0 PERFORMANCE FEATURES

The Streaming Tape Controllers are designed for optimum performance in fixed disk back-up applicational and as a result embody the following features:

- 20 megabytes of formatted mass storage at low cost for small systems users.
- Industry standard 8" flexible disk DC power voltages.
  1. Simplifies integration into floppy disk based systems.
  2. +24 and +5 VDC power allows for use of available power supplies.
- Controls up to four basic drives for a total capacity of 80 megabytes of formatted mass storage.
- Uses SELECTED LED on basic drive to tell operator when not to remove cartridge.
- High speed (approximately 90 ips) for non read/write tape motion operation with 30 ips drives.
- Use of 8" floppy disk mount simplifies integration and reduces costs.
- Formats data into convenient blocks of 512 user data bytes.
- Provides simple, easy to interface, byte wide interface with full handshake controls.
- Contains on board buffering for automatic rewrite of blocks containing read-after-write errors.
- Extensive read retry capability to recover "hard to read" blocks.
- Provides multiple file and file ID search capability.
- Underrun and Error Statistics.
- High Through-put.

5.0 OPERATIONAL SPECIFICATION

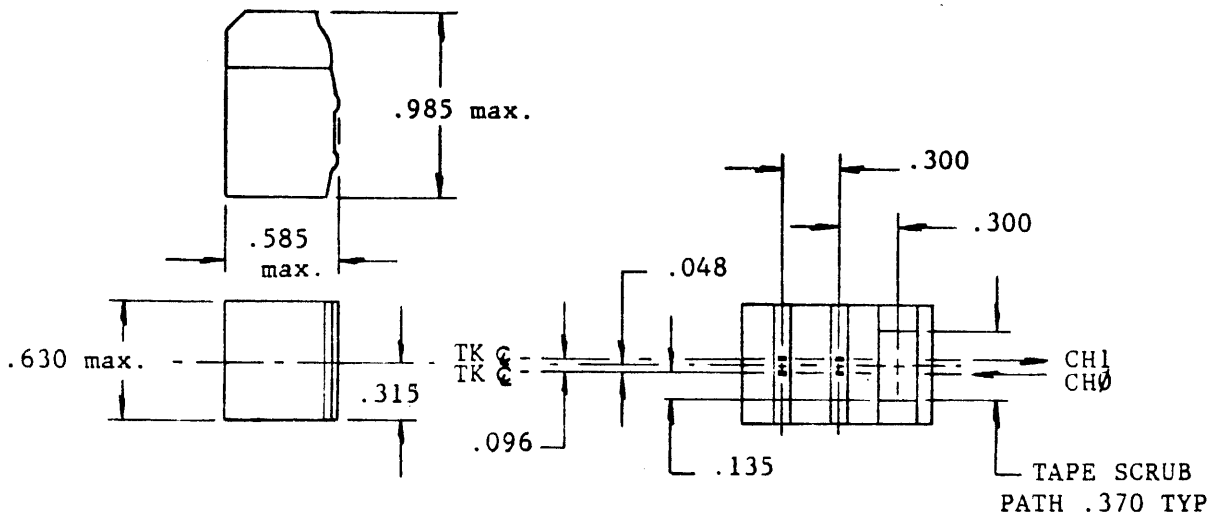
5.1 DATA HANDLING

Capacity, Streaming	20.83 +4% M bytes
Number of Recording Tracks	4
Average Streaming Write Transfer Rate MODEL 9020I	86.7 +/- .01% k bytes/sec
Average Streaming Write Transfer Rate MODEL 3020I	28.9 +/- .01% k bytes/sec
Burst Data Transfer Rate	200 k bytes/sec max
Average Streaming Read Transfer Rate MODEL 9020I	86.7 +4% k bytes/sec
Average Streaming Read Transfer Rate MODEL 3020I	28.9 +4% k bytes/sec
Recording Form	4 track "serpentine"
Recording Code	(0,2) run length limited
Head type	Read after write with separate erase bar

"Serpentine" refers to the technique of recording logically adjacent tracks in opposite directions, even numbered tracks in a forward direction and odd tracks in a reverse direction. Tracks are recorded serially one at a time. This technique eliminates the need of rewinding the tape to read or write the next track of data and allows the tape to logically appear as one track 1800 feet long.

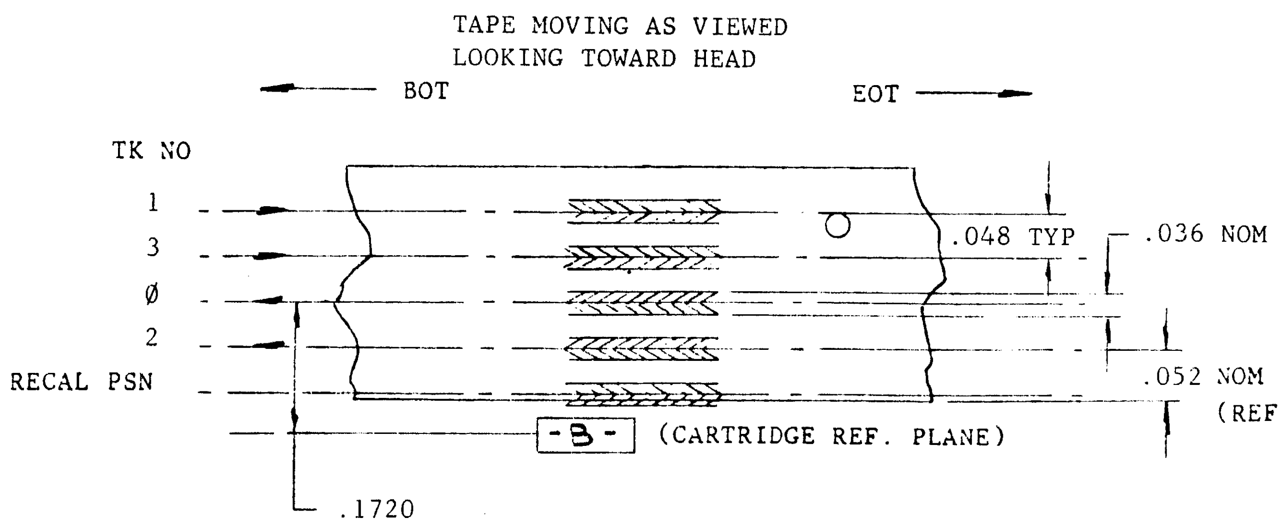
Run length codes (d,k) are recording codes in which flux transitions (ones) are separated by at least "d" zeros (not flux transitions) but no more than "k" zeros.

The erase bar is full width and can erase the tape in one pass. See Figure 1 for recording head characteristics, Figure 2 for recording track layout and Figure 3 for tape cartridge characteristics.



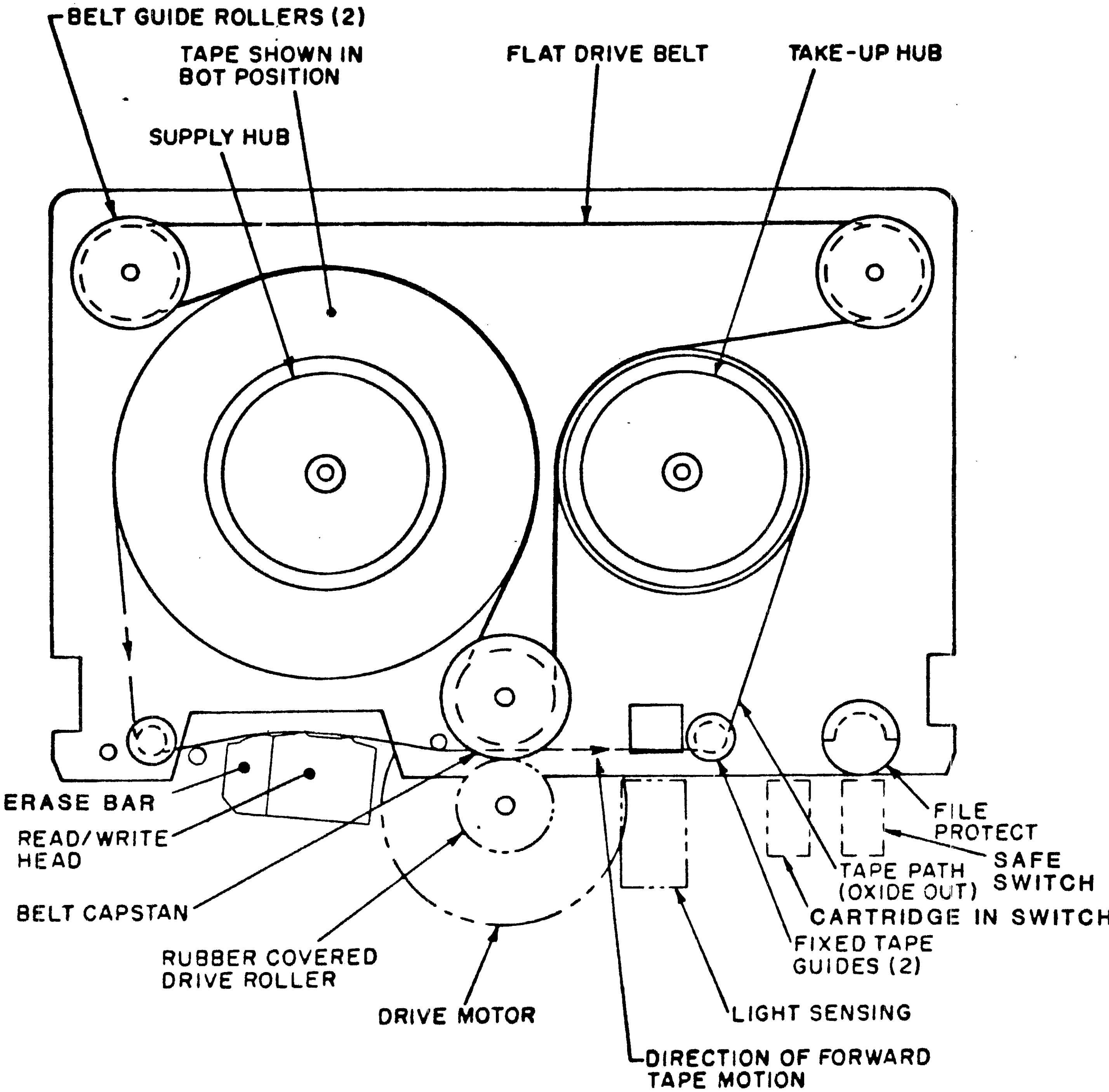
HEAD DETAIL

FIGURE 1
SCALE: 1:1



TRACK DETAIL

FIGURE 2



CARTRIDGE DETAIL
FIGURE 3

5.2 DATA RELIABILITY

Read soft error rate	Not more than 1 in 1E8 bits
Read hard error rate	Not more than 1 in 1E10 bits

A soft error is one that can be recovered in 16 or less retries. A hard error is one that cannot be recovered in 16 or less retries. The Archive MODEL 09C 8000 BPI Data Cartridge (or equivalent) is required to achieve these error rates.

(the term E = X10 raised to the power of the number following)

5.3 POWER REQUIREMENTS

5.3.1 INTELLIGENT DRIVE

DC Voltage	+24 volts	+5 volts
Tolerance including max peak to peak ripple of	+/-10% 500 millivolts	+/-5% 100 millivolts
Current		
standby	0.2 amps nom	3.5 amps max
operational	0.8 amps nom 1.7 amps max	3.5 amps max
tape start surge	2.5 amps max for up to 300 millisec (may be longer for defective cartridge)	N/A
power on surge thru capacitance of	1250 uF max	100 uF max
Voltage rise time	N/A	50 msec max, else use RST-
Power sequence	turn on 24 VDC before 5 VDC, else use RST-	N/A

Power Dissipation
35 watts typical
60 watts maximum

The DC Power Connector (J2) is an AMP P/N 1-480426-0. The mating connector (P2) requires an AMP P/N 10480424-0 and uses AMP P/N 60619-1 female contacts. The power connections are as follows:

Pin 1	+24VDC
Pin 2	+24VRET
Pin 3	+5VRET
Pin 4	+5VDC

Pins 2 and 3 are connected together at the controller.

5.3.2 BASIC DRIVE

DC Voltage	+24 volts	+5 volts
Tolerance including max peak to peak ripple of	+/-10% 500 millivolts	+/-5% 100 millivolts
Current		
standby	0.1 amps nom	1.0 amps max
operational	0.8 amps nom 1.6 amps max	1.0 amps max
tape start surge	2.5 amps max for up to 300 millisec (may be longer for defective cartridge)	N/A
power on surge thru capacitance of	1250 uF max	50 uF max
Voltage rise time	N/A	50 msec max, else use RST-
Power sequence	turn on 24 VDC before 5 VDC, else use RST-	N/A

Power Dissipation
30 watts typical
50 watts maximum

The DC Power Connector (J2) is an AMP P/N 1-480426-0. The mating connector (P2) requires an AMP P/N 10480424-0 and uses AMP P/N 60619-1 female contacts. The power connections are as follows:

Pin 1	+24 VDC
Pin 2	+24VRET
Pin 3	+5VRET
Pin 4	+5VDC

Pins 2 and 3 are connected together at the drive.

5.4 PHYSICAL CHARACTERISTICS

5.4.1 INTELLIGENT DRIVE DIMENSIONS

DEPTH	14.00 +/-.01 in	336.6 +/-.25 mm
WIDTH	8.55 +/-.01 in	217.2 +/-.25 mm
HEIGHT	4.5 +0,-.2 in	114.3 +0,-5.1mm
WEIGHT	4.0 +/-.2 lb	1.81+/-.09 kg

5.4.2 BASIC DRIVE DIMENSIONS

DEPTH	14.00 +/-.01 in	336.6 +/-.25 mm
WIDTH	8.55 +/-.01 in	217.2 +/-.25 mm
HEIGHT	4.5 +0,-.2 in	114.3 +0,-5.1mm
WEIGHT	3.0 +/-.1 lb	1.36+/-.05 kg

5.4.3 MOUNTING

Physical mounting of the SIDEWINDER INTELLIGENT or BASIC Drive is achieved with the Archive standard 8" floppy disk mount (Figure 6, OUTLINE DRAWING, INTELLIGENT TAPE DRIVE).

The drive is tested for alignment in the horizontal plane and in the vertical plane with the head below the motor. It is recommended that the units be mounted only in one or other of these orientations.

If the drive is mounted for operation in a dirty environment, positive measures should be taken to ensure that contaminants do not enter the drive.

SIDEWINDER DRIVES can be optionally supplied with a front panel. There is no rear panel. All connections are made directly to the printed wiring board via ribbon cable (I/O) and AMP (power) type connectors.

5.5 CARTRIDGE LOADING AND UNLOADING

The cartridge is loaded by pushing it to a hard stop through the loading aperature. There is only one orientation of the cartridge which allows it to be loaded.

The cartridge is unloaded by pulling it from the drive.

5.6 MEAN TIME BETWEEN FAILURES

The Mean Time Between Failures (MTBF) shall be greater than 3500 hours. This time includes all power on and operational time but excludes any maintenance periods. The operational versus power on time is assumed to be 30%.

5.7 CLEANING

The recording head should be cleaned after the first 2 hours of tape movement of a new cartridge and thereafter every 8 hours of tape movement with a lintless cotton swab coated with isopropyl alcohol or IBM Cleaner.

5.8 ENVIRONMENTAL CHARACTERISTICS

5.8.1 TEMPERATURE

Equipment Operational	+5 to +45 degrees C
Equipment Non-Operational	-30 to +60 degrees C

5.8.2 RELATIVE HUMIDITY

Equipment Operational	20 to 80% non-condensing
Maximum Wet Bulb Temperature	26 degrees C
Equipment Non-Operational	0 to 99% non-condensing

5.8.3 THERMAL GRADIENT

Equipment Operational	1.0 degree C/min

5.8.4 ALTITUDE

Equipment Operational	-1,000 ft to 15,000 ft
Equipment Non-Operational	-1,000 ft to 50,000 ft

5.8.5 AMBIENT CONDITIONS

Free air flow is required to prevent the drive ambient temperature from rising above 45 degrees C (113 degrees F) under operating conditions. Otherwise forced cooling to achieve the operating temperature requirements should be supplied.

5.8.6 SHOCK

Equipment Operational	2.5 g max., 1/2 sine wave, 11 msec duration on any axis
Equipment Non-Operational Cartridge and Front Panel Installed	25 g max., 1/2 sine wave, 11 msec duration on any axis
Equipment Non-Operational Cartridge and Front Panel Not Installed	50 g max., 1/2 sine wave, 11 msec duration on any axis

5.8.7 VIBRATION

Equipment Operational	0.005 inch max peak to peak displacement 0 to 63 Hz, 1 g max. acceleration 63 to 500 Hz
Equipment Non-Operational	0.1 inch max peak to peak displacement 0 to 17 Hz, 1.5 g max. acceleration 17 to 500 Hz

5.9 MEAN TIME TO REPAIR

The Mean Time To Repair (MTTR) is the average time required by an Archive Field Engineer (or equivalent) to diagnose and repair a defective Archive Intelligent Cartridge Tape Drive by replacement of any of three major electronic or any of three major mechanical assemblies and shall be less then 0.5 hours over the design life of the product.

