REV.	ZONE	ECO #	REVISION	APPD	DATE

Double Sided Disk Drive Specs

AUGUST 16, 1985

TOLERANCES UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. DECIMALS .X ± ___ .XX ± ___ .XXX ± ___ ANGLES XX.X ± ___ FRACTIONS ± ___ DIMENSIONS IN PARENTHESIS ARE IN MILLIMETERS.	DRAWN BY DATE CHECKED BY DATE APPROVED BY DATE RELEASED BY DATE	apple computer inc.	
		TITLE 3.5 INCH DOUBLE SIDED DISK DRIVE	
	MATERIAL:	SIZE A	DRAWING NUMBER 699-0321
NEXT ASSY.	FINISH:	SCALE:	SHEET 1 OF

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1.0 DESCRIPTION

This specification defines double sided 3.5 inch Floppy Disk Drive mechanisms, Part Numbers 699-0326 Macintosh external drive and 699-0321.

2.0 SPECIFICATION

This drive shall satisfy the following specifications when a diskette meeting the Apple disk specification, specification number 003-0002, is used.

2.1 Configuration

The drive consists of two read/write heads, head positioning mechanism, disk monitor, interface logic circuit, read/write circuit, motor control circuitry, and auto inject/eject, and uses a 3.5 inch microfloppy diskette, as shown in Figure 2.1. The drive itself shall meet UL 478 and CSA C22.2 No. 15401983 requirements for safety.

2.2 Mechanism Dimensions

Mounting hole locations are shown in Figure 2.2, along with the emergency eject tab location.

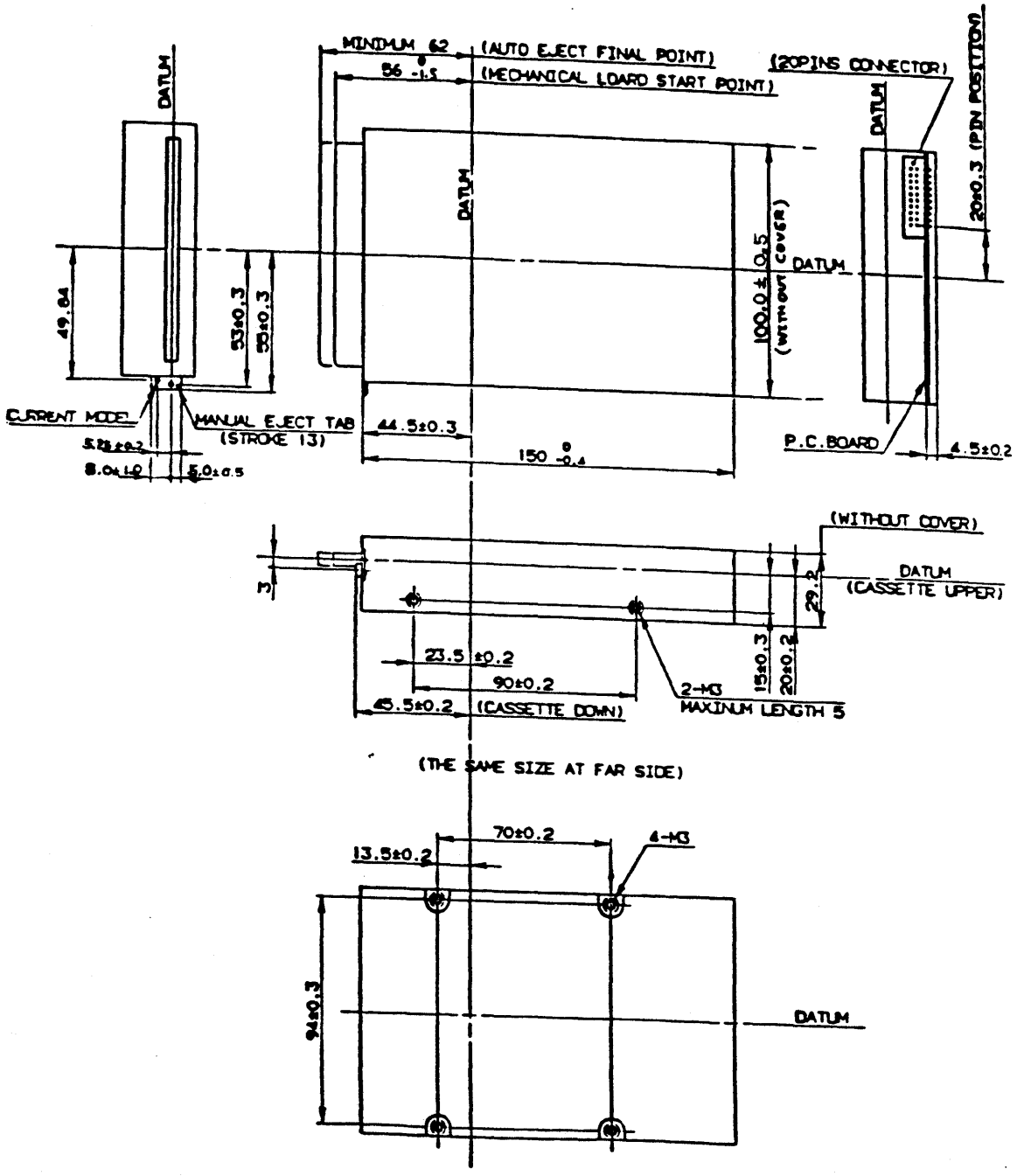
2.3 Performance

2.3.1 Capacity and Encoding Method - See Appendix B.

2.3.2 Transfer Rate

Detected flux transitions shall occur not less than 1.89 usec nor more than 6.36 usec apart. The data transfer rate from system to drive to be 489.6k bits/sec +/- 0.1%.

FIGURE 2.2



apple computer inc.	SIZE A	DRAWING NUMBER 699-0321
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2.3.3 Access Time

a. Track to track slew rate : 6 msec Max.
b. Track to track step settling time : 30 msec Max.
(These times are satisfied when the head is positioned and stable within 0.035 mm of its absolute position as defined in 2.11).
c. Speed group to speed group motor
settling time : 150 msec Max
The definition is defined in 2.17 and 3.4.3.2.
d. Motor start time : 600 msec Max.
The definition is defined in 2.17 and 3.4.4

2.3.4 Functional

a. Rotational Speed

The motor speed is variable to allow recording to be done at fixed density as the head moves from the outer edge of the diskette toward the center. The speed is discretely variable from 394 to 590 rpm.
The detailed specifications on disk motor speed are given in 2.17.

b. Recording Density

The maximum recording density assumes all 2 usec transistions while the minimum density assumes all 6 usec transitions even though the format doesn't allow more than one 6 usec interval to be written at a time.

Maximum : 8897 FCI
Minimum : 2379 FCI

c. Track Density :0.1875mm track-track

d. Cylinders : 80

e. Tracks :160

f. R/W Head : 2

2.3.5 Weight: 450 Grams (without drive cover or shield)

2.4 Input Power Requirements

Voltage	Max. Ripple		Current
+12.0V +/-5%	0.1p-p	Standby	10uA (motor off)
		R/W	185mA Max
		Stepping Cross Speed Block Change	600mA Max
		MOTORSTART	600mA
		EJECT	500mA
+5.0V +/-5%	0.1p-p	Standby	10mA
		Typical	200mA

NOTE: See Appendix C for peak current wave forms

2.5 Environmental Limits

2.5.1 Temperature

Operating : 5° C to 50° C (40° F 140°F) ambient

Non-Operating : -40°C to 60°C (-40°F to 140°F)
The temperature cycling shall not result in condensation.

2.5.2 Humidity

Operating : 5% to 90% relative humidity with a max wet bulb temperature of 29°C (85°F), with no condensation.

Non-Operating : 5% to 95% relative humidity with a max. wet bulb temp 29°C (85°F), with no condensation.

2.5.3 Vibration

Operating : The unit shall perform read/write operation without errors with continuous vibration range from 5 to 100Hz at max of 0.5G along each of the three mutually perpindicular axes. The heads shall be loaded.