6.0 CONTROLLER OPERATIONAL SEQUENCES

This section describes the typical sequences of events that occur within the controller for various commands. Also, this section deals only with the error free operational sequences for the controller.

6.1 POWER-ON/RESET SEQUENCE

The POWER-ON/RESET sequence provides the host with the information on "power on" occurrences in the controller. It also provides a convenient mechanism for initializing the controller during hardware and software debugging of the host interface.

1. The host applies power to the controller or applies a pulse on the controller reset line. Controller circuitry is reset. EXCEPTION is asserted.
2. When the power on reset times out, or when the reset pulse terminates, the controller micro-computer initializes operating parameters, clears the "at position" flag (see below) and "light" bit (see 9.0), resets all drives and defaults to drive 0 for subsequent commands.
3. The controller waits for the host to issue a command.
4. If the command issued was a Read-Status command, the controller now executes the command by transferring the six status bytes, byte 1 (the second byte) bit 0 of which is set to indicate that a power-up or reset has occurred.

The "at position" flag determines where read and write operations begin on the tape as follows:

"AT POSITION" FLAG	READ OR WRITES BEGIN
OFF	AT BOT
ON	AT CURRENT TAPE POSITION

6.2 SELECT COMMAND SEQUENCE

The select command allows the host to select one of up to four drives connected to the controller.

1. The host issues the SELECT command.
2. The controller saves the drive address and "light" bit.
3. If the "light" bit is on, the controller selects the drive and indicates command completion to the host (see 6.17). The drive will remain selected until changed by another SELECT command or RESET (6.1).

6.3 READ STATUS COMMAND SEQUENCE

The READ STATUS command provides host with information about the controller and selected drive.

1. The host issues the READ STATUS command.
2. The controller selects the drive and obtains drive status.

3. The controller transfers all six bytes to the host.
4. The controller deselects the drive if the cartridge is at BOT and if the "light" bit is off (see 6.17).

6.4 BOT COMMAND SEQUENCE

The BOT command allows the host to position the tape in the cartridge in the selected drive to BOT (beginning of tape).

1. The host issues the BOT command.
2. The controller selects the drive.
3. The controller selects high speed, sets reverse direction, clears the "at position" flag and enables the capstan motor.
4. The controller delays until the tape BOT holes pass the drive tape hole sensor.
5. The controller deselects the drive if the "light" bit is off and indicates command completion to host (see 6.17).

6.5 RETENSION COMMAND SEQUENCE

Tape RETENSION is recommended by cartridge tape suppliers before writing or reading data when the cartridge has been subjected to a change in environment or not used for 2 or more weeks. It should also be used to assist in recovering data from "difficult to read" cartridges.

1. The host issues the RETENSION command.
2. The controller selects the drive.
3. The controller selects high speed, clears the "at position" flag and moves the tape to BOT.
4. The controller selects high speed and moves the tape to EOT.
5. The controller selects high speed and moves the tape to BOT.
6. The controller deselects the drive if the "light" bit is off and indicates command completion to the host (see 6.17).

6.6 ERASE COMMAND SEQUENCE

The ERASE command is used to completely clear the tape before writing the first file of what is intended to become a multiple file tape. Also, it is equivalent to a RETENSION.

1. The host issues the erase command.
2. The controller selects the drive.
3. The controller selects high speed, clears the "at position" flag and moves the tape to BOT.
4. The controller enables the erase bar which will erase the entire tape, selects high speed and moves the tape to EOT.
5. The controller disables the erase bar, selects highspeed and moves the tape to BOT.
6. The controller deselects the drive if the "light" bit is off and indicates command completion to the host (see 6.18).

6.7 WRITE COMMAND SEQUENCE

Steps 2 through 5 apply if the "at position" flag is off, otherwise the controller performs a write reposition sequence (6.12).

1. The host asserts ONLINE and issues the WRITE command.

2. The controller requests and transfers the first block of data.

3. The controller selects the drive, positions the tape to BOT and selects Track 0.

4. The controller enables the erase bar which will erase the entire tape just prior to recording it. The controller also enables the write head and writes gap.

5. The controller enables the drive capstan motor and delays until the write head is over the certified media area (past the tape load point hole).

6. The controller requests the second block from the host and begins recording blocks of data on the tape, adding gap, sync, block address and CRC. The controller attempts to keep all buffers filled by initiating a block transfer as soon as a buffer becomes available.

7. As each block reaches the read head, the block is checked for errors.

8. After a block has been verified with a read after write check, the corresponding buffer is released for further data transfers from the host.

9. Steps 6, 7 and 8 are repeated for each data block (about 10,000 per track) until the controller detects the tape early warning hole. At this time, the controller ceases to transfer additional blocks from the host and writes all buffers to tape, verifying each with a read after write check.

10. The controller continues to erase and write gap until the tape EOT holes have reached the tape hole sensors. Then the controller deselects the write mode, disables the erase bar and stops the capstan motor.

11. The controller requests and transfers the first data block, switches to Track 1, starts writing gap, reverses the capstan motor direction, enables the capstan motor, delays until the write head is over certified media (past the tape early warning hole) and resumes writing.

12. Unless the host discontinues data transfers, Steps 9, 10 and 11 are repeated for each additional pair of tracks.

13. If the host does not discontinue data transfers by the early warning hole of the last track, the controller performs an "end of media" sequence (6.14).

14. The host discontinues writing by issuing a WRITE-FILE-MARK command. The controller performs a WRITE-FILE-MARK sequence (6.9).

15. The host may discontinue writing by deactivating ONLINE in which case the controller performs a write off line sequence (6.15).

6.8 READ COMMAND SEQUENCE

Steps 2 through 3 apply if the "at position" flag is off, otherwise the controller performs a read reposition sequence (6.13).

1. The host asserts ONLINE and issues the READ command.

2. The controller selects the drive, positions the tape to BOT and selects Track 0.

3. The controller enables the capstan motor, delays until the tape is up to speed (past the tape load point hole) and then searches for the first data block.

4. The controller reads the entire data block to the read buffer and checks the CRC and the block address number.

5. If the CRC and block address are good, the block is transferred to the host.

6. Steps 4 and 5 are repeated for all of the recorded blocks on Track 0.

7. When the EOT tape holes are detected for Track 0, the controller stops the capstan motor, selects Track 1, reverses the direction of the drive's capstan motor, enables the capstan motor and delays until the tape is up to speed (past the early warning hole).

8. All of the records on Track 1 are read, error checked and transferred to the host.

9. Tracks 2 and 3 are handled in the same manner as Tracks 0 and 1.

10. The Read command is terminated by the controller if a file mark is detected. The host is informed by means of an EXCEPTION and a READ STATUS sequence.

11. The host may terminate the READ command by deactivating ONLINE. The controller then performs an off line sequence (6.16).

12. The host may alternatively terminate the READ command by issuing a READ-FILE-MARK command. No further data is transferred. The controller performs a READ-FILE-MARK command beginning with step 4 of section 6.10.

13. If instead a Read command is issued, the command is accepted and the drive simply continues reading.

The host may write file ID (identification) data in the first block or blocks of a file. File ID search can be performed by reading the first block or blocks of a file and checking the ID fields. If it is not the desired file, the READ command can be changed to a READ-FILE-MARK command by the host to avoid handling the remaining blocks of the file.

6.9 WRITE-FILE-MARK COMMAND SEQUENCE

The WRITE-FILE-MARK (WFM) command will generate a standard length data block with unique codes in the user data field, a block address and a CRC. The host does not transfer any data for the file mark block.

Steps 1 through 4 apply if the controller is executing a WRITE command.

1. The host issues the WRITE-FILE-MARK command at any data block boundary.
2. The controller writes the remaining blocks of data in controller buffers.
3. The controller generates a file mark block and writes this block on the tape.
4. The controller performs a "last block" sequence (6.11).

If the host terminates a WRITE command without issuing a WRITE-FILE-MARK command (i.e. by dropping ON LINE), the controller will automatically generate the file mark by performing steps 2 through 4 above, followed by steps 3 through 5 of the BOT COMMAND SEQUENCE (6.4).

There is no restriction concerning the number of file marks that can be placed on the tape, or the number of user data blocks placed between the file marks. After issuing a WRITE-FILE-MARK command, the host can immediately issue another WRITE-FILE-MARK command or WRITE command and continue transferring subsequent files to the tape.

If the controller were not executing a WRITE command the host must assert ONLINE in step 1 above prior to issuing the WRITE-FILE-MARK command. If the "at position" flag were not set the controller would substitute steps 2, 4 and 5 of the WRITE sequence (6.7) in place of step 2. If the "at position" flag were set, the controller would substitute steps 2 through 9 of the write reposition sequence (6.12) in place of step 2.

6.10 READ-FILE-MARK COMMAND SEQUENCE

The READ-FILE-MARK command reads data but none is transferred to the host. Steps 2 through 3 apply if the "at position" flag is off, otherwise the controller performs a read reposition sequence (6.13).

1. The host asserts ONLINE and issues a READ-FILE-MARK command.

2. The controller selects the drive, positions the tape to BOT and selects track 0.

3. The controller enables the capstan motor, delays until the tape is up to speed (past the tape load point hole).

4. The controller then searches for the first data block containing file mark data.

5. The controller terminates the READ-FILE-MARK command if a file mark or EOT holes for the last track is detected by stopping the capstan motor, setting the "at position" flag and informing the host by means of an EXCEPTION and READ STATUS.

6. If host terminates the READ-FILE-MARK command by dropping ONLINE, the controller continues until the file-mark is found, and then performs an "off line sequence" (6.16).

6.11 LAST BLOCK SEQUENCE

The LAST BLOCK SEQUENCE was called from WRITE-FILE-MARK (6.9) step 4.

1. The read channel is read checking the last block.

2. The write channel finishes writing the last block and commences to rewrite the last block.

3. The read channel finishes read checking the last block and commences to read but not read check the rewritten last block.

4. The write channel finishes writing the rewritten last block and commences to write a long gap (0.3 inches).

5. The read channel finishes reading but not read checking the rewritten last block and tests for 2 milliseconds of long gap.

6. The erase bar is disabled, writing is disabled, the "at position" flag is set and the capstan motor is stopped.

6.12 WRITE REPOSITION SEQUENCE

The WRITE REPOSITION SEQUENCE was called from WRITE command (6.7) when the "at position" flag was set. The tape is stopped.

1. The controller transfers the next data block.

2. The controller reverses direction and enables the capstan motor.

3. The controller delays for 640 milliseconds.

4. The controller delays for 10 blocks (128 blocks for more than two consecutive write repositions).

5. The controller stops the capstan motor, selects original direction and enables the capstan motor.

6. The controller delays for 640 milliseconds.

7. The controller searches for a block containing the address of the last written block.

8. The controller searches for the long gap and delays 1 millisecond.

9. The controller starts writing gap and enables erase if on track 0.

10. The controller resumes the WRITE command sequence at step 6 of WRITE command sequence (6.7).

6.13 READ REPOSITION SEQUENCE

The READ REPOSITION sequence was called from the READ command sequence (6.8) when the "at position" flag is set. The tape is stopped.

1. If any read buffers contain data, the controller requests and transfers a block to the host.

2. If any read buffer still contains data, the controller requests a block transfer. The controller reverses the direction and enables the capstan motor.

3. The controller delays for 640 milliseconds.

4. The controller delays for 10 blocks (128 blocks for more than two consecutive read repositions).

5. The controller stops the capstan motor, selects the original direction and enables the capstan motor.

6. The controller delays for 640 milliseconds.

7. The controller searches for the data block containing the address of the last block read.

8. The controller resumes at steps 4 of the READ command sequence (6.8).

6.14 END OF MEDIA SEQUENCE

The END OF MEDIA sequence was called from WRITE command (6.7) step 13.

1. The early warning hole of the last track is detected by the controller.

2. The controller ceases to transfer additional data blocks from the host and writes all buffers to tape verifying each with a read after write check. A last block sequence (6.11) is performed on the last block.

3. The controller terminates the WRITE command and reports END OF MEDIA by means of an EXCEPTION and READ STATUS.

4. The controller waits for the next command from the host.

If host issues a WRITE command, one block is transferred as part of the write reposition sequence (6.12) and one block is transferred at step 6 of the WRITE sequence (6.7) for a total of two blocks. The controller then repeats the end of media sequence. The cartridge is now full and further writing of data should not be attempted.

6.15 WRITE OFF LINE SEQUENCE

The WRITE OFF LINE sequence was called by the WRITE command (6.7) step 15.

1. Host deactivates ONLINE during WRITE sequence.

2. Controller ceases to transfer additional data blocks and writes remaining buffers to tape.

3. Controller performs a WRITE-FILE-MARK sequence (6.9).

4. Controller clears the "at position" flag and moves tape to BOT.

5. Controller deselects drive if the "light" bit is off (see 6.17).

6.16 OFF-LINE SEQUENCE

The OFF-LINE sequence was called from the READ command (6.8) step 11.

1. Host deactivates ONLINE.

2. Controller terminates READ command, if one was in progress, at the next block boundary.
3. Controller clears the "at position" flag and moves tape to BOT.

4. Controller deselects drive if the "light" bit is off (see 6.17).

6.17 CARTRIDGE EXTRACTION DURING COMMAND EXECUTION SEQUENCE

The SELECT LIGHT on the selected drive is lit while the drive is selected. The nature of the controller/drive interface is such that a drive is required to be continuously selected during the performance of any function. Therefore the SELECT LIGHT will be lit during execution of BOT (6.4), RETENSION (6.5), ERASE (6.6), WRITE (6.7), READ (6.8), WRITE-FILE-MARK (6.9), and READ-FILE-MARK (6.10) commands and will serve as a warning to the operator that the cartridge should not be removed by the operator. The drive is de-selected if the "light" bit is off after completion of the above commands (see above sequence) in order to extinguish the SELECT LIGHT on the drive and allow the operator to change cartridges. Should the cartridge be removed while SELECT LIGHT is on, the controller will perform the following sequence:

1. The controller will set the internal "cartridge not inplace" status bit to a "one".

2. The controller informs the host that the cartridge was removed by means of an EXCEPTION and READ STATUS.

A drive is selected momentarily (too short to be readily observed when the "light" bit is off) during a READ STATUS COMMAND to input drive status. Cartridge removal during a READ STATUS COMMAND is not monitored as in the above if the "light" bit is off.

For the case when the "light" bit is on (SELECT LIGHT of the drive on), the host must select the drive with the "light" bit off (see 9.0) in order to allow the operator to remove the cartridge without causing a cartridge removal exception condition.

7.0 ERROR PROCESSING AND RECOVERY

The Archive controller provides extensive error processing and recovery sequences which are invisible to the host CPU. This feature greatly reduces the software effort required to interface the controller. Because the error processing and recovery is invisible to the host system, the controller provides statistical information on the number of errors automatically processed. These statistics can be very useful during the evaluation phase of determining system performance. In the operational environment, these statistics are useful in providing media integrity data necessary for maintaining an acceptable level of data integrity.

The following error processing discussions will assume noncompounded (not multiple) errors. This does not imply that the controller cannot handle compounded errors, but that this discussion is intended to introduce only the basic principles of error recovery.

7.1 WRITE BUFFER UNDERRUN

Since tape streaming implies constant tape motion with small gaps between the data blocks, the host CPU must maintain an uninterrupted transfer of blocks to the controller. Once writing has been initiated and a full buffer is not available to the write channel when it is required, a WRITE UNDERRUN has occurred and it is logged in the statistical counters. The controller will initiate a last block sequence (6.11), rewriting the last block. If a full buffer is available before the read channel finishes checking the last block in step 3 of (6.11), writing continues without decreasing the system through-put by terminating tape motion. If a full buffer was not available, the last block sequence is completed and tape is stopped. A write reposition sequence (6.12) is then initiated.

A complete last block sequence requires 0.528 inches for the rewritten last block plus 0.300 inches for the extended gap. The write reposition sequence (6.12) adds 8.0 milliseconds which is 0.240 inches for 30 ips drives and 0.720 inches for 90 ips drives. Therefore, each write underrun requires:

ips	Inches	Blocks
90	1.548	2.929
30	1.068	2.033

Each underrun will subtract from the total tape capacity by the above amount and, by terminating the tape motion, will decrease the total data through-put. For these reasons, write buffer underruns are highly undesirable and should be considered when designing the host hardware and software.

7.2 READ AFTER WRITE ERRORS

To store 20 Megabytes of information on a streaming cartridge tape drive requires almost 1800 feet of recording length. At a density of 10,000 FCI, the information is recorded in 0.0001 inch increments. This means that for totally error-free recording, the recording area must be free of all contamination and imperfections approaching 0.0001 inches. This is a difficult requirement and, therefore, the controller must be designed to accomodate occasional data errors. To ensure that the data has been written correctly, a read check is performed on each block of data immediately following the write operation. If an error is found during the read check, that block will be rewritten. The three controller buffers are allocated as follows for executing a WRITE command: one for the block currently being written, one for the block being read checked so that the data is available for rewriting, and one for receiving the next data block from the host.

In order to perform read-after-write checking, the drive tape head has two gaps, one for writing and one for reading. These gaps are separated by a distance of 0.3 inches. For tape streaming, the inter-record gap length is only 0.013 inches. Therefore, the controller must begin writing the next record before the previous record has been completely verified by the read-after-write check.