Non-Operating : The unit shall be able to withstand continuous vibration from 5Hz to 300Hz with a maximum level of 2.0G along each of the three mutually perpindicular axes, with disks or dummy disks, without degredation of performance.

2.5.4 Shock

Operating : The unit shall be able to withstand a 1.0G shock for 11 milliseconds with a 1/2 sine wave shape in each of three mutually perpindicular axes while performing normal read/write functions without damage or any loss of data.

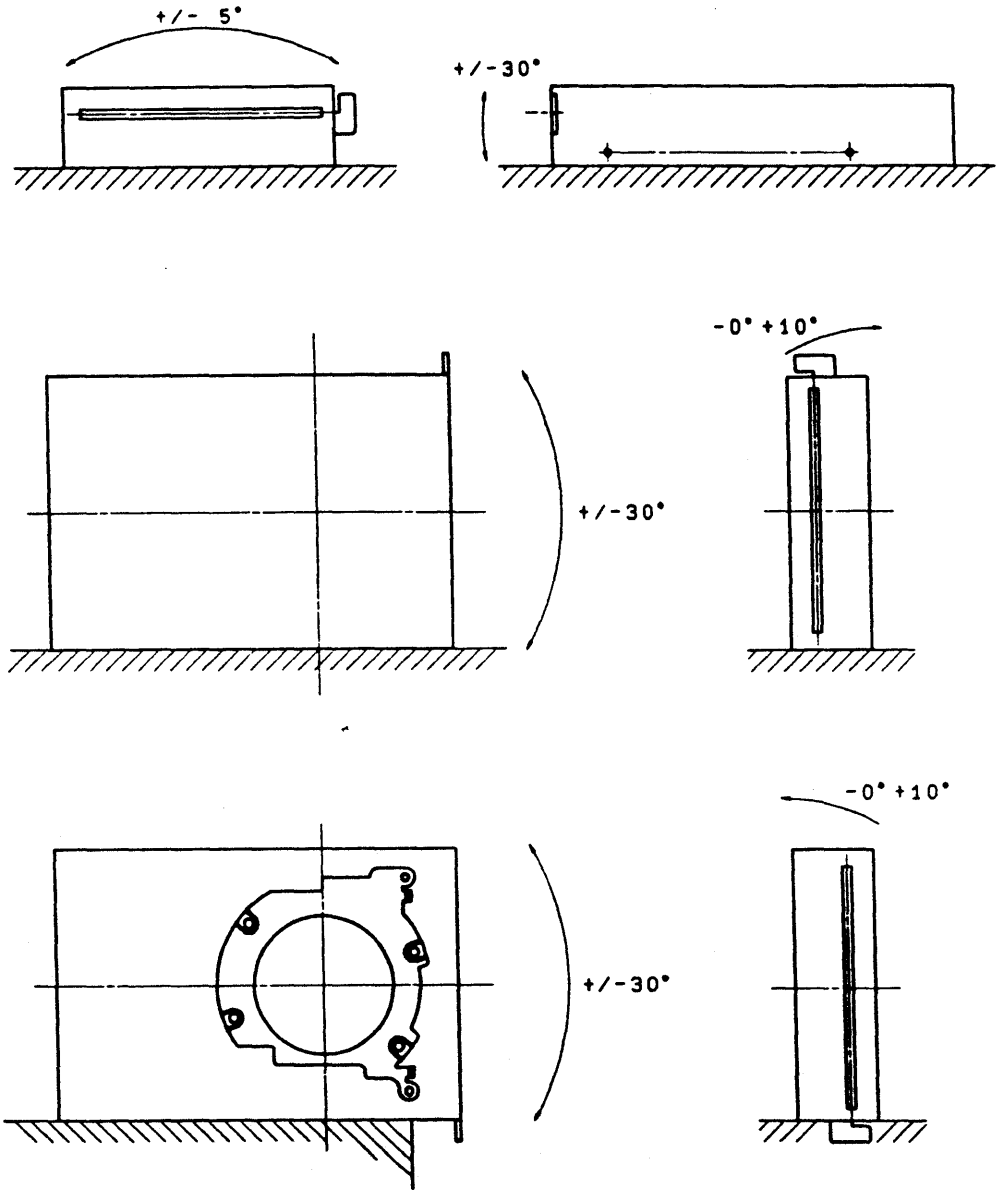
Non-Operating : The unit when unpacked shall withstand a 60G shock for 11ms with 1/2 sine swape on any of three mutually perpindicular axes, with a disk or dummy disk in place.

2.6 Accoustical Noise

Operating : Noise from the drive shall be less than 50 dba at a point 50cm from the drive

2.7 Orientation

The drive may be used in the three orientation shown in Figure 2.3.



ALLOWABLE ORIENTATIONS

2.8 Reliability

a. Mean Time Between Failure (MTBF) : 8000POH
b. Mean Time To Repair (MTTR) : 30 Minutes
c. Preventative Maintenance (PM) : Not Required
d. Component Life : 5 Years or 15000 POH
e. Error Rate

1. Soft Read : 1 per 10E9 bits read
2. Hard Read : 1 per 10E12 bits read
3. Seek Error : 1 per 10E6 seeks

2.9 Overwrite Characteristics

Testing to be conducted using Double Sided Reference Surface Diskettes Apple Part No. 899-2006. This applies to both side 0 and side 1.

The residual level of 1F (125 KHz) measured as follows shall be down 30db.

To measure, first record the 1F signal on TK0, then write over the track once with a 2F (250 KHz) signal, and measure the residual level of 1F at the read head.

Residual signal level ratio (db):

1F signal level (db) - residual level of 1F (db)

2.10 Time Margin

2.10.1 Definition of Time Margin

Time margin is measured using the Apple jitter generating fixture. This circuit jiters the read pulse coming from the drive under test randomly. The time margin is defined as the largest value of time that the read pulse can be jittered while still allowing the controller to read with fewer than one error in ten million bits read. The schematic of the margin generator, Apple Part No. 821-2007 is shown in Appendix A.

The data read is comprised of a random pattern of flux changes including all legal combinations of 2.4. and 6 usec periods between flux changes.

Track format and Sector format is defined in Appendix B.

2.10.2 Self Read/Write Time Margin

The self read/write time margin shall be: 250 nsec.

2.10.3 Off-Track Reliability

Using a reference disk on which random data is written +0.035mm and -0.035mm off-track, there shall be no errors for a period of 1E6 bits. This applies to both heads.

2.11 Alignment Accuracy

Track position is defined by:

RN = 39.5 - 0.1875 x N for side 0
= 38.0 - 0.1875 x N for side 1

Where RN: Absolute track position from disk center
N: Track number from 0 to 79

Alignment Accuracy at all tracks shall be +/- 0.035mm

2.12 Azimuth Angle

Azimuth Angle shall be:

Angle=arcsin [0.35 / (X-YN)] =/-0 degrees 30'

Where: X=38.0 for side 1
X=39.5 for side 0
Y=0.1875
N=Track number (0 to 79)

2.14 Head Life

Head life shall be more than (20,000,000) passes. Measured as follows:

a. Using a new disk, which is used as the reference disk for signal level, a new drive, more the head to track 35, then record 2F signal on both side 0 and side 1. Measure the output signal level (Lr).
b. Insert another new disk in the drive. Move the head from track 0 to track 79 and back to track 0 about 3,000,000 passes.
c. Change the disk to another new disk.
d. Repeat (b) and (c) until total number of passes is 20,000,000.
e. Change the disk to the reference level disk used is (a). Move the head to track 35, measure the output signal (Lx) on both sides.
f. The ratio of Lx over Lr shall be > 80% as follows:

$$\frac{Lx}{Lr} \times 100\% > 80\%$$

2.15 Media Wear

2.15.1 Double-Sided

Write the 2F signal on every track of a new disk, and read the output level of all of the tracks and record. After 3,000,000 read passes on track 35, the output level of all tracks should be 80% minimum of the originally measured value of each new track. Media Part No. double-sided is 003-0002.