Taking into account the above parameters, a read-after-write check will have the following sequence:

1. Begin writing block N.
2. When block N reaches the read head, read checking begins.
3. The write channel finishes writing block N.
4. A short resynchronization gap is generated and written.
5. The write channel begins writing block N+1.
6. The read channel finishes reading block N.
7. Block N has an error.

The read after write or block address error in 7 above will initiate the following error recovery sequence:

1. The controller finishes writing block N+1.

2. The write channel begins rewriting block N.

3. When block N (rewritten) reaches the read head, read checking begins.

4. The write channel finishes rewriting block N.

5. The write channel begins writing block N+1 (again).

6. The read channel finishes reading block N (rewritten).

If block N has a CRC error, the above error recovery sequence is repeated until no CRC error occurs or until the limit of 16 consecutive same block rewrites occurs.
If only one block remains to be written, a slightly altered sequence is performed (see last block sequence 6.11).

1. Begin writing block N (last block).

2. When block N reaches the read head, read checking begins.

3. The write channel finished writing block N.

4. A short resynchronization gap is generated and written.

5. The write channel begins writing block N again.

6. The read channel finishes readchecking block N. If a CRC error occurred in block N, the sequence resumes at step 2 and continues until no CRC error occurs or until the 16 same block rewrite limit occurs.

7. If the read check of block N at the read head is okay, the read channel commences to read but not read check the rewritten last block (step 3 of last block sequence 6.11).

8. Steps 4, 5 and 6 of last block sequence (6.11) are performed.

If the 16 same block rewrite limit occurs, the controller will terminate the write command and inform the host of an unrecoverable data error. Read after write error recovery is automatically processed by the controller. Since this process is invisible to the host, a statistical counter is provided to inform the host of the number of blocks automatically rewritten by the controller. As with write underruns, these rewritten blocks will subtract from the total capacity of the tape. Each rewritten block subtracts one block from the total capacity of the tape. Since each error recovery sequence normally rewrites two blocks, the statistical counter will normally contain an even number and usually represents the number of soft errors times two.

7.3 READ BUFFER UNDERRUN

With normal read operations the controller will locate a block of data, transfer it to the controller buffer memory and perform CRC check for errors. If no error occurs, the block will be transferred to the host. Since the controller contains three buffer memories, one is allocated to the read channel, one to the host, and one held in reserve in case the host system temporarily gets behind the transfer rate of the read channel. This scheme provides a one block buffer to allow for short term host system contentions before the read channel overruns the controller buffer memories.

However, if the host system fails to stay ahead of the read channel, a read buffer underrun will occur. This condition arises when the read channel has located the next block of data and none of the three controller buffer memories are available. In order to prevent the loss of this block, the controller must stop the tape. The controller then performs a read position sequence (6.13) and then resumes the normal read sequence (6.8).

Since the read channel buffer underrun recovery is invisible to the host, a statistical counter is provided to keep track of the number of underruns.

7.4 READ DATA ERRORS

The controller verifies the write data with a read-after-write check. This ensures that the data was correctly written onto an acceptable area of the magnetic tape. The number of variables associated with rereading this data is quite large and occasionally will result in temporary read errors. These errors must be expected and an error recovery scheme is mandatory if a satisfactory level of data integrity is to be achieved. The error recovery scheme for the Archive Controller involves rereading the block-in-error (BIE) 16 times before informing the host of an unrecoverable tape error. The process of rereading the BIE will be referred to as a soft error retry. (not to be confused with a "soft error" as defined in 5.2). During a read operation, if the controller encounters a data block with an error, the following sequence will be initiated:

1. Read the data block.

2a. If the next data block contains no CRC error and the same block address as the BIE, then the BIE was rewritten during the write operation.

This is an expected condition and will be invisible to the host. The controller will continue the read operation without informing the host of any unexpected conditions.

2b. If the next block contains no CRC error and a block address 1 greater than the BIE, then the BIE may or may not have been rewritten.

This is also an expected condition and will be invisible to the host. The controller will continue the read operation without informing the host of any unexpected conditions.

2c. If the next data block contains no CRC error and a block address 2 or more greater than the BIE, then the BIE was NOT rewritten.

The controller will perform a soft error retry. The soft error retry sequence is as follows:

1. Stop the tape.

2. Perform a reposition sequence (6.13) which continues the read sequence (6.8).

If the data block has not been successfully recovered after sixteen (16) retries, the controller will transfer the block in error (BIE) if it can be located, terminate the read operation and inform the host of an unrecoverable read error. A block is always transferred unless:

A. A read or write abort error occurs (7.6).
B. No more data is recorded on the media (7.7).

If the block transferred is not the block in error, the host will be notified.

Since soft errors are invisible to the host, a statistical counter is available. This counter is updated for each soft error (as defined in 5.2). The data blocks with CRC errors that were rewritten during the write process will not increment the soft error counter during a READ.

7.5 READ SEQUENCE ERRORS

The controller appends a block address byte to each data block written to the tape. As previously mentioned, during the write operation a data block with a read-after-write error will be rewritten. Rewritten blocks will alter the normal sequence of blocks. The controller will use the block address byte to maintain the proper sequence of data blocks sent to the host.

During read operations when a data block is read from the tape without a CRC error and an unexpected block address is encountered, a block sequence error will result. Block sequence errors will automatically invoke a soft error retry. The soft error retry sequence is the same as the sequence described for read data errors (7.4). The soft error counter will be incremented for each soft error as defined in 5.2. Retries continue until the proper sequence is re-established or until the limit of 16 retries is exceeded. If the 16 retry limit is exceeded, the controller will transfer the block-in-error (BIE) if it can be located, terminate the Read command and inform the host of an unrecoverable data error. A block is always transferred unless:

A. A read or write abort error occurs (7.6).
B. No more data is recorded on the media (7.7).

The host will be informed if the block transferred is not the BIE.

7.6 READ OR WRITE ABORT ERROR

A read or write abort error is an error which prevents a read or write sequence from being continued and consists of the following:

A. 16 same block rewrites on a WRITE sequence.
B. Unrecoverable reposition error.

7.7 NO DATA DETECTED ERROR

The read channel searches for a block over a length of tape equivalent to 32 block times in 30 ips operation (about 0.6 seconds). No recoverable blocks are found. The controller performs a long reposition sequence (see 6.13) and repeats for up to 2 attempts. If error persists, the controller informs the host of an unrecoverable data error, no data detected. No data is transferred.

8.0 HOST INTERFACE

This section will describe the interface between the host and the Archive controller. The interface hardware architecture is intended to minimize the number of interconnects between the host and the controller. Data and commands are transferred to and from the controller on an 8 bi-directional data bus using asynchronous handshaking techniques to eliminate rigorous timing constraints.

8.1 INPUT/OUTPUT SIGNAL PIN ASSIGNMENTS AND SIGNAL DESCRIPTION

PIN#	NAME	TO	DESCRIPTION
02	SPR-	X	SPARE - spare signal line
04	SPR-	X	
06	SPR-	X	
08	SPR-	X	
10	SPR-	X	
12	HB7-	B	HOST BUS BIT 7 - most significant bit of 8-bit host bi-directional data bus
14	HB6-	B	HOST BUS BIT 6
16	HB5-	B	HOST BUS BIT 5
18	HB4-	B	HOST BUS BIT 4
20	HB3-	B	HOST BUS BIT 3
22	HB2-	B	HOST BUS BIT 2
24	HB1-	B	HOST BUS BIT 1
26	HB0-	B	HOST BUS BIT 0 - least significant bit of 8-bit host bi-directional data bus
28	ONL-	C	ON LINE - host-generated control signal which is activated prior to transferring a READ or WRITE command and deactivated to terminate that READ or WRITE command.

30	REQ- C	REQUEST - host-generated control signal which indicates that command data has been placed on the data bus in COMMAND MODE or that status has been taken from the data bus in STATUS INPUT MODE, can be asserted by host only when RDY- or EXC- is asserted by controller.
32	RST- C	RESET - causes controller to perform same sequence as a POWER-ON sequence
34	XFR- C	TRANSFER - host-generated control signal which indicates that data has been placed on the data bus in WRITE MODE or that data has been taken from the data bus in READ MODE.
36	ACK- H	ACKNOWLEDGE - controller-generated signal which indicates that data has been taken from the data bus in WRITE MODE or that data has been placed on the data bus in READ MODE.
38	RDY- H	READY - controller-generated signal which indicates the following: (1) data has been taken from the data bus in COMMAND TRANSFER MODE (2) data has been placed on the data bus in STATUS INPUT MODE (3) a BOT, RETENSION or ERASE COMMAND is completed following issuance (4) a buffer is ready to be filled by the host, or a WFM command can be issued in WRITE MODE (5) a WFM command is completed in WRITE FILE MARK mode (6) a buffer is ready to be emptied by the host in READ MODE (7) OTHERWISE, controller is ready to receive a new command
40	EXC- H	EXCEPTION - controller-generated signal which indicates that an exception condition exists in the controller, that host MUST issue STATUS COMMAND and perform a STATUS INPUT to determine cause

42	DIR- H	DIRECTION - controller-generated signal which when false causes host data bus drivers to assert their data bus levels and controller data bus drivers to assume high impedance states, when true causes host data bus drivers to assume high impedance states and controller data bus drivers to assert their data bus levels
44	SPR- X	
46	SPR- X	
48	SPR- X	
50	SPR- X	

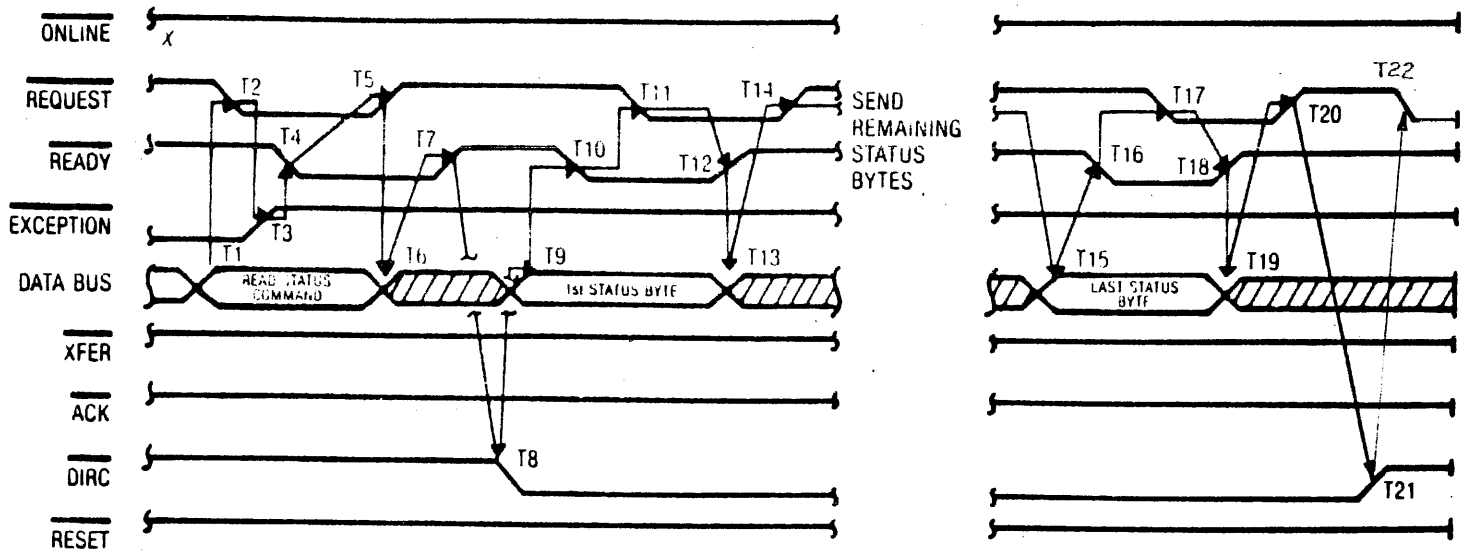
All odd pins are signal returns, are connected to signal GND at the controller and should be connected to signal GND at the Host. The "TO" nomenclature above is as follows:

X = UNDEFINED
B = BI-DIRECTIONAL
C = CONTROLLER
H = HOST

8.2 INTERFACE TIMING

Interface signal timing is presented in the following timing diagrams.

8.2.1 READ STATUS COMMAND TIMING



READ STATUS COMMAND

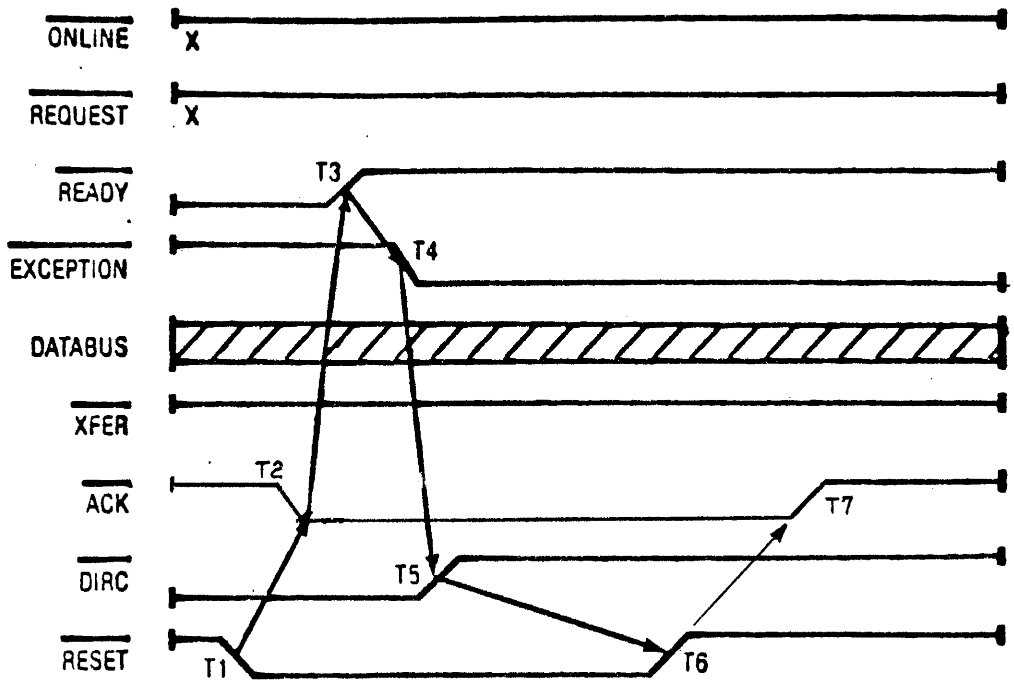
ACTIVITY	CRITICAL TIMING
T1-HOST COMMAND TO BUS	N/A
T2-HOST SETS REQUEST	T1→T2>Ø U sec.
T3-CONTROLLER RESETS EXCEPTION	T3→T4>10 U sec.
T4-CONTROLLER SETS READY	20<T2→T4<500 U sec.
T5-HOST RESETS REQUEST	T4→T5>Ø U sec.
T6-BUS DATA INVALID	T4→T6>Ø U sec.
T7-CONTROLLER RESETS READY	20<T5→T7<100 U sec.
T8-CONTROLLER CHANGES BUS DIRECTION	N/A
T9-1ST STATUS BYTE TO BUS	N/A
T10-CONTROLLER SETS READY	T7→T10>20 U sec
T11-HOST SETS REQUEST	T10→T11<500 U sec.
T12-CONTROLLER RESETS READY	T11→T12<0.25 U sec.
T13-BUS DATA INVALID	T11→T13>Ø U sec.
T14-HOST RESETS REQUEST	20<T11→T14<500 U sec.
T15-LAST STATUS BYTE TO BUS	N/A
T16-SAME AS T10	SAME AS T10
T17-SAME AS T11	SAME AS T11
T18-SAME AS T12	SAME AS T12
T19-SAME AS T13	SAME AS T13
T20-SAME AS T14	SAME AS T14
T21-CONTROLLER CHANGES BUS DIRECTION	T20→T21>Ø
T22-CONTROLLER SETS READY	T21→T22>Ø

X-DON'T CARE

ARCHIVE

TITLE	CARTRIDGE TAPE DRIVE INTELLIGENT PRODUCT DESCRIPTION
SIZE	A
DWG. NO.	20092-007
REV	E
SCALE	
DO NOT SCALE DWG	
SHEET	41 OF 74

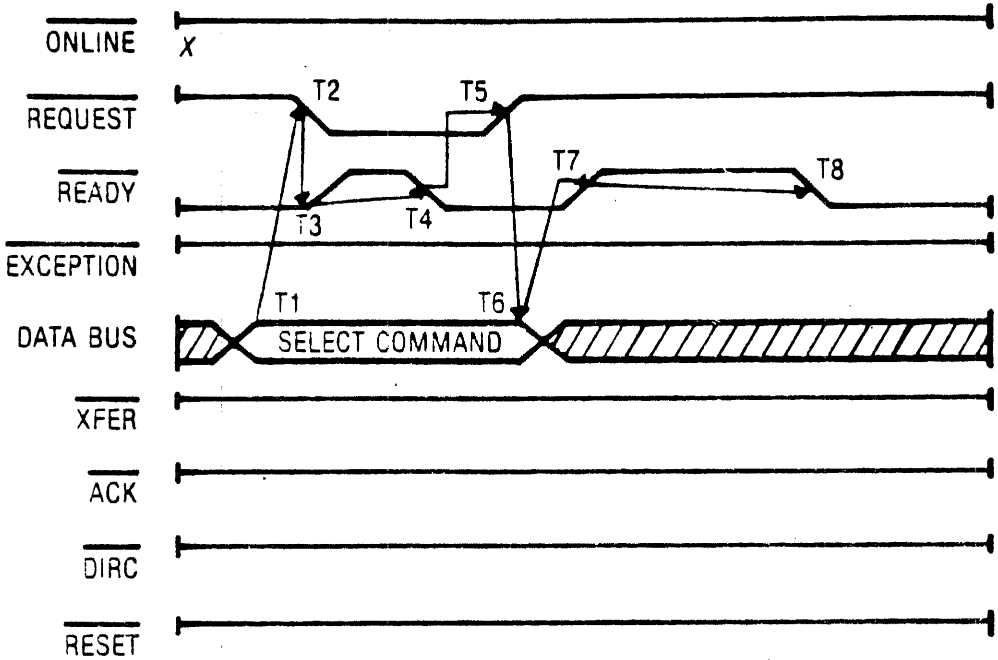
8.2.2 RESET TIMING



RESET TIMING

ACTIVITY	CRITICAL TIMING
T1-HOST ASSERTS RESET	NA
T2-CONTROLLER ASSERTS ACK	T1→T2<0.25 U sec.
T3-CONTROLLER DISABLES READY	T1→T3<0.25 U sec.
T4-CONTROLLER ASSERTS EXCEPTION	T1→T4<3 U sec.
T5-CONTROLLER DISABLES DIRC	T1→T5<3 U sec.
T6-HOST DISABLES RESET	T1→T6>13 U sec.
T7-CONTROLLER DISABLES ACK	T6→T7<3 U sec.
X-DON'T CARE	

8.2.3 SELECT COMMAND TIMING

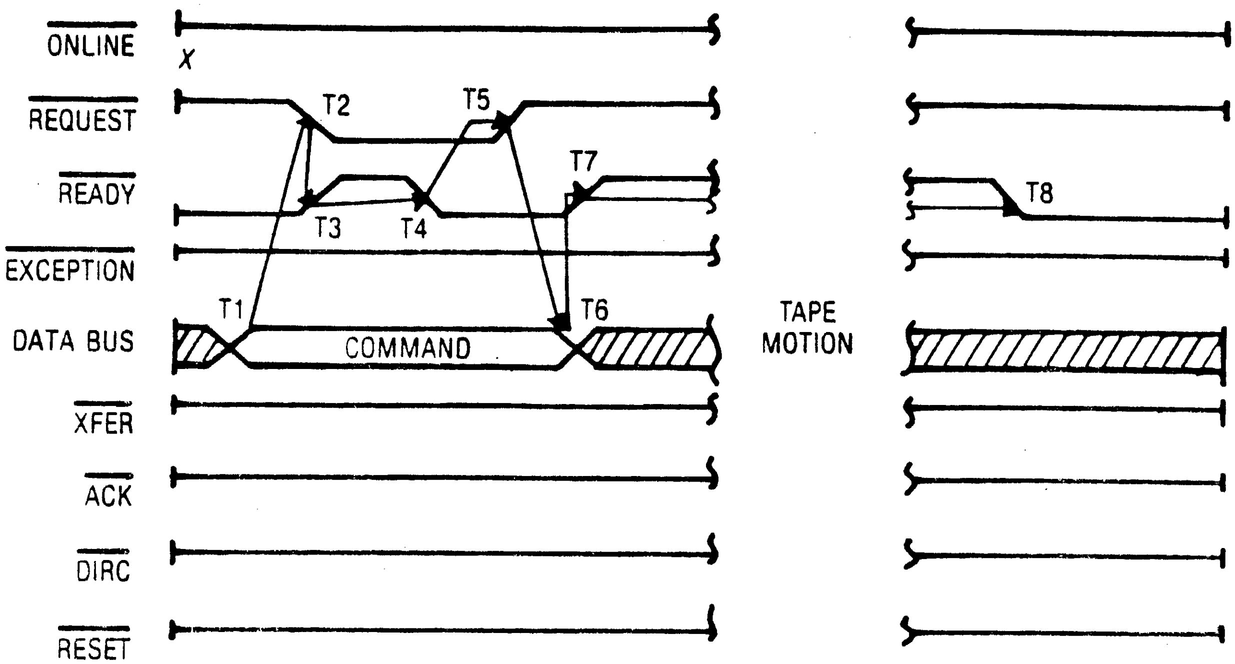


SELECT COMMAND

ACTIVITY	CRITICAL TIMING
T1-HOST COMMAND TO BUS	N/A
T2-HOST SETS REQUEST	T1→T2>Ø U sec.
T3-CONTROLLER RESETS READY	T2→T3<0.25 U sec.
T4-CONTROLLER SETS READY	50<T3→T4<500 U sec.
T5-HOST RESETS REQUEST	T4→T5>Ø U sec.
T6-BUS DATA INVALID	T4→T6>Ø U sec.
T7-CONTROLLER RESETS READY	20<T5→T7<100 U sec.
T8-CONTROLLER SETS READY	T7→T8>20 U sec.

X-DON'T CARE

8.2.4 BOT, RETENSION, OR ERASE TIMING

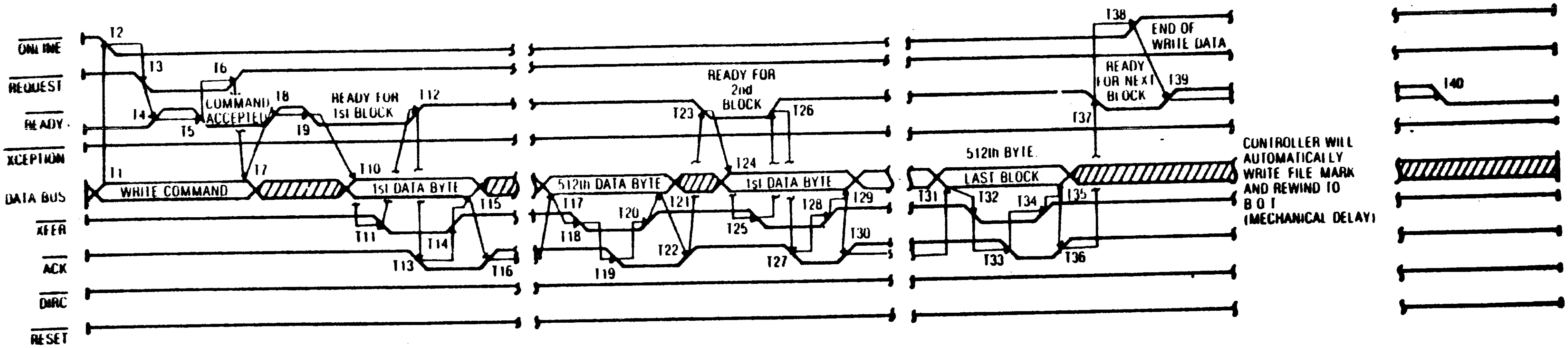


BOT, RETENSION OR ERASE COMMAND

ACTIVITY	CRITICAL TIMING
T1-HOST BUS DATA VALID	N/A
T2-HOST SETS REQUEST	T1→T2 = >Ø U sec.
T3-CONTROLLER RESETS READY	T2→T3 = <0.25 U sec.
T4-CONTROLLER SETS READY	20<T3→T4<500 U sec.
T5-HOST RESETS REQUEST	T4→T5 = >Ø U sec.
T6-BUS DATA INVALID	T4→T6>Ø U sec.
T7-CONTROLLER RESETS READY	20<T5→T7<100 U sec.
T8-CONTROLLER SETS READY	T7→T8 = >20 U sec.

X-DON'T CARE

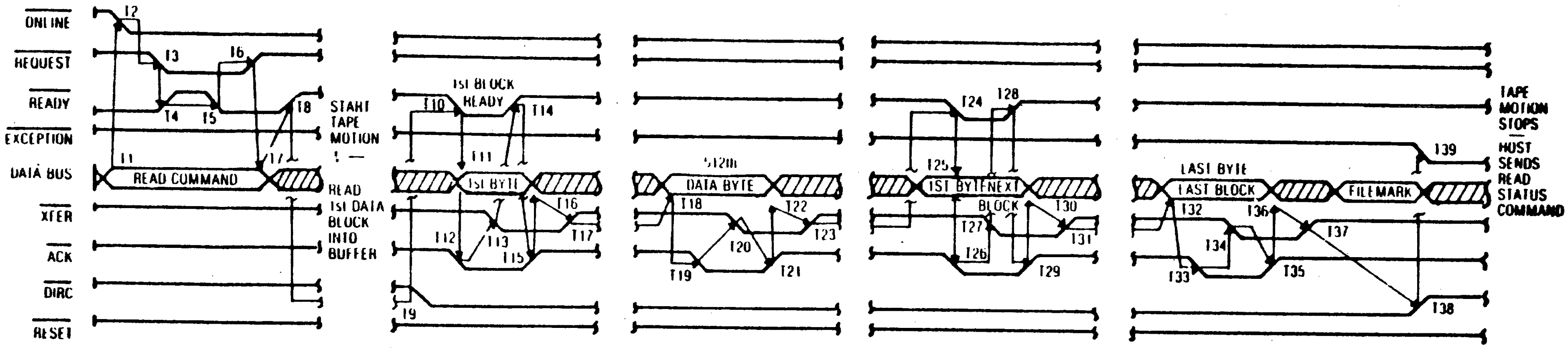
8.2.5 WRITE DATA TIMING



WRITE DATA COMMAND

ACTIVITY	CRITICAL TIMING
T1 HOST COMMAND TO BUS	N/A
T2 HOST SETS ONLINE	N/A
T3 HOST SETS REQUEST	T2→T3>Ø U sec
T4 CONTROLLER RESETS READY	T3→T4<Ø 25 U sec
T5 CONTROLLER SETS READY	20<T4→T5<500 U sec
T6 HOST RESETS REQUEST	T5→T6>Ø U sec
T7 BUS DATA INVALID	T5→T7>Ø U sec
T8 CONTROLLER RESETS READY	20<T6→T8<100 U sec
T9 CONTROLLER SETS READY	T8→T9>20 U sec
T10 HOST DATA TO BUS	N/A
T11 HOST SETS XFER	T10→T11>-40 NANO sec
T12 CONTROLLER RESETS READY	T11→T12<0 25 U sec
T13 CONTROLLER SETS ACK	56<T11→T13<4 47 U sec
T14 HOST RESETS XFER	T13→T14>Ø U sec
T15 BUS DATA INVALID	T13→T15>Ø U sec
T16 CONTROLLER RESETS ACK	0<T14→T16< 56 U sec
T17 HOST DATA TO BUS	N/A
T18 SAME AS T11	SAME AS T11
T19 SAME AS T13	SAME AS T13
T20 SAME AS T14	SAME AS T14
T21 SAME AS T15	SAME AS T15
T22 SAME AS T16	SAME AS T16
T23 CONTROLLER SETS READY	T22→T23>100 U sec
T24 HOST DATA TO BUS	N/A
T25 HOST SETS XFER	SAME AS T11
T26 CONTROLLER RESETS READY	SAME AS T12
T27 CONTROLLER SETS ACK	SAME AS T13
T28 HOST RESETS XFER	SAME AS T14
T29 BUS DATA INVALID	SAME AS T15
T30 CONTROLLER RESETS ACK	SAME AS T16
T31 HOST DATA TO BUS	N/A
T32 HOST SETS XFER	SAME AS T18
T33 CONTROLLER SETS ACK	SAME AS T19
T34 HOST RESETS XFER	SAME AS T20
T35 BUS DATA INVALID	N/A
T36 CONTROLLER RESETS ACK	SAME AS T22
T37 CONTROLLER SETS READY	SAME AS T23
T38 HOST RESETS ONLINE	N/A
T39 CONTROLLER RESETS READY	N/A
T40 CONTROLLER SETS READY	N/A

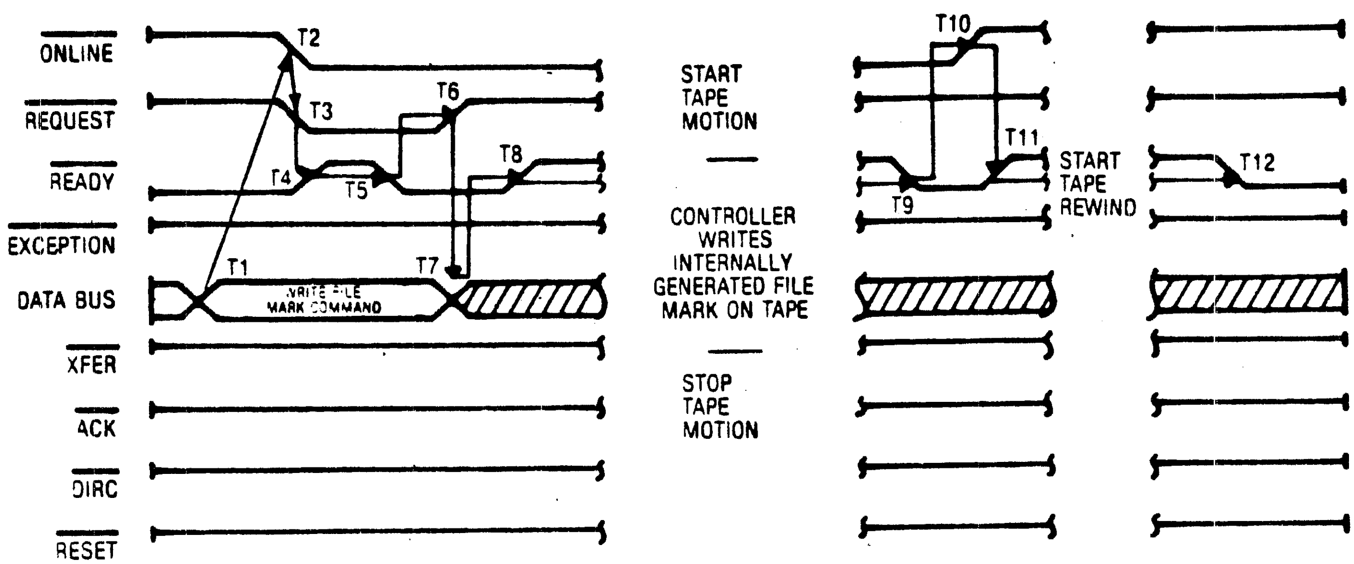
2.6 READ DATA TIMING



READ DATA COMMAND

ACTIVITY	CRITICAL TIMING	ACTIVITY	CRITICAL TIMING	ACTIVITY	CRITICAL TIMING
T1 HOST COMMAND TO BUS	N/A	T14 CONTROLLER RESETS READY	T13→T14< 25 U sec	T27 HOST SETS XFER	SAME AS T13
T2 HOST SETS ONLINE	N/A	T15 CONTROLLER RESETS ACK	56<T13→T15<1 12 U sec	T28 CONTROLLER RESETS READY	SAME AS T14
T3 HOST SETS REQUEST	T2→T3>Ø U sec	T16 BUS DATA INVALID	T13→T16>0 U sec	T29 CONTROLLER RESETS ACK	SAME AS T15
T4 CONTROLLER RESETS READY	T3→T4<0 25 U sec	T17 HOST RESETS XFER	T15→T17>0 U sec	T30 BUS DATA INVALID	SAME AS T16
T5 CONTROLLER SETS READY	20<T4→T5<500 U sec	T18 BUS DATA VALID	N/A	T31 HOST RESETS XFER	SAME AS T17
T6 HOST RESETS REQUEST	T5→T6 Ø U sec	T19 CONTROLLER SETS ACK	SAME AS T12	T32 LAST BYTE TO BUS	N/A
T7 BUS DATA INVALID	T5→T7>Ø U sec	T20 HOST SETS XFER	SAME AS T13	T33 CONTROLLER SETS ACK	SAME AS T12
T8 CONTROLLER RESETS READY	20<T6→T8<100 U sec	T21 CONTROLLER RESETS ACK	SAME AS T15	T34 HOST SETS XFER	SAME AS T13
T9 CONTROLLER CHANGES DIRC	N/A	T22 BUS DATA INVALID	SAME AS T16	T35 CONTROLLER RESETS ACK	SAME AS T15
T10 CONTROLLER SETS READY	-50 Usec<T10→T12<-20 Usec(REF)	T23 HOST RESETS XFER	SAME AS T17	T36 BUS DATA INVALID	SAME AS T16
T11 FIRST DATA BYTE TO BUS	N/A	T24 CONTROLLER SETS READY	N/A	T37 HOST RESETS XFER	SAME AS T17
T12 CONTROLLER SETS ACK	T11→T12>-40 NANO sec	T25 1ST BYTE TO BUS	N/A	T38 CONTROLLER SETS EXCEPTION	N/A
T13 HOST SETS XFER	T12→T13>Ø U sec	T26 CONTROLLER SETS ACK	SAME AS T12	T39 CHANGE BUS DIRECTION	N/A