2.15.2 Single-Sided

1,000,000 Read Passes

2.16 Disk Monitor

The rotational speed to be determined by the measure unit of the time between a minimum of 4 consecutive Track Pulses.

Track 00 to track 15 : 394 RPM
Track 16 to track 31 : 429 RPM
Track 32 to track 47 : 472 RPM
Track 48 to track 63 : 525 RPM
Track 64 to track 79 : 590 RPM

The speed tolerance shall be ± 2.5% including continuous and instantaneous speed variations while /READY is low.

2.17 Eject/Inject Mechanism Life

2.17.1 Eject timing and Position

From the leading edge of the eject signal, the total eject time shall be less than 1.5 seconds. A disk shall be ejected 62mm min from center of disk motor spindle but at a maximum point of eject the disk will remain in the drive. The drive to be in the horizontal position for this measurement.

2.17.2 Insert (Inject) Position and Force

The auto insert starts when the disk is inserted to 54.5 to 56mm from the center of disk spindle.

The auto insert is completed within 1.5 seconds. The force required to insert the disk shall be less than 300 gr.

2.17.3 Eject/Inject Mechanism Life

The mechanism shall have a minimum life of 20,000 insertions and ejections. Both insertion and ejection shall be smooth and quiet.

2.17.4 Manual Eject

A mechanism shall be provided which allows manual eject of the diskette. The maximum pressure necessary to eject the diskette using this mechanism shall be 1.8Kg.

2.17.5 Auto Insert and Eject Operation

a. There shall be no electrical or mechanical damage even if the disk is held during the automatic portion of insertion or ejection.

b. When the power is turned on:

- If the insert/eject mechanism is not in the disk ejected position and is not in the disk inserted position, it will automatically move to the ejected position ready to receive a disk.
- If the mechanism is at the disk insertion position and the disk is in place, it will remain there.

c. The eject operation will continue to completion even if the /ENBL goes high.

3.0 INTERFACE

3.1 General Description

The interface between the host system and the dirve consists of 6 input signals (SEL, CA2, CA1, CA0, /ENBL and LSTRB) and one output signal (RD).
For any communication with the dirve, the /ENBL line must be low.

3.1.1 Reading Status or Data from Drive

The host system can read the status of the drive or data on the disk using the RD line by setting the CA0, CA1, CA2, and SEL signals as shown in the table. The RD line is a tristate line which is in the high impedance state unless /ENBL is low.

3.2.2 /ENBL

This line enables all communication with the dirve. When the /ENBL is high (drive disabled), the RD line goes to high impedance state, and the control latches are preset to their indicated state.

When /ENBL is high it will be in the power save mode except for the following conditions:

a. The head has not reached its destination
b. Disk eject operation is not complete
c. During auto disk rotation

3.2.3 LSTRB:

This line is used to send a command to the drive. After setting CA0, CA1, CA2 and SEL to the desired state, LSTRB is brought first high then low. At the rising edge of LSTRB the level of CA2 will be set into the latch designated by CA0, CA1 and SEL.

3.2.4 RD:

This is the only output line from the drive to the host computer. It is multiplexed by the control lines and allows the host to read drive status information as well as data (See Table 1).

3.2.4.1 /DIRTN:

This signal sets the direction of head motion. A zero sets direction toward the center of the disk and a one sets direction towards outer edge. When /ENBL is high /DIRTN is set to zero.

Change of /DIRTN command is not allowed during head movement nor head settlying time.

3.4.2.2 /STEP:

At the falling edge of this signal the destination track counter is counted up or down depending on the /DIRTN level. After the destination counter in the drive received the falling edge of /STEP, the drive sets /STEP to high.

3.4.2.3 /MOTORON:

When this signal is set to low, the disk motor is turned on. When /ENBL is high, /MOTORON is set to high.

3.4.2.4 EJECT:

At the rising edge of the LSTRB, EJECT is set to high and the ejection operation starts. EJECT is set to low at rising edge of /CSTIN or 2 sec maximum after rising edge of EJECT.

When power is turned on, EJECT is set to low.

3.4.2.5 RDDATA:

RDDATA is the data from the disk. When SEL is a zero, data on side 0 are read through RD line. When SEL is a one, data on side 1 are read through RD line. RDDATA shall be gated with /PWM in 699-0326 drive units. See section 3.4.9.

3.2.4.6 /SINGLE SIDE:
A status bit which is read as one for double sided drive.

3.2.4.7 /DRVIN:

This status bit is read as a zero only if the selected drive is connected to the host computer.

3.2.4.8 /CSTIN:

This status bit is read as a zero only when a diskette is in the drive or when the mechanism for ejection and insertion is at the disk-in position without diskette.

3.2.4.9 /WRTPRT:

This status bit is read as a zero only when a diskette is in the drive or no diskette is inserted in the drive.

3.2.4.10 /TKO:

This status bit is read as a zero when a head is on track 00 or outer position of track 00.

NOTE: /TKO is an output signal of a latch whose status is decided by the track 00 sensor only while the drive is not in power save mode.

3.2.4.11 /TACH:

This signal is used to monitor the disk motor speed. /TACH signal specification is as follows:

Number of pulse per rotation	: 60
Accuracy of period	: +/- 0.2% (STD)

3.2.4.12 /READY

This status line is used to indicate that the host system can read the recorded data on the disk or write data to the disk

/READY is a zero when the head position is settled on desired track, motor is at the desired speed, and a diskette is in the drive.

3.2.4.13 REVISED:

This status line is used to indicate that the interface definition of the connected external drive. When REVISED is a one, the drive Part No. will be 699-0326 or when REVISED is a zero, the drive Part No. will be 699-0285.

3.2.5 /WRTGATE:

When /WRTGATE is a zero, when /ENBL is a zero and if the inserted disk is not write protected, data on WRTDATA are recorded on the disk.

3.2.6 WRTDATA:

This line is to be used to record data on the disk. Each change in the level of WRTDATA causes a flux transition to be written.

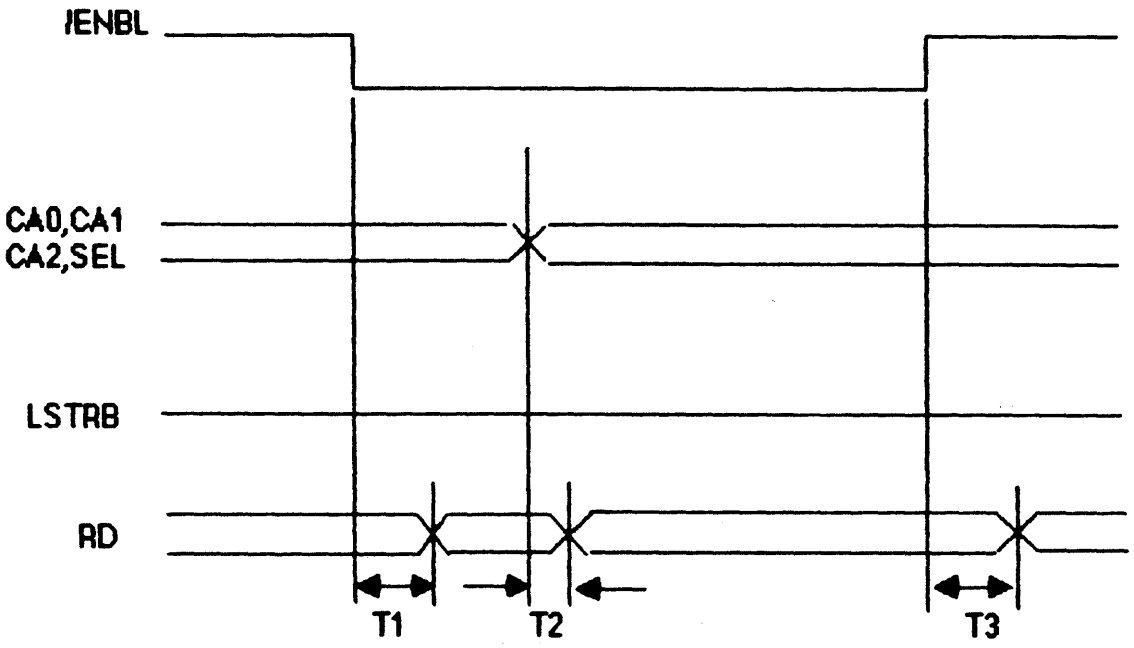
3.2.7 /PWM:

/PWM is a signal of 22 KHz, which controls disk motor speed of single sided drive Part No. 699-0285. If PWM signal is held high, drive Part No. 699-0326 the read signal will be valid.

3.4 Timing Requirements

The following sections contain timing diagrams which show the relationship between the input and output signals.

3.4.1 /DIRTN, /STEP, /MOTORON, /EJECT, /SINGLE SIDE, /RDDATA, /DRVIN, /TACH, /READY, /CSTIN, WRTPRT, /TKO, and REVISED

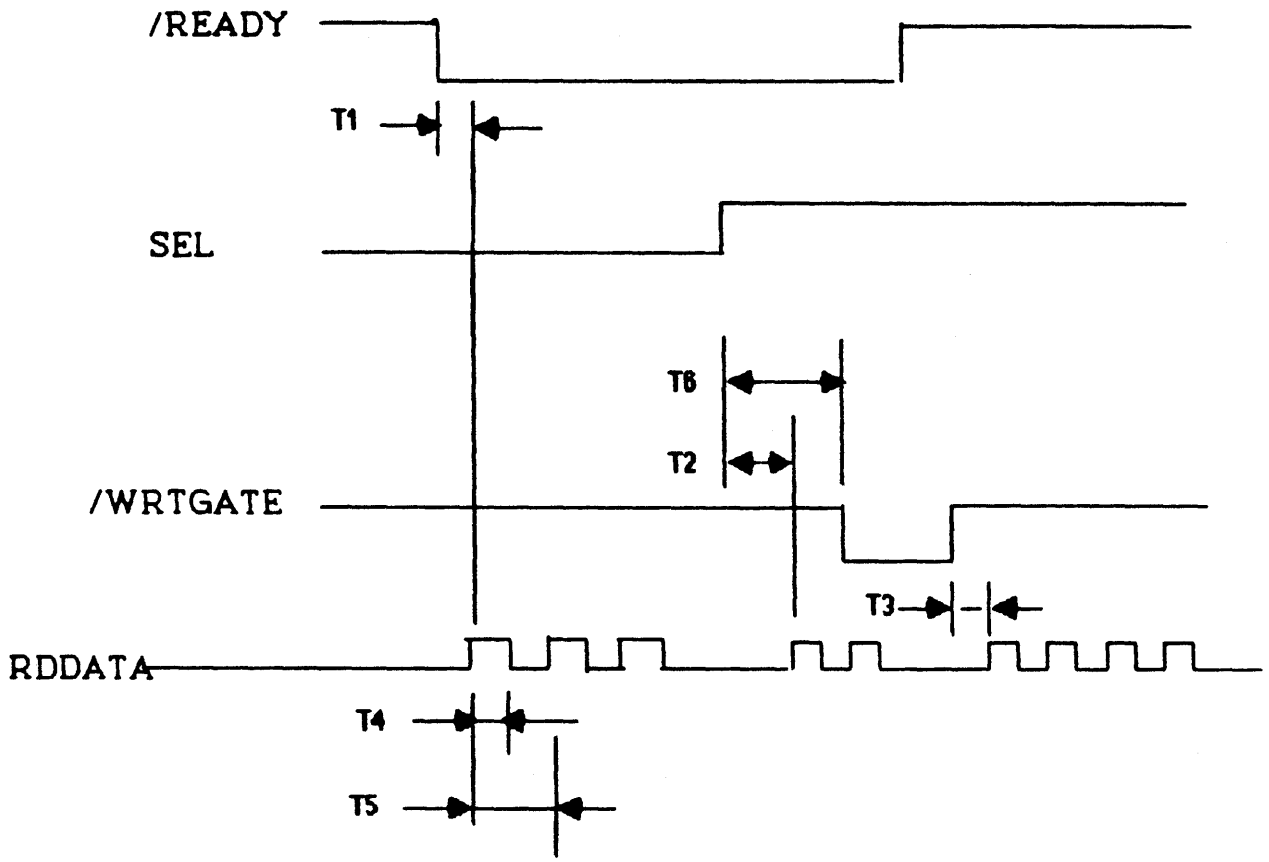


T1: 0.5us max

T2: 0.5us max

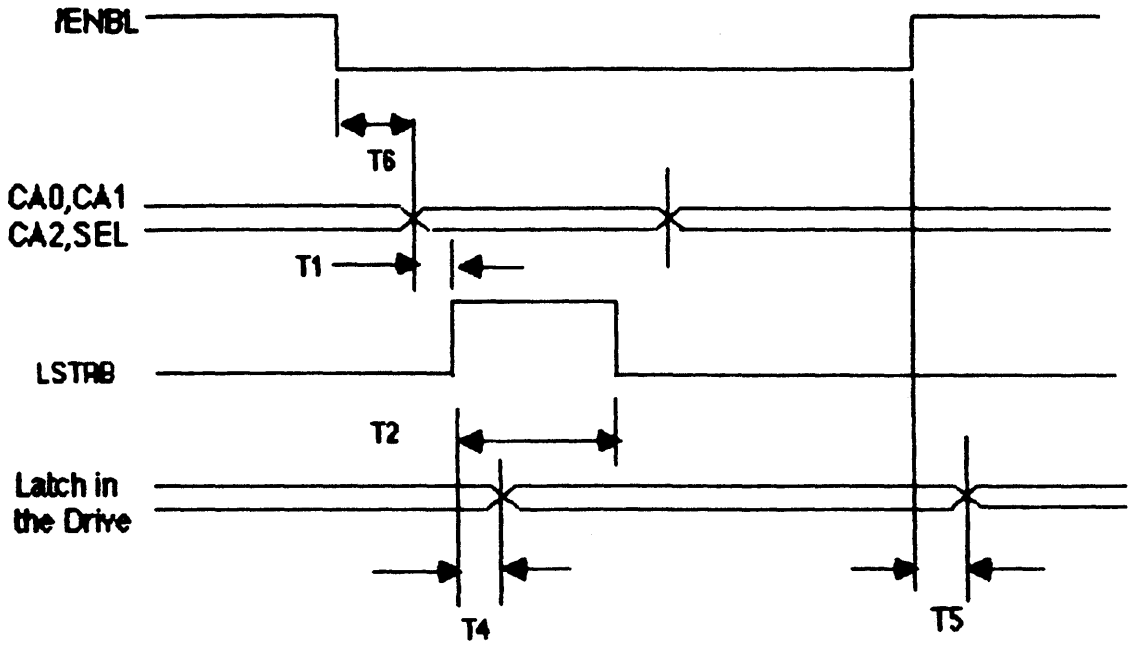
T3: 0.5us max for high impedance state

3.4.1.2 RDDATA



T1: 0.5us max
T2: 100us max
T3: 620 msec max
T4: 0.3us min, 0.8us max
T5: 2,4,6us nominal
T6: 100 usec min