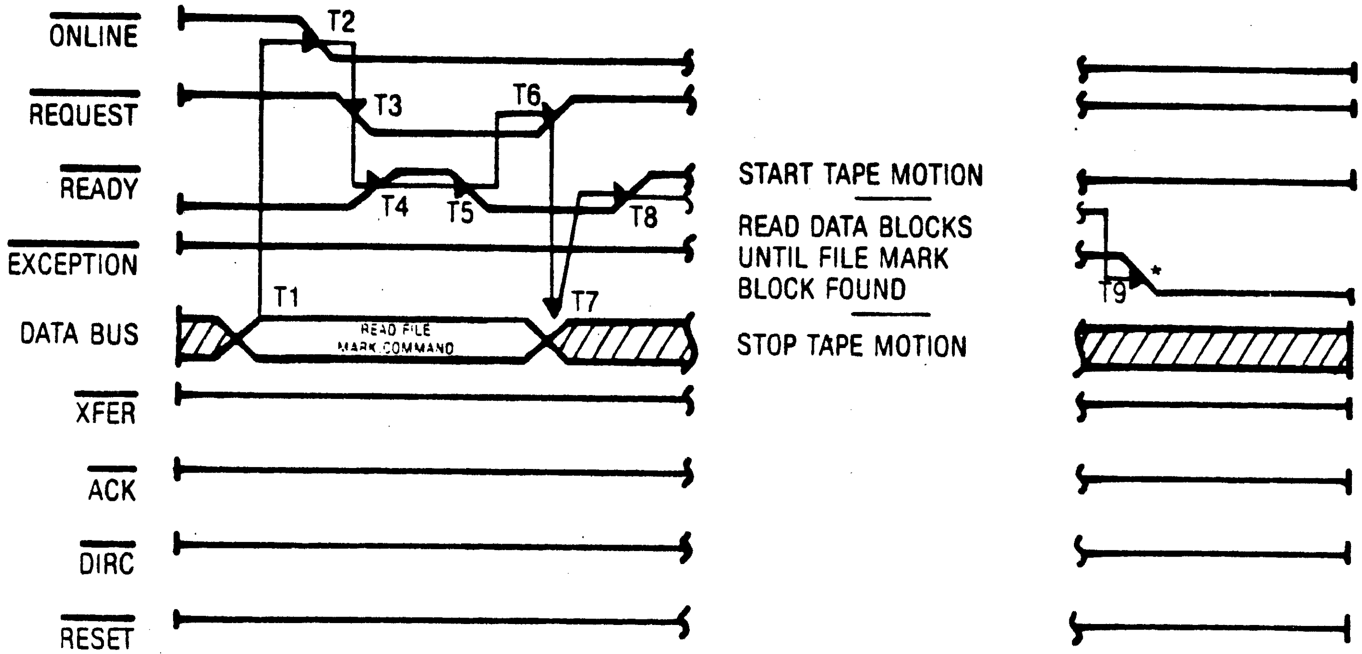
8.2.7 WRITE-FILE-MARK TIMING



WRITE FILE MARK COMMAND

ACTIVITY	CRITICAL TIMING
T1-HOST COMMAND TO BUS	N/A
T2-HOST SETS ONLINE	T1→T2>0 U sec.
T3-HOST SETS REQUEST	T2→T3>0 U sec.
T4-CONTROLLER RESETS READY	T3→T4<0.25 U sec.
T5-CONTROLLER SETS READY	20<T4→T5<500 U sec.
T6-HOST RESETS REQUEST	T5→T6>0 U sec.
T7-BUS DATA INVALID	T5→T7>0 U sec.
T8-CONTROLLER RESETS READY	20<T6→T8<100 U sec.
T9-CONTROLLER SETS READY	N/A
T10-HOST RESETS ONLINE	T9→T10>0 U sec.
T11-CONTROLLER RESETS READY	N/A
T12-CONTROLLER SETS READY (AT B.O.T.)	N/A

8.2.8 READ-FILE-MARK TIMING



READ FILE MARK COMMAND

ACTIVITY	CRITICAL TIMING
T1-HOST COMMAND TO BUS	N/A
T2-HOST SETS ONLINE	T1→T2>Ø U sec.
T3-HOST SETS REQUEST	T2→T3>Ø U sec.
T4-CONTROLLER RESETS READY	T3→T4<0.25 U sec.
T5-CONTROLLER SETS READY	20<T4→T5<500 U sec.
T6-HOST RESETS REQUEST	T5→T6>Ø U sec.
T7-BUS DATA INVALID	T4→T7>Ø U sec.
T8-CONTROLLER RESETS READY	20<T6→T8<100 U sec.
T9-CONTROLLER SETS EXCEPTION	N/A

**SYSTEM MUST ISSUE READ STATUS COMMAND*

8.3 INTERFACE SIGNAL LEVELS

All signals to the Host shall be standard TTL levels as follows:

FALSE, Logic 0 (high)	= 2.4 to 5.25 VDC
TRUE, Logic 1 (low)	= 0 to 0.55 VDC

All signals to the Controller shall be standard TTL levels as follows:

FALSE, Logic 0 (high)	= 2.0 to 5.25 VDC
TRUE, Logic 1 (low)	= 0 to 0.8 VDC

Voltages shall be measured at the Controller connector and the cable length shall not exceed 10 meters.

8.4 SIGNAL TERMINATIONS

The standard termination is 220 ohms to +5VDC and 330 ohms to GND at the Host, with 180 ohms to 4.3 VDC and 390 ohms to GND at the controller. Resistance tolerance is +/-10%. The bi-directional data bus and the four control signals from the Host to the Controller are terminated at the Controller. The Host shall terminate the bi-directional data bus and the four signals from the Controller to the Host at the Host.

Note: If the Controller-to-Drive signal cable is longer than 12 inches, terminators must be inserted in locations 1A and 3A on the drive Main PWB and 6B on the Controller PWB.

8.5 SIGNAL LOADING

Signals from the Host to the Controller are loaded by no more than one TTL load (1.6 mA) plus required terminations. The Host shall not load the signals from the Controller with more than one terminator and one TTL load.

8.6 INPUT/OUTPUT SIGNAL CONNECTOR

The signal connector on the Controller is a 50 conductor edge connector. Mating connector 3M type 3415-0001 or equivalent may be used.

9.0 CONTROLLER COMMANDS

All controller commands are single byte commands as defined in the COMMAND BYTE SUMMARY (9.1). ALL CONTROLLER STATUS is contained in 6 byte groups as defined in the STATUS BYTE SUMMARY (9.2).

9.1 COMMAND BYTE SUMMARY

BIT 7654 3210	DESCRIPTION	REFERENCE SEQ	TIMING DIAG	FLOW DIAG
000L 0001	SELECT Drive 0	6.2	8.2.3	10.10
000L 0010	SELECT Drive 1	6.2	8.2.3	10.10
000L 0100	SELECT Drive 2	6.2	8.2.3	10.10
000L 1000	SELECT Drive 3	6.2	8.2.3	10.10
0010 0001	BOT	6.4	8.2.4	10.9
0010 0010	ERASE	6.6	8.2.4	10.7
0010 0100	RETENSION	6.5	8.2.4	10.8
0100 0000	WRITE	6.7	8.2.5	10.4
0110 0000	WRITE-FILE-MARK	6.9	8.2.7	10.6
1000 0000	READ	6.8	8.2.6	10.3
1010 0000	READ-FILE-MARK	6.10	8.2.1	10.5
1100 0000	READ STATUS	6.3	8.2.1	10.13
1110 XXXX	RESERVED			

Note: L=0 Drive's Select light off at BOT, on otherwise.
L=1 Drive's Select light always on, (see 9.5.1).

9.2 STATUS BYTE SUMMARY

```
       BYTE 0        BYTE 1             EXS      DESCRIPTION
BIT   76543210      76543210
      !!!!!!!!      !!!!!!!+------- POR  power on/reset occured
      !!!!!!!!      !!!!!!+-------- RES  reserved for future use
      !!!!!!!!      !!!!!+--------- RES  reserved for future use
      !!!!!!!!      !!!!+---------- BOM  beginning of media
      !!!!!!!!      !!!+----------- RT8  8 or more read retries
      !!!!!!!!      !!+------------ NDT  no data detected
      !!!!!!!!      !+------------- ILL  illegal command
      !!!!!!!!      !+------------- ST1  status byte 1 bits
      !!!!!!!!
      !!!!!!!+--------------------- FIL  file mark detected
      !!!!!!+---------------------- BNL  bad block not located
      !!!!!+----------------------- UDE  unrecoverable data error
      !!!!+------------------------ EOM  end of media
      !!!+------------------------- WRP  write protected cartridge
      !!+-------------------------- USL  unselected drive
      !+--------------------------- CNI  cartridge not inplace
      +---------------------------- STO  status byte 0 bits

       BYTE 0        BYTE 3             DEC  data error counter

       BYTE 4        BYTE 5             URC  underrun counter
```

9.3 STATUS BYTE DESCRIPTION

Bytes 0 and 1 contain exception status (EXS) to define the reason that the controller asserted EXCEPTION. Refer to EXCEPTION STATUS SUMMARY and EXCEPTION STATUS DESCRIPTION for further explanation.

Bytes 2 and 3 contain the data error counter (DEC) which accumulates the number of blocks rewritten for WRITE operations and the number of read errors during READ operations.

Bytes 4 and 5 contain the underrun counter (URC) which accumulates the number of times streaming was interrupted because host failed to maintain minimum through-put rate.

All status bits are cleared when read except for the hard status bits CNI, USL, WRP, BOM and EOM which are obtained from the selected cartridge drive.

9.4 EXCEPTION STATUS SUMMARY

	BYTE 0	BYTE 1		DESCRIPTION
1.	110X0000	00000000	------------	NO CARTRIDGE
2.	11110000	00000000	------------	NO DRIVE
3.	10010000	X000X000	------------	WRITE PROTECTED
4.	10001000	00000000	------------	END OF MEDIA
5.	100X0100	10001000	------------	READ OR WRITE ABORT
6.	100X0100	00000000	------------	READ ERROR, BAD BLOCK XFER
7.	100X0110	00000000	------------	READ ERROR, FILLER BLOCK XFER
8.	100X0110	10100000	------------	READ ERROR, NO DATA
9.	100X1110	10100000	------------	READ ERROR, NO DATA & EOM
10.	100X0001	00000000	------------	READ A FILEMARK
11.	XXXX0000	1100X000	------------	ILLEGAL COMMAND
12.	XXXX0000	1000X001	------------	POWER ON/RESET
13.	XXXXXXXX	1XXX1XXX	------------	8 OR MORE READ RETRIES

Note: X denotes "could be either 0 or 1" condition.

9.5 EXCEPTION STATUS DESCRIPTION

1. NO CARTRIDGE - Selected drive did not contain a cartridge when BOT, RET, ERASE, WRITE, WFM, READ or RFM was issued or cartridge was removed while the drive select light was on. FATAL.
2. NO DRIVE - Selected drive was not present when BOT, RET, ERASE, WRITE, WFM, READ or RFM was issued. FATAL.
3. WRITE PROTECTED - Selected drive contained write protected (safe) cartridge when ERASE, WRITE or WFM was issued. FATAL.
4. END OF MEDIA - Tape has passed the early warning hole ofthe last track during WRITE command. CONTINUABLE.
5. READ OR WRITE ABORT - 16 same block rewrites occurred during a WRITE or WFM command or unrecoverable reposition error occurred during a WRITE, WFM, READ or RFM command. Tape has returned to BOT. FATAL.
6. READ ERROR, BAD BLOCK XFER - 16 same block retries failed to recover block without CRC error, last block without CRC error, last block transferred contained data from the erroneous data block for off line reconstruction. CONTINUABLE.
7. READ ERROR, FILLER BLOCK XFER - 16 same block retries failed to recover block without CRC error, last block transferred contained filler data to keep total block count correct. CONTINUABLE.
8. READ ERROR, NO DATA - 2 same block retries failed to recover the next or subsequent blocks or a FILE MARK. No filler data is transferred. CONTINUABLE.
9. READ ERROR, NO DATA & EOM - 16 same block retries failed to recover the next or subsequent blocks and the logical end of tape holes on the last track were encountered. CONTINUABLE.
10. FILEMARK READ - A filemark block was read during a READ or RFM command. CONTINUABLE.
11. ILLEGAL COMMAND - One of the following events occurred:
    - a. Attempt to select 0, 2, 3 or 4 drives.
    - b. Attempt to change drive selection while "at position" flag is set.

c. Attempt to BOT, RETENSION or ERASE simultaneously.
d. Attempt to WRITE, WFM, READ or RFM with ONLINE off.
e. Attempt to issue a command other than WRITE or WFM during a WRITE command.
f. Attempt to issue any command other than a READ-FILE-MARK command during a READ command. FATAL.

12. POWER ON/RESET - A power on reset or a reset by the host has occurred. FATAL.
13. 8 OR MORE READ RETRIES - 8 or more retries were attempted on the same block. (Indicative of a cartridge nearing end of life.) CONTINUABLE.

10.0 HOST INTERFACE DESIGN GUIDE

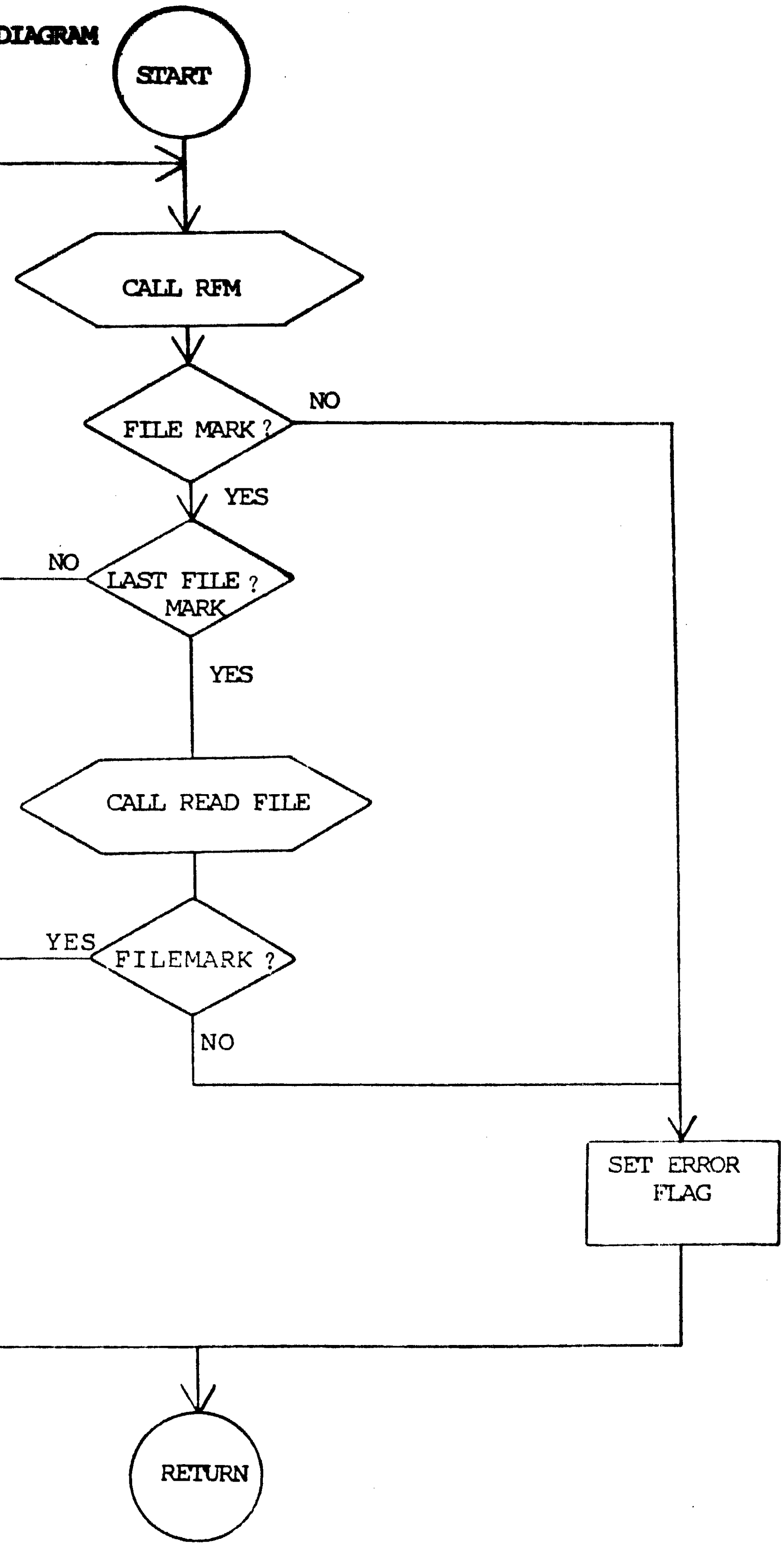
For most applications, the host can readily generate the interface signals ONL-, REQ-, and RST- by host computer programmed OUTPUT to interface adapter register latches and drivers. Similarly, the controller generated signals RDY- and EXC- should be made available through receivers for host computer programmed INPUT. Command transfer is easily accomplished by loading the command into a register connected through drivers to the bi-directional bus and implementing the required control signal protocol by host computer program. Status input can be similarly implemented by host computer programmed control. Implementation of a RDY and EXC interrupt is desirable to avoid prolonged host computer tie-up awaiting controller command completion.