3.4.2 Sending One of Control Commands



T1: 0.5us min

T2: 1.0us min

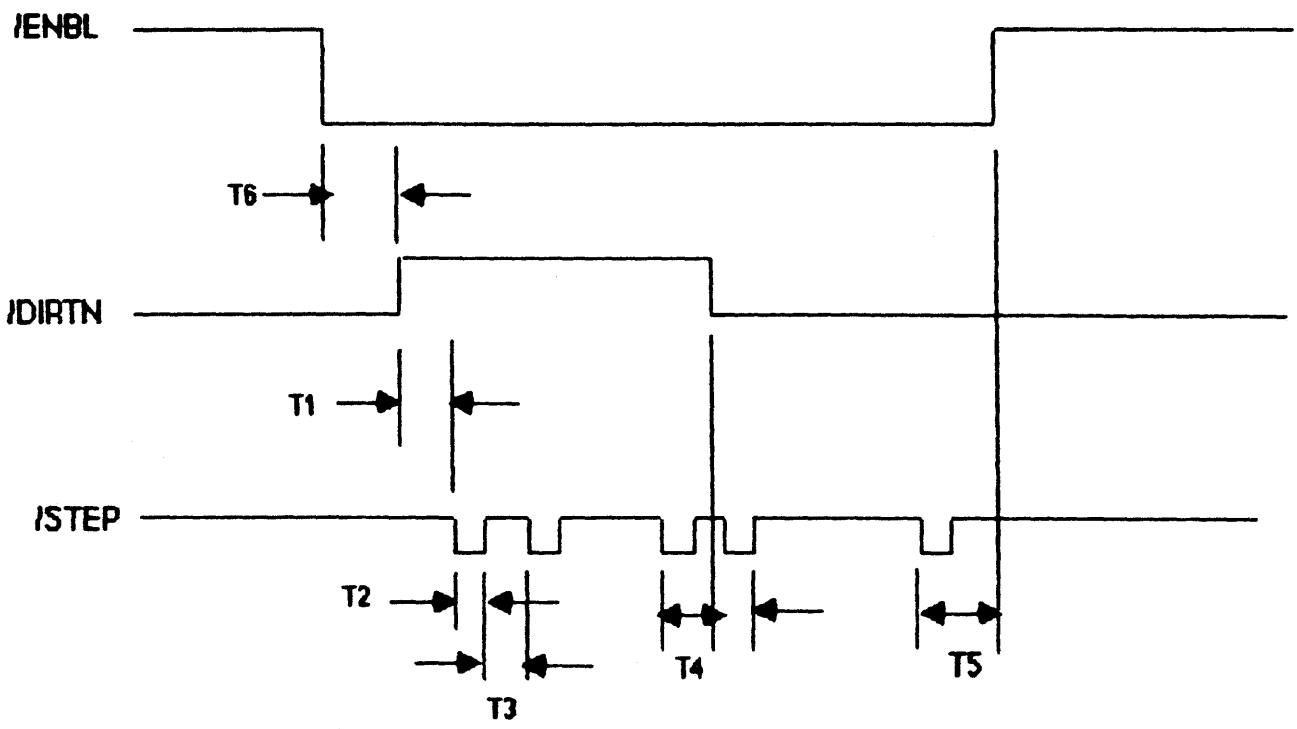
T4: 1.0us min

T5: 0.5us min

T6: 0.5us min

3.4.3 Head Access

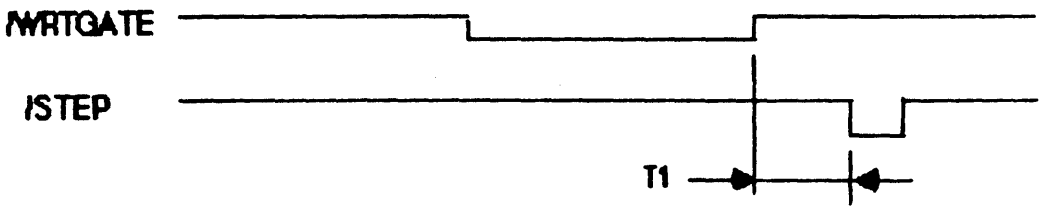
3.4.3.1 /STEP and /DIRTN Timing



T1: 1.0us min
T2: 0.5us min, 72us max
T3: 0.5us min
T4: 0.5us min
T5: 0.5us min
T6: 0.5us min

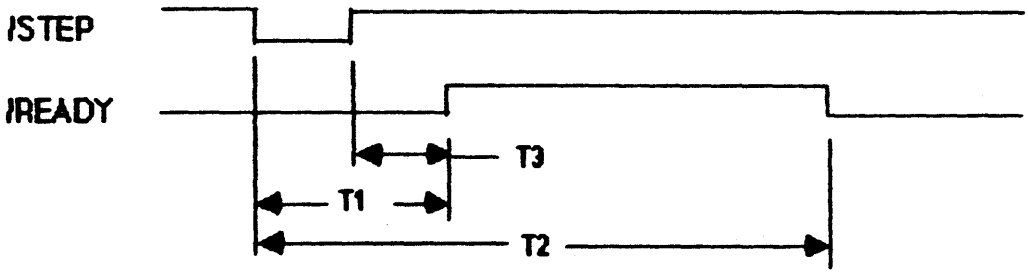
NOTE: It is not allowed to change /DIRTN during the head movement or head settling period

3.4.3.2 /STEP and /WRTGATE



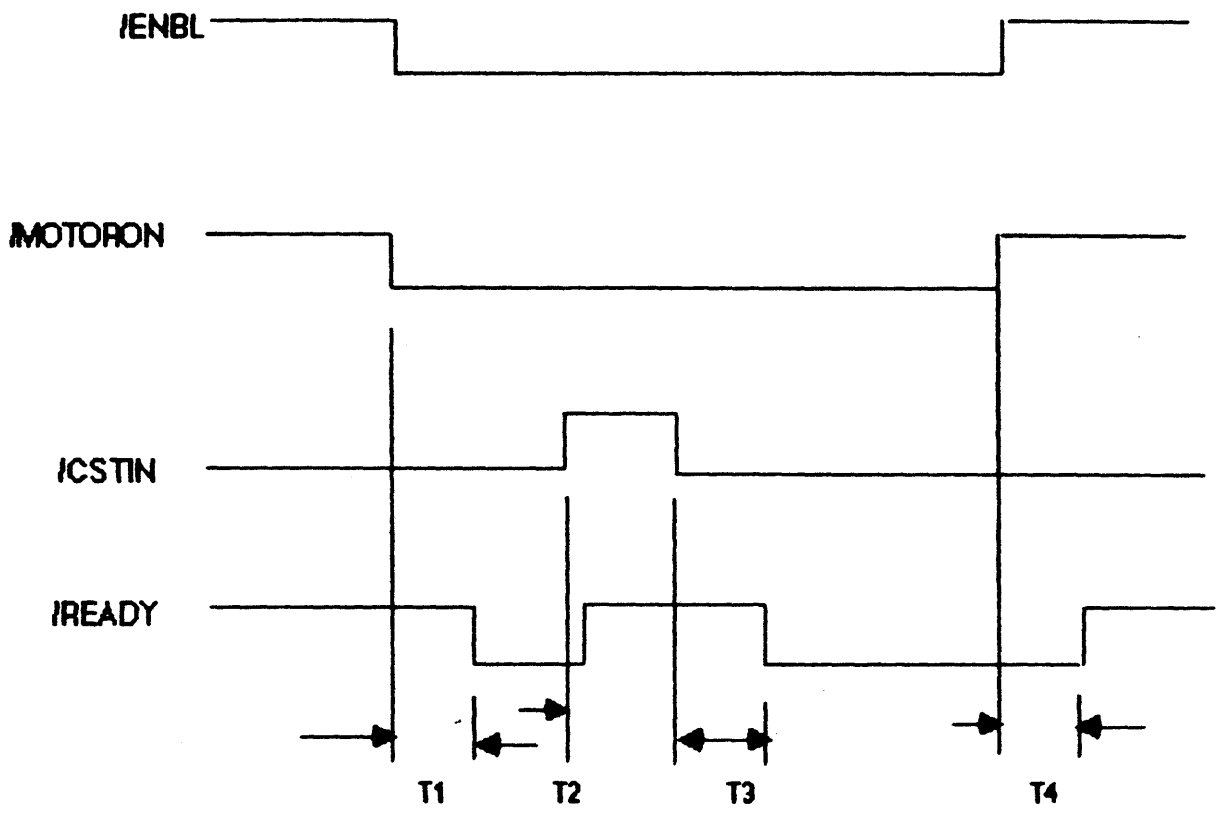
T1: 620us min

3.4.3.3 /READY for Track Access



T1: 150us max
T2: 36ms to move one track without speed block change
: 152ms max to move one track with speed block change
: 600ms max for any case when step pulses are sent at the maximum rate
T3: 150us max