A DMA channel should be used to transfer the 512 byte block.

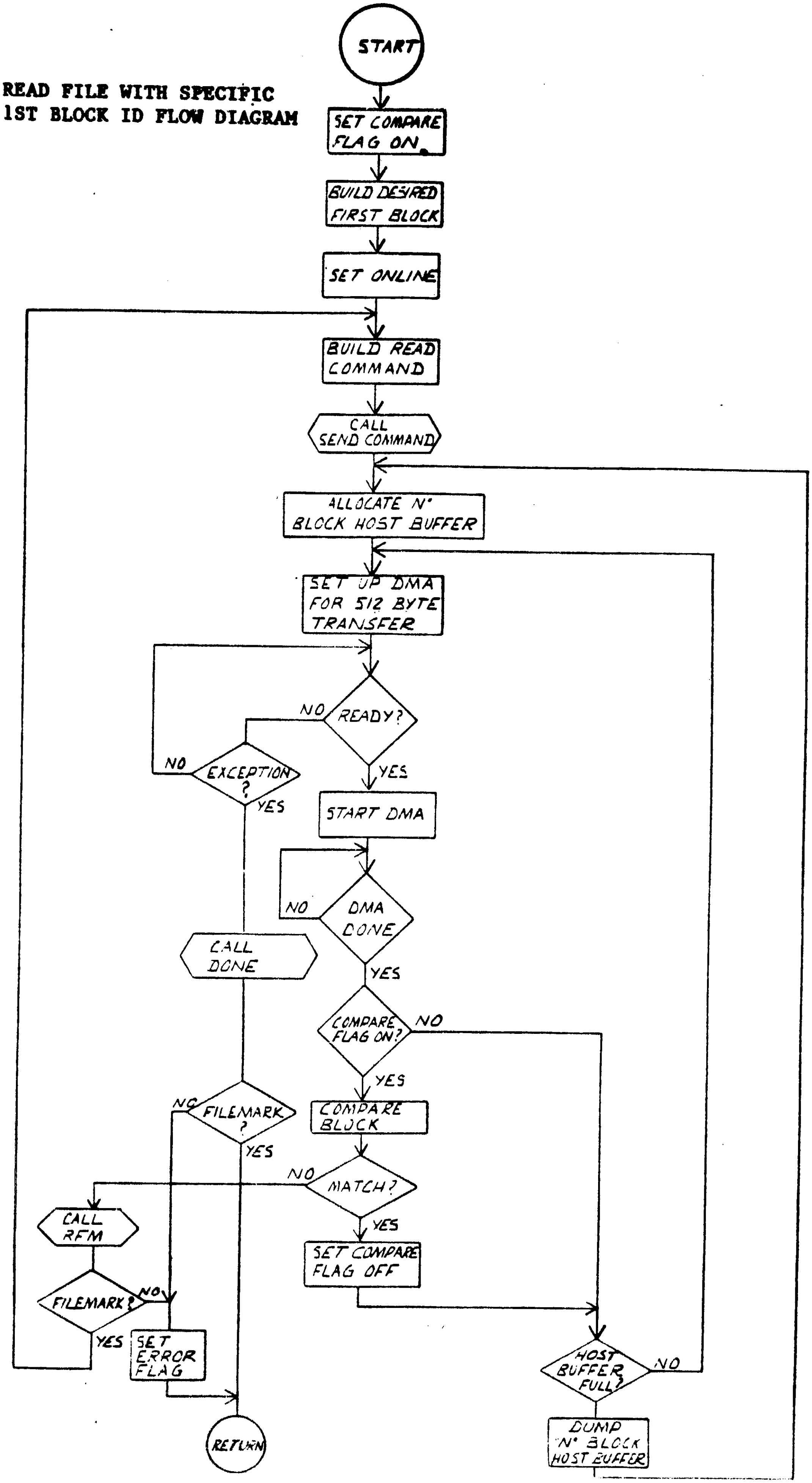
The bi-directional bus control signal DIR- should only be used by the host interface adapter to enable the host's bus driver.

The following FLOW DIAGRAMS are intended as a guide to creating a set of lower level calls useful for operating the ARCHIVE intelligent drive.