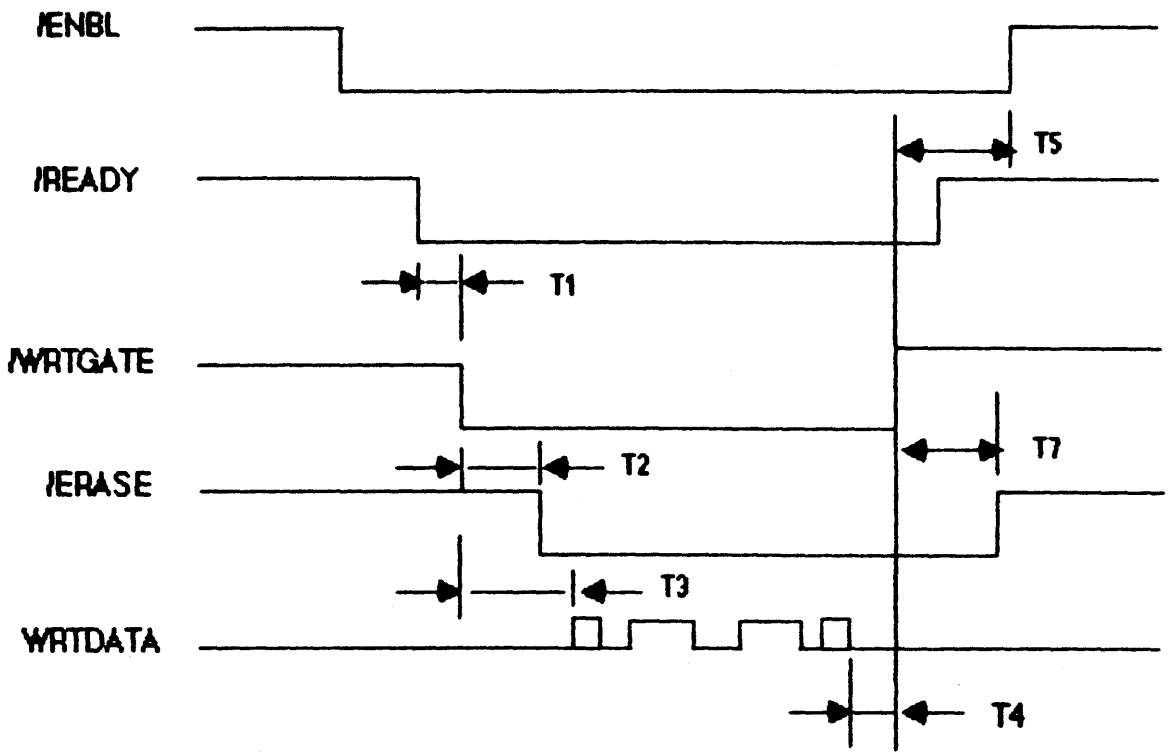
3.4.4 /READY for Motor-On or Disk-In



T1: 600ms max
T2: 0.5us max
T3: 1.0s max
T4: 50 msec max to be valid

3.4.5 Write Data Timing

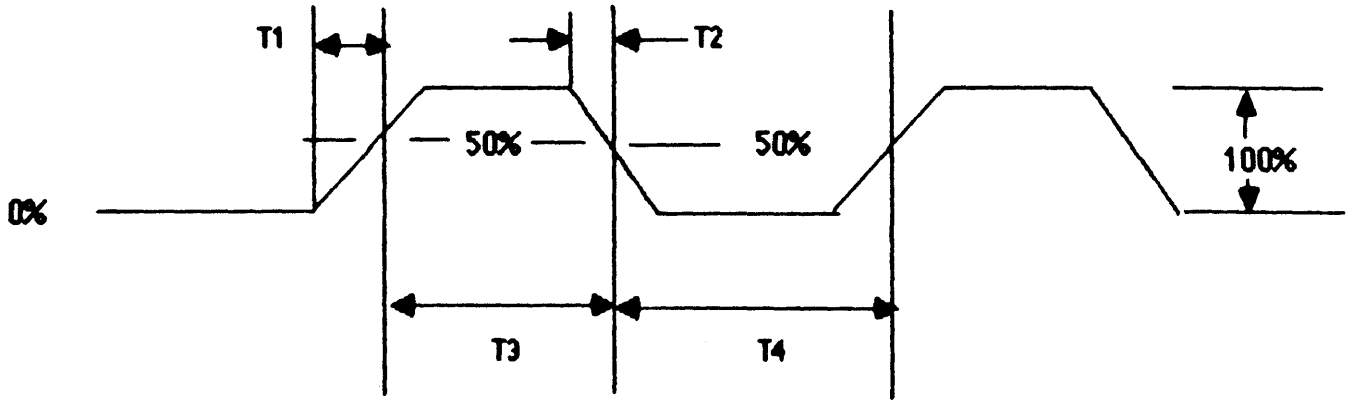
3.4.5.1 /WRTGATE, WRTDATA, and /ERASE Timing



T1: 0.5us min
T2: 0us min, 43us max
T3: 1.8us min
T4: 2us minimum
T5: 0.5us min
T7: 480us min, 590us max

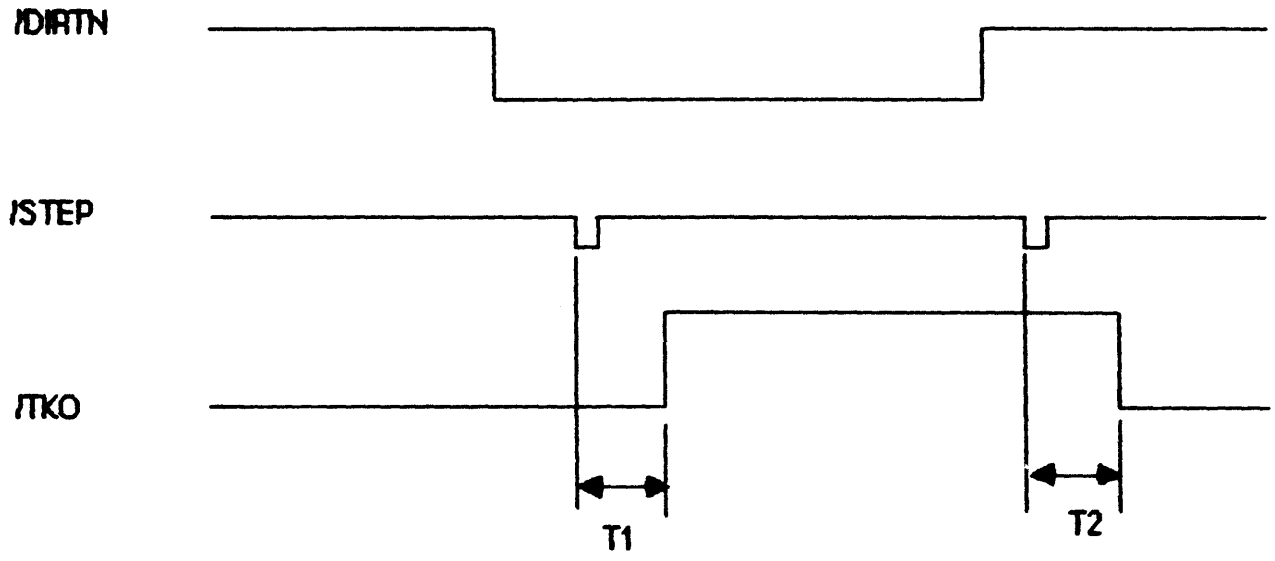
NOTE: /ERASE is a signal internal to the drive