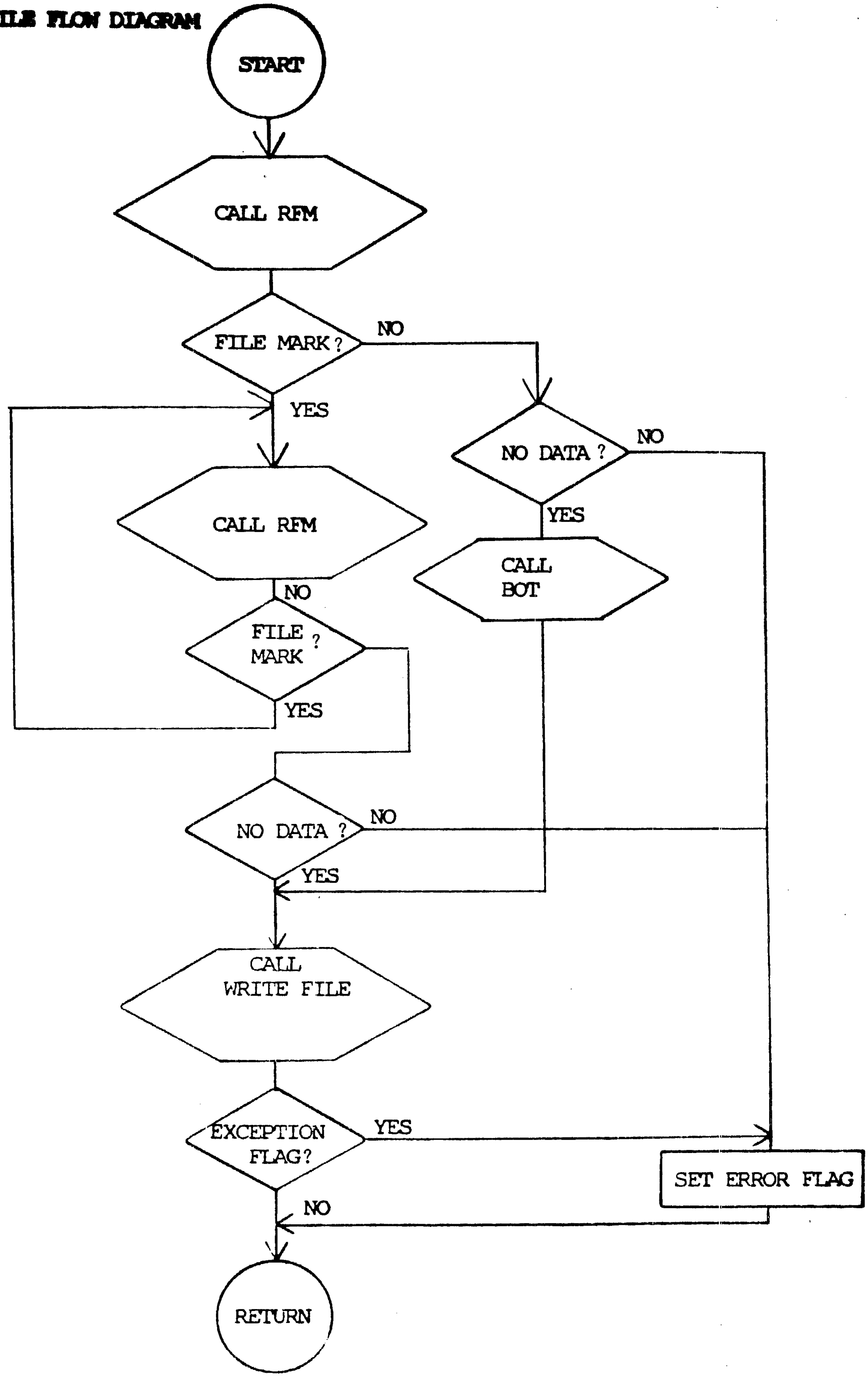
10.1 READ NTH FILE FLOW DIAGRAM



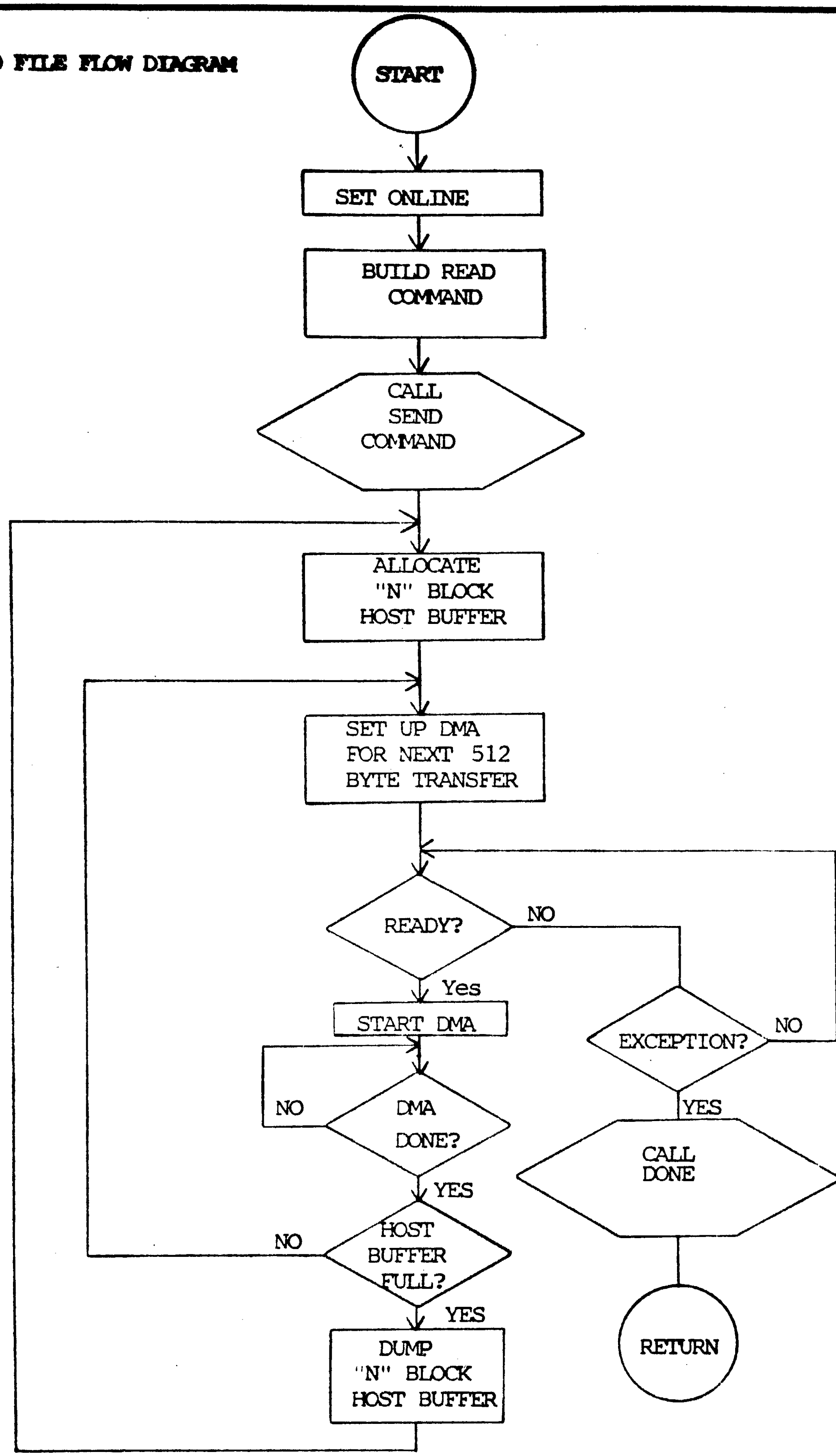
10.2 READ FILE WITH SPECIFIC 1ST BLOCK ID FLOW DIAGRAM



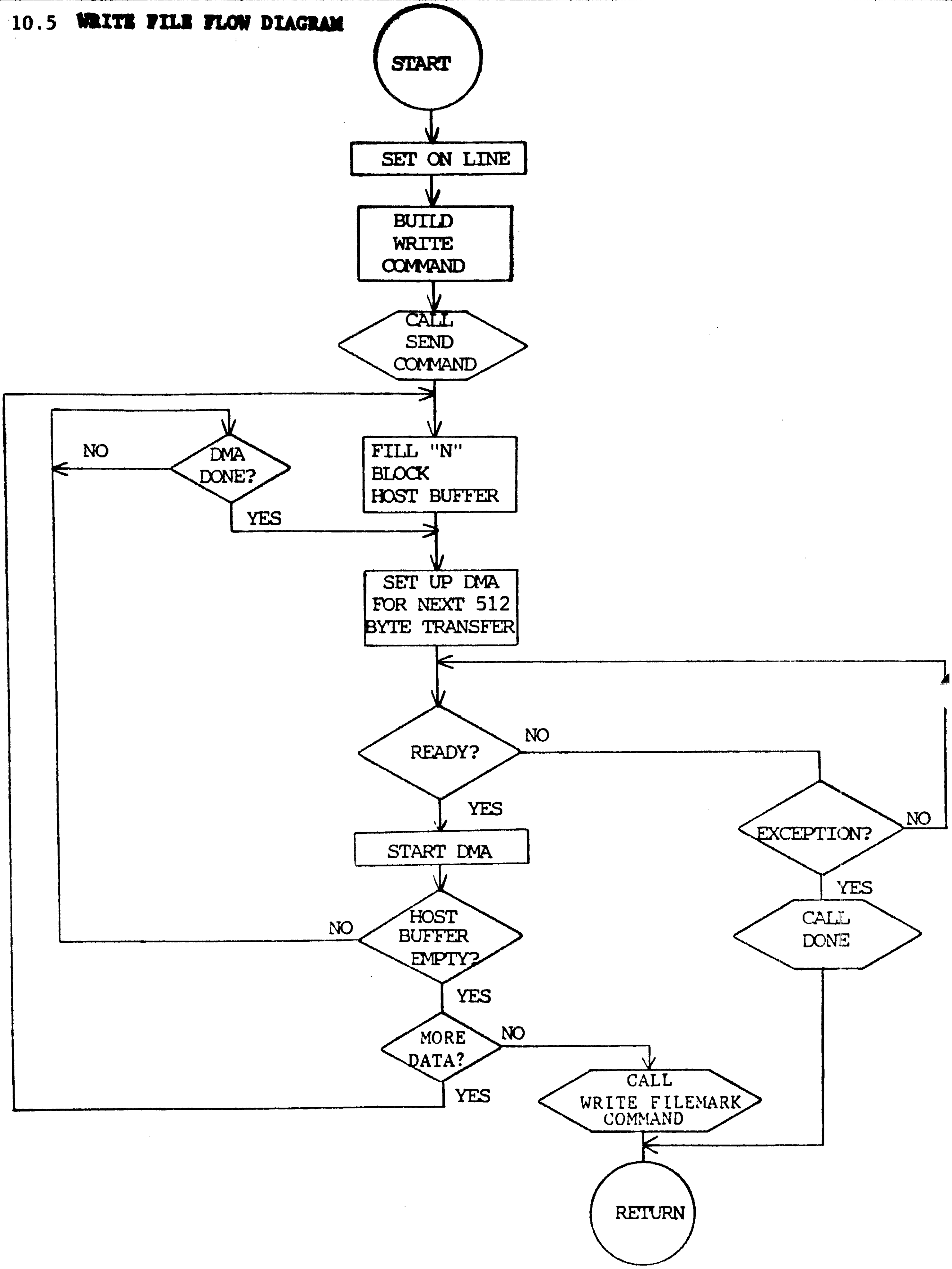
10.3 **APPEND FILE FLOW DIAGRAM**



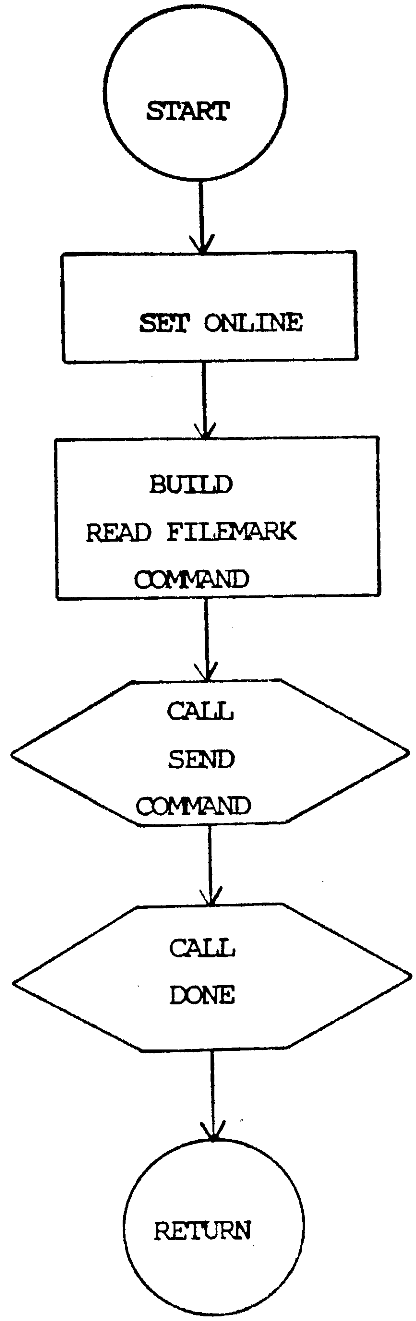
10.4 READ FILE FLOW DIAGRAM



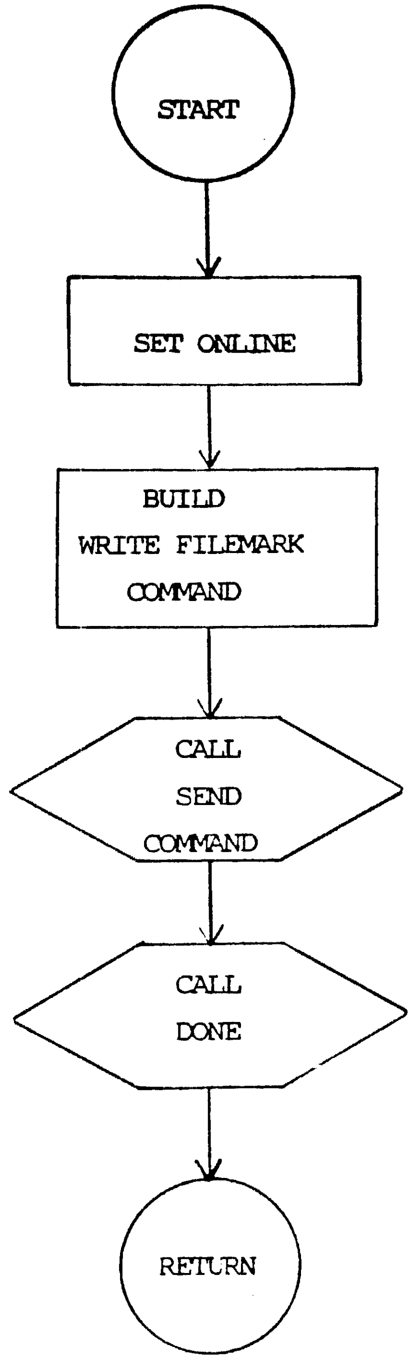
10.5 WRITE FILE FLOW DIAGRAM



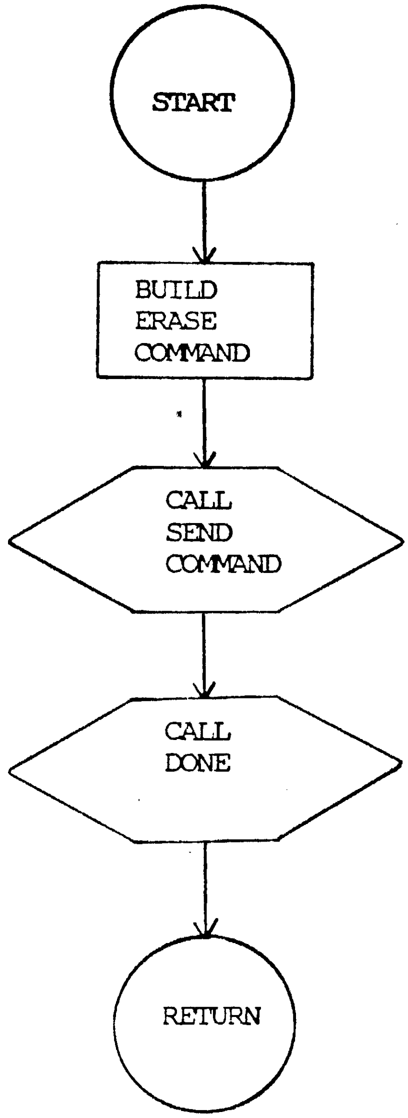
10.6 READ-FILE-MARK COMMAND FLOW DIAGRAM



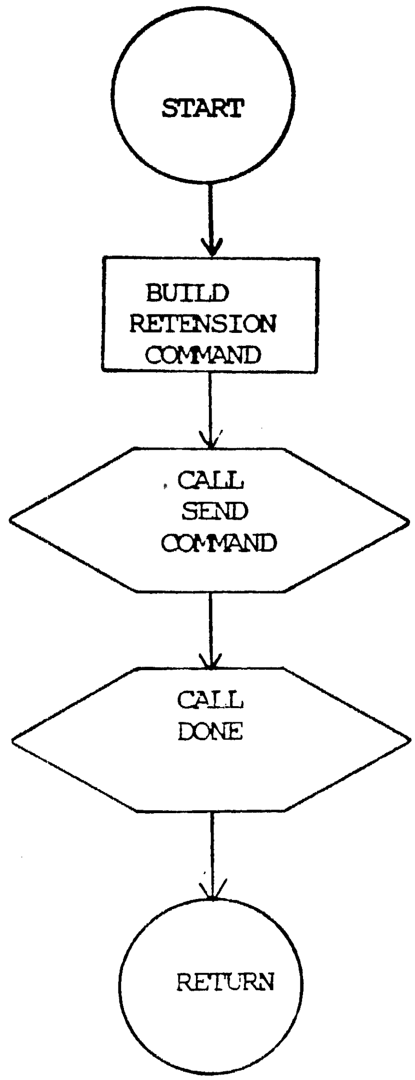
10.7 WRITE-FILE-MARK COMMAND FLOW DIAGRAM



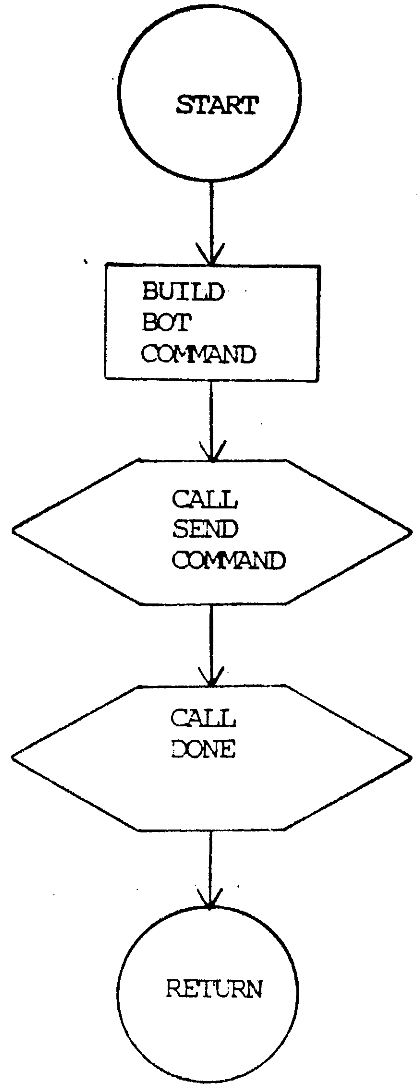
10.8 ERASE COMMAND FLOW DIAGRAM



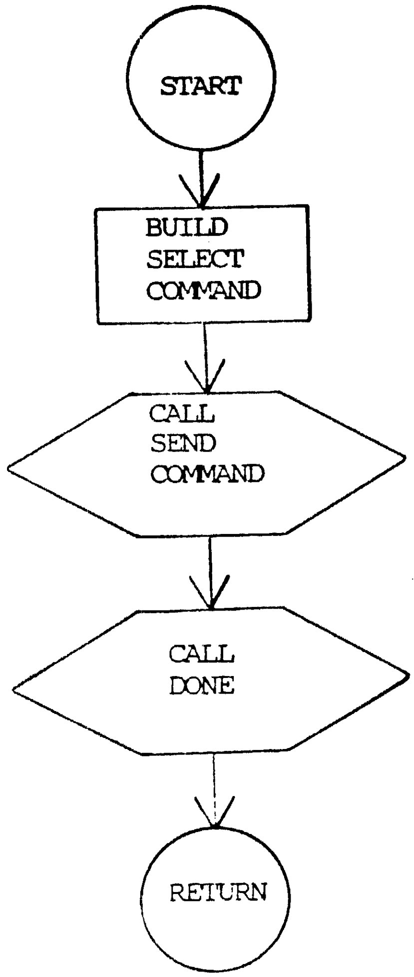
10.9 RETENSION COMMAND FLOW DIAGRAM



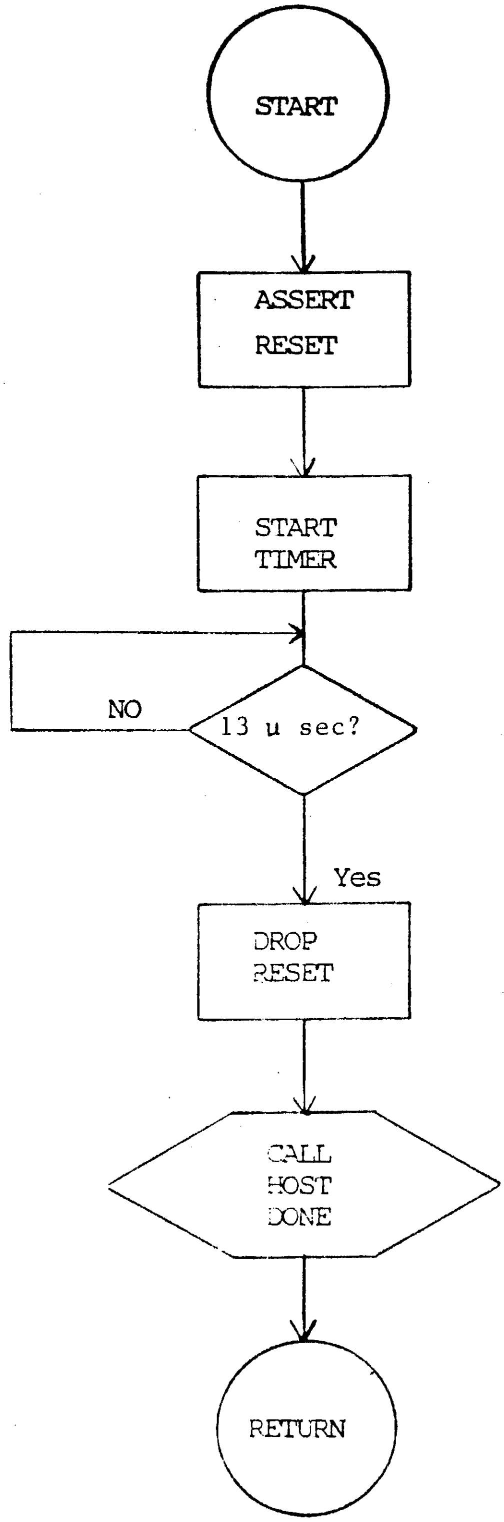
10.10 BOT COMMAND FLOW DIAGRAM



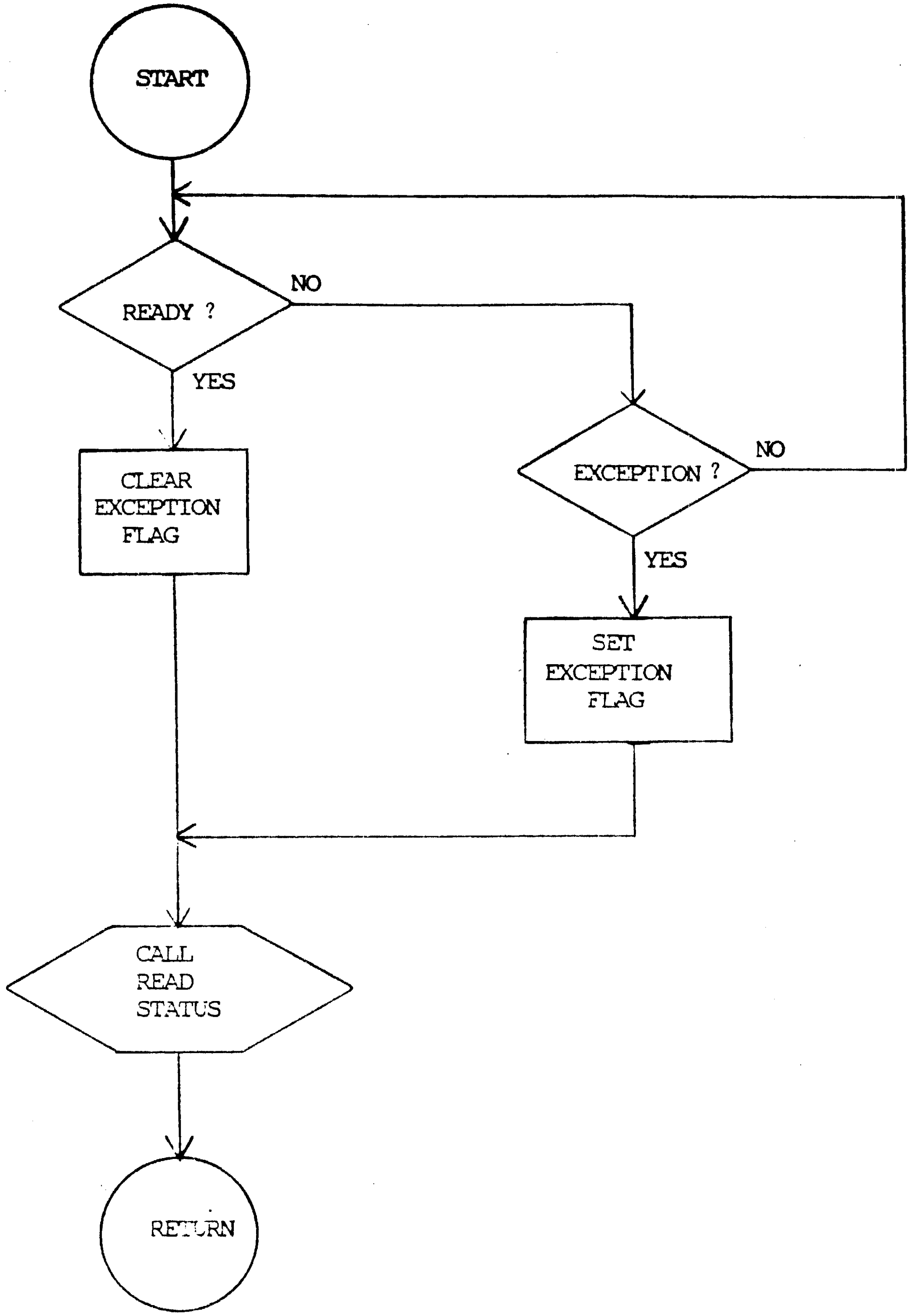
10.11 SELECT COMMAND FLOW DIAGRAM



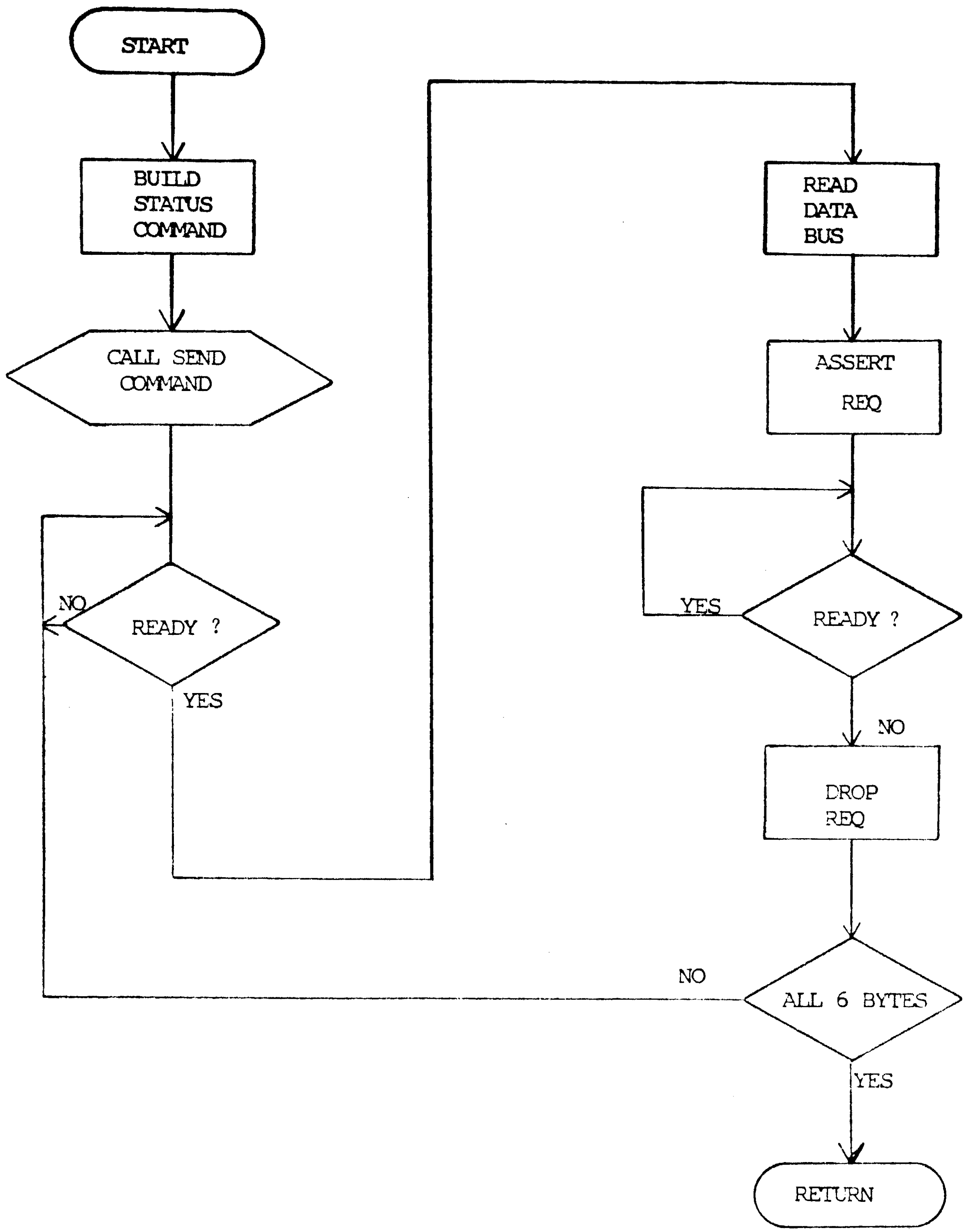
10.12 RESET FLOW DIAGRAM



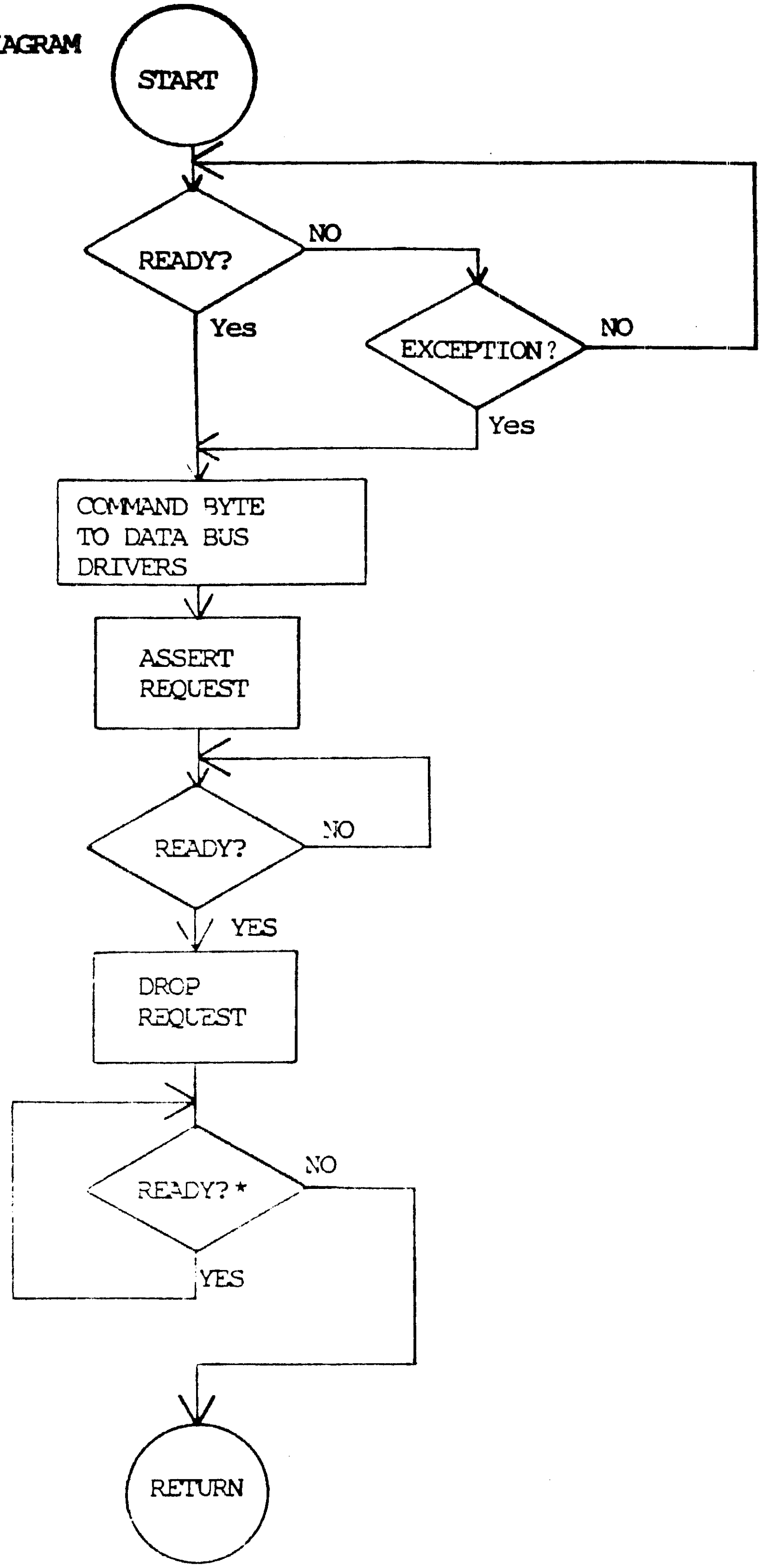
10.13 HOST DONE FLOW DIAGRAM



10.14 READ STATUS FLOW DIAGRAM



10.15 **SEND COMMAND FLOW DIAGRAM**



*20 µsec loop max., see timing

11.0 MULTIPLE DRIVES

11.1 CONTROLLER/DRIVE SIGNAL LEVELS

All signals to the Controller shall be standard TTL levels as follows:

FALSE, Logic 0 (high)	=2.4 to 5.25 VDC
TRUE, Logic 1 (low)	=0 to 0.55 VDC

All signals to the Drive shall be standard TTL levels as follows:

FALSE, Logic 0 (high)	=2.0 to 5.25 VDC
TRUE, Logic 1 (low)	=0 to 0.8 VDC

Voltages shall be measured at the drive connector and the cable length shall not exceed 10 meters.

11.2 SIGNAL TERMINATIONS

The standard termination is 220 ohms to +5VDC and 330 ohms to GND at the Host, with 180 ohms to +4.3 VDC and 390 ohms to GND at the controller. Resistance tolerance is +/-10%. For controller at one end of the bus, all signal lines to controller shall be terminated both at the controller and the last drive; signal lines to drives may be terminated only at the last drive if active pull up drivers (74S240 or equiv) are used; otherwise terminators at both ends are required. For controller in the middle of the bus, all signal lines shall be terminated at the drives on each end of the bus. (see 11.6)

11.3 SIGNAL LOADING

Signal sources from the drive are capable of driving two (2) terminations and one TTL load (1.6 mA). Signals from the controller to the drives are loaded by no more than one TTL load at each drive (4 TTL loads max.) plus required terminations. The controller shall not load the signals from the drive with more than one terminator and one TTL load.

11.4 CONTROLLER/DRIVE SIGNAL CONNECTOR

The signal connector on both controller and drive is a 50 conductor edge connector. Mating connector 3M type 3415-0001 or equivalent may be used.

11.5 CONTROLLER/DRIVE PIN ASSIGNMENTS AND SIGNAL DESCRIPTION

PIN#	NAME	TO	DESCRIPTION
02	GO-	D	Go Control for Capstan Servo
04	REV-	D	Direction Control for Capstan Servo
06	RES	D	Reserved for Track Select Bit 3
08	RES	D	Reserved for Track Select Bit 2
10	TR1-	D	Track Select Bit 1
12	TR0-	D	Track Select Bit 0
14	RST-	D	Reset
16	DS3-	D	Drive 3 Select Control
18	DS2-	D	Drive 2 Select Control
20	DS1-	D	Drive 1 Select Control
22	DS0-	D	Drive 0 Select Control
24	RDL-	H	Read Level Output - a digitized derivative of the analog read signal
26	RDP-	H	Read Pulse Output - a pulse per flux transition
28	UTH-	H	Upper Tape Position Code
30	LTH-	H	Lower Tape Position Code
32	SLD-	H	Selected Response from Selected Drive
34	CIN-	H	Cartridge In Place
36	USF-	H	Unsafe - Cartridge Safe Plug is in "unsafe" position (i.e. writing is enabled)
38	TCH-	H	Capstan Tachometer Pulses - each pulse equals 0.145 +/-3% inches tape movement
40	WDA-	D	Write Data Signal
42	WDA+	D	Inverse Write Data Signal
44	RES	D	Reserved
46	HSD-	D	High Speed Select Control for Model 3020B
48	WEN-	D	Write Enable Control
50	EEN-	D	Erase Enable Control

All odd pins are signal returns, are connected to signal GND at the drive and should be connected to signal GND at the Controller.

11.6 BASIC DRIVE ADDRESSING AND TERMINATIONS

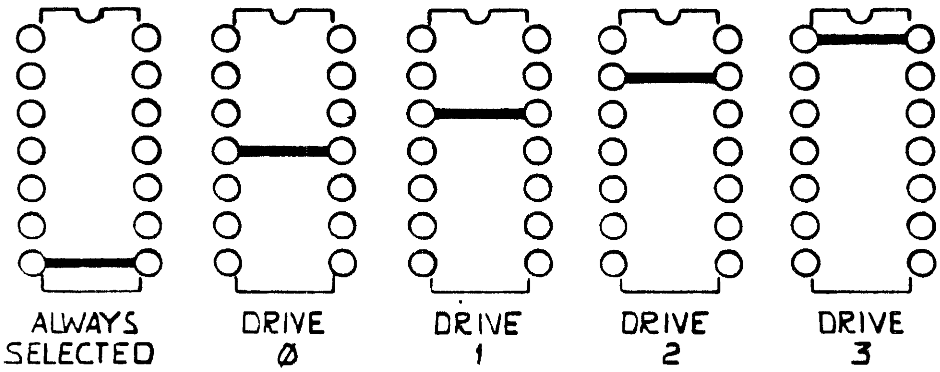
Drive addressing is user programmed using jumpers at location 2B of the upper drive electronics PWB as shown in Figure 4. The drive is jumpered to respond to Drive 0 address at the factory.

Locations 1A and 3A contain 14 pin 180/390 ohm resistor network DIPS and must be present only in the last Drive or Drives on the Bus as shown in Figure 5.

For "Controller in the middle" configurations, terminator at location 6B is removed from the controller.

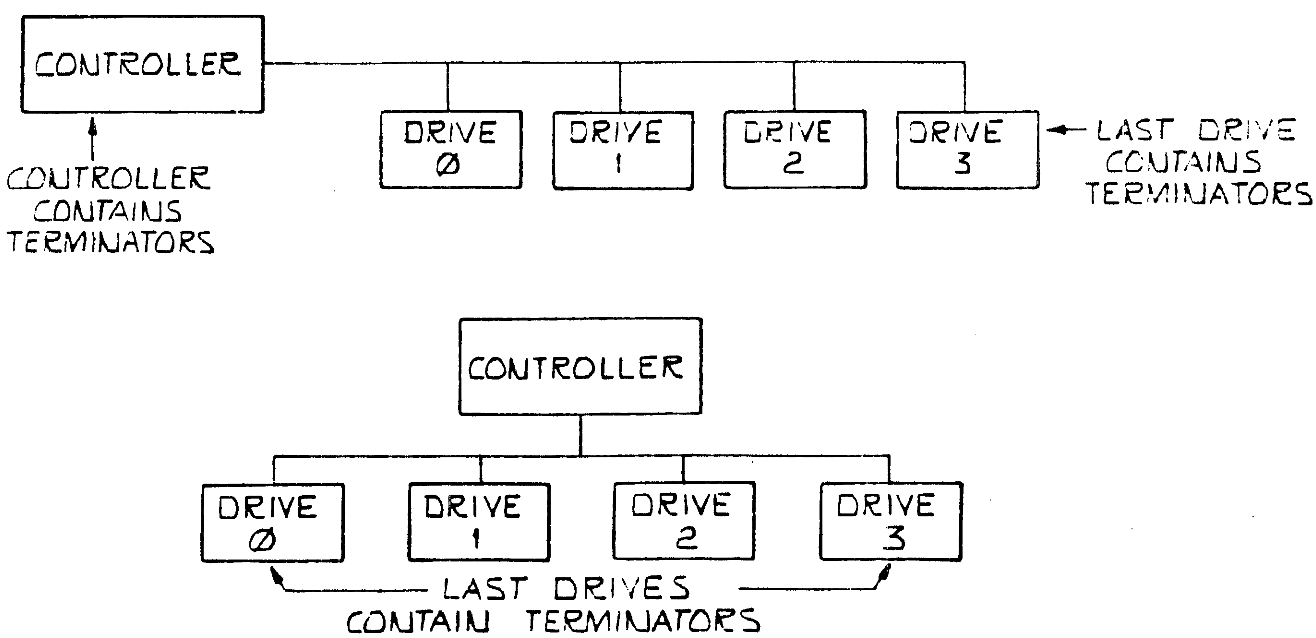
DRIVE ADDRESSING

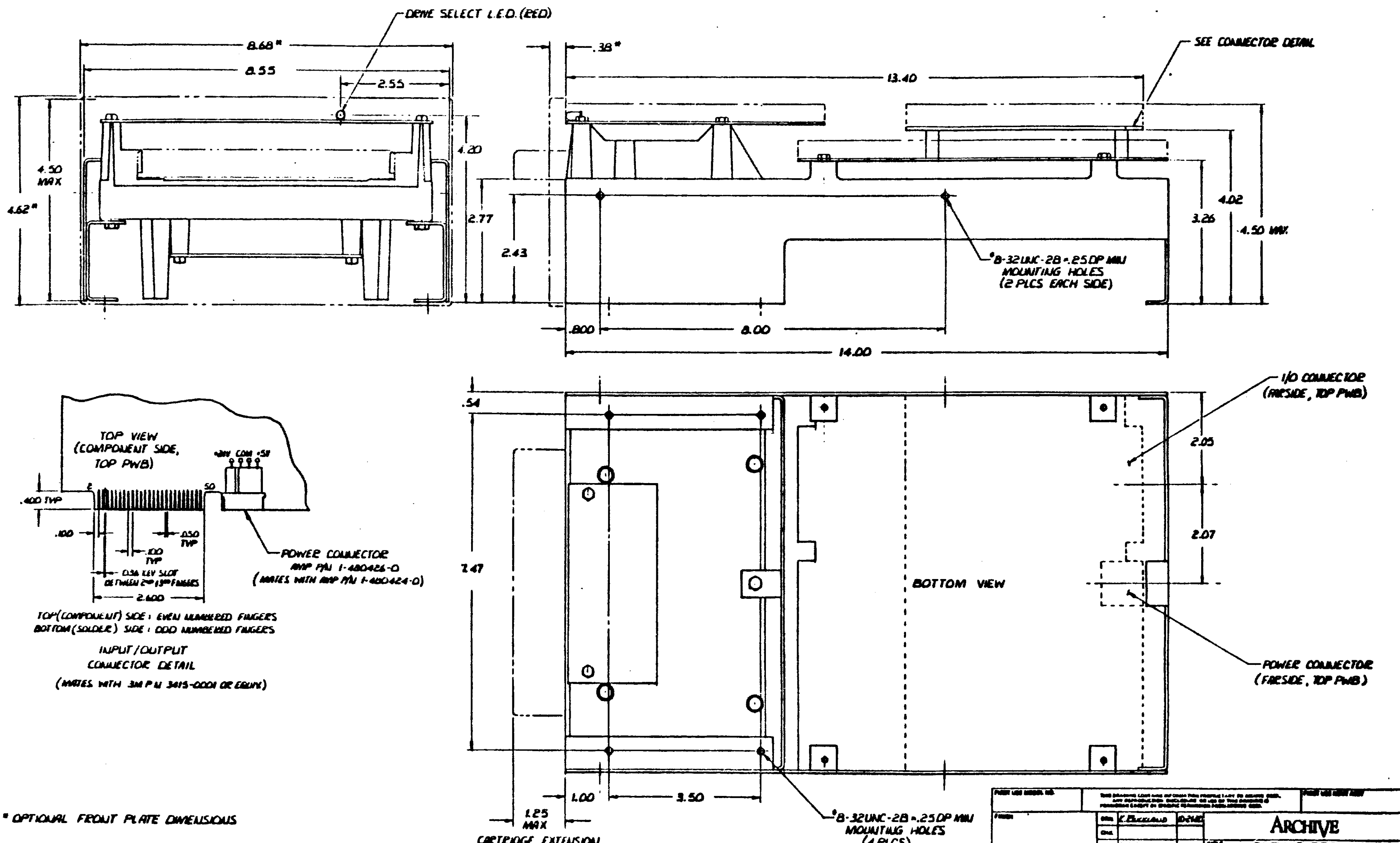
FIGURE 4



CONTROLLER/DRIVE TERMINATIONS

FIGURE 5





OUTLINE DRAWING

FIGURE 6

ARCHIVE

OUTLINE DRAWING, INTELLIGENT CARTRIDGE TAPE DRIVE

SCALE 1:1 | SIZE D | 50016-002 | REV A

DWG. NO. 20092-007 | REV E | SHEET 74 OF 74