3.4.5.2 Waveform of WRTDATA



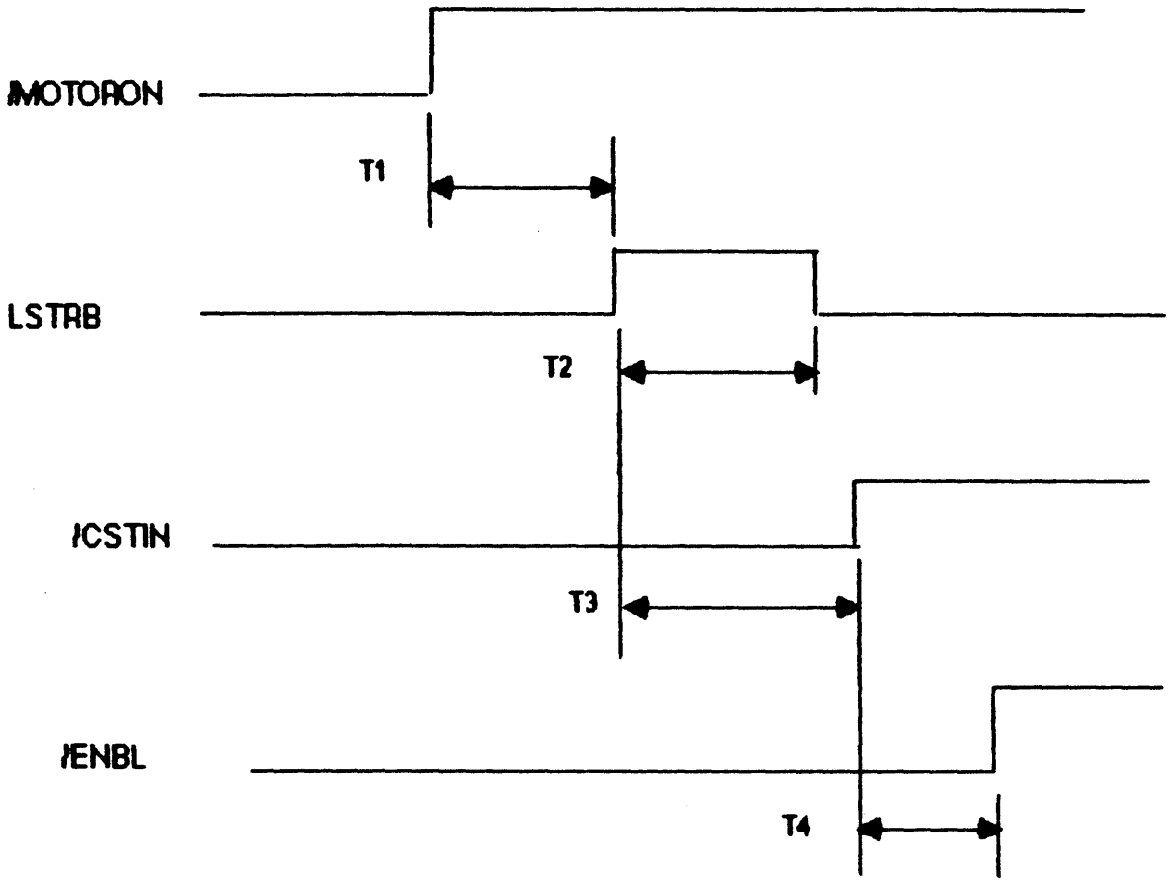
T1 - T2 : 50ns max
T3 - T4 : 2,4,6us nominal

3.4.6 /TKO Timing



T1: 6.0ms max
T2: 6.0ms max

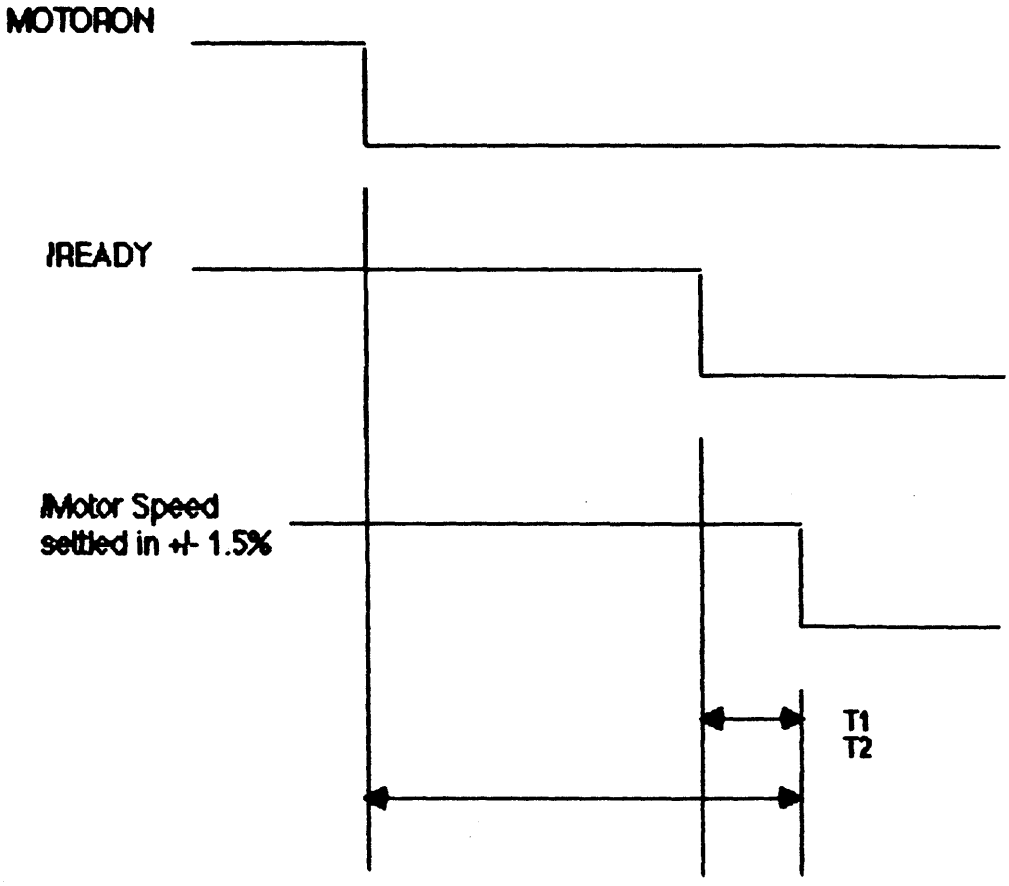
3.4.7 EJECT and /MOTORON



T1: 200 msec min
T2: 1.0us min (300 msec) max
T3: 1.5s max
T4: 150 us min

3.4.8 Format Motor Speed (+ 1.5% Speed Tolerance)

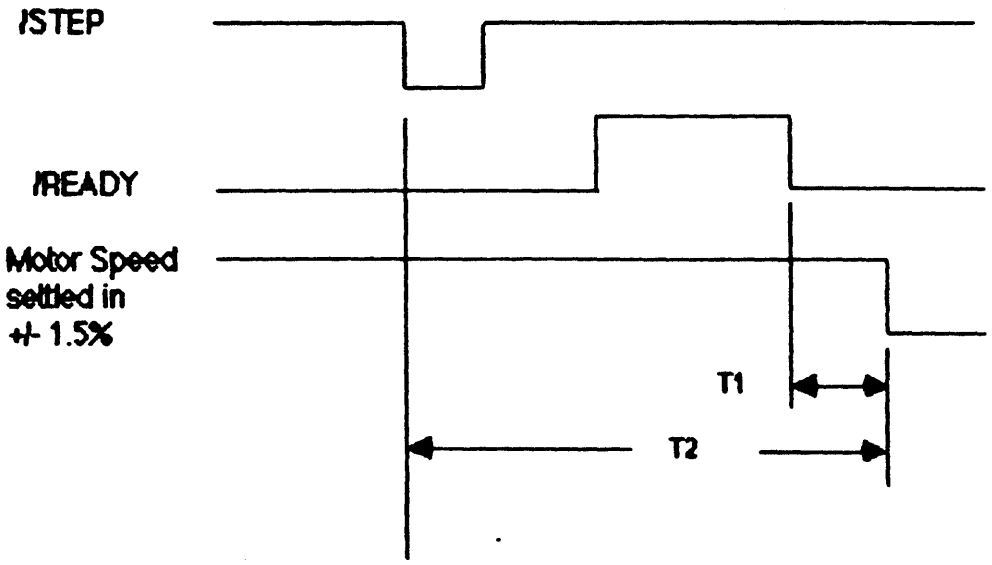
3.4.8.1 Motor Start



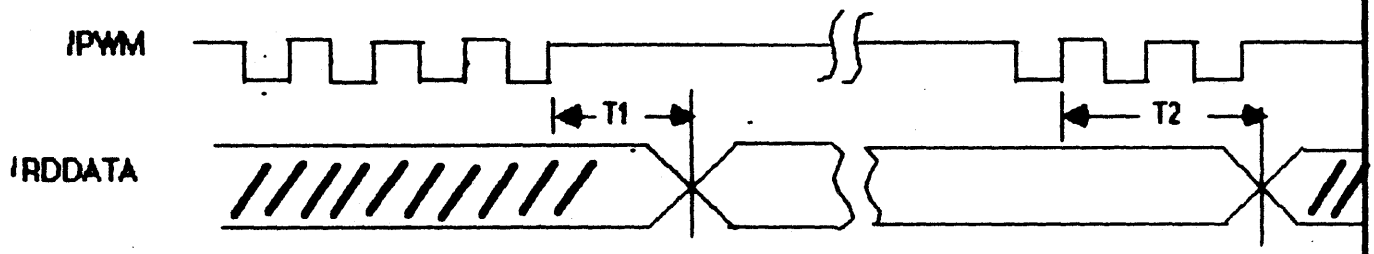
T1: 300 ms max
T2: 900 ms max

T1: 50 ms max
T2: 200 ms max

3.4.8.2 SETTLING TIME



3.4.9 /PWM and RDDATA



T1: 4us max to be valid RDDATA after PWM pulses stop.

T2: 5ms max to be invalid RDDATA after PWM pulses start.

3.5 Power On and Off Requirements

3.5.1 Data Protection

There shall be no damage to recorded data on the disk during either a power on or power off operation as long as the disk is not in the middle of a write when power is turned off.

3.5.2 Power Supply Sequencing

No special power supply sequencing shall be required by the disk as long as both the +5 volt and +12 volt power supplies have a monotonic rise time of less than 200 milliseconds. That is, there shall be no ringing on the supplies during turn on or turn off which causes them to rise above then fall below their specified voltage. Some ringing is tolerable as long as it doesn't cause the voltage to exceed or fall below the specified limits (+/- 5%).

After turn off, both supplies must fall monotonically to zero volts, however there are no sequencing or timing requirements.

3.5.3 Head Position Initialization

At power on, the head shall be automatically accessed to track 0.

3.5.4 Communication With the Host Computer at Power On

No communication should be attempted until 1 sec minimum after power supply stable.

3.6 Disk Motor Rotation at the Disk Insertion

The disk motor automatically rotates for 2 seconds maximum when a diskette is inserted in the above dirve.

3.7 Condition for the Power Save Mode

The drive is in Power Save Mode when /ENBL is high, except for:

(a) When the Eject Motor is running
(b) During Automatic Disk Motor Rotation
(c) When Head Access is being executed
(d) During Erase Operation

3.8 Requirement for Proper Chucking

If a disk is already in the drive when the power is turned on, the host system shall rotate the disk for 500 msec minimum to guarantee the chucking.

When the new disk is inserted, it is required to access TRK 00 and rotate the disk.

Note: When /ENBL is high and the diskette is manually ejected and reinserted, then the Auto Disk Motor Rotation does not occur.

3.9 Interface Connector and Pin Assignment

The interface connector shall be a 20 pin connector, 3m J3428-5202C or equivalent. The pinouts are as follows:

Pin Number	Signal Name	Pin Number	Signal Name
1	GND	2	CA0
3	GND	4	CA1
5	GND	6	CA2
7	GND	8	LSTRB
9	N/C	10	/WRTGATE
11	+5v	12	SEL
13	+12v	14	/ENBL
15	+12v	16	RD
17	+12v	18	WRTDATA
19	+12v	20	/PWM

4.0 Labeling

The drive shall have two labels attached when it is shipped to Apple.

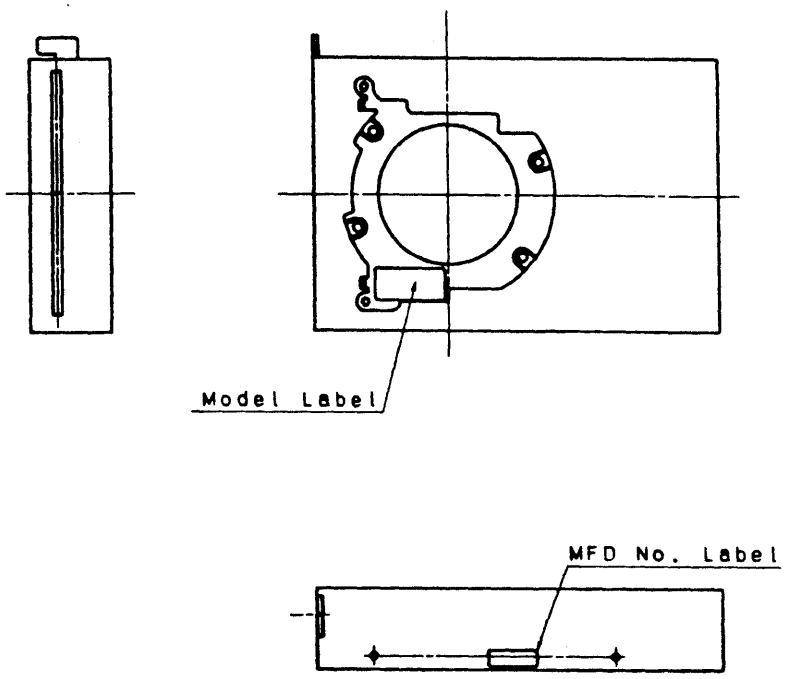
4.1 Label Position

The serial number label shall be attached to the right side, and the Model label shall be attached to the motor housing as shown in Figure 4.1.

4.2 Label Contents

The shape and contents of the serial number label shall be as shown in Figure 4.1. The date label shape and size may be picked by the drive manufacturer, but must included the month and year of manufacturer and be clearly legible.

Figure 4.1



LABEL LOCATION

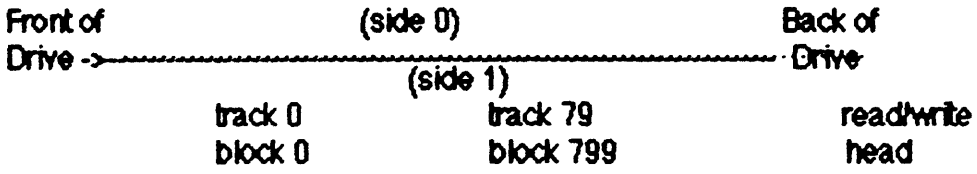
APPENDIX A. MARGIN BOARD SCHEMATIC

See drawing number 050-0152.

APPENDIX B. SECTOR FORMAT

This document describes the sector format used for double-sided 3 1/2 inch diskettes.

The diagram below shows a side-view of a drive, the dotted line representing a diskette.



There are 80 tracks on the drive, numbered from track 0 (the outermost track) through track 79 (the innermost track). The single side is side 0: The top side is side 1.

The number of sectors per track varies from 12 on the outside tracks to 8 on the inside tracks as shown in the following table. Speed represents a data transfer rate of 489.6K bits/sec. The different speeds record the data at a fixed density and allow the diskettes to be interchanged.

Track	Speed Group	Sectors/Track	Speed
0-15	1	12	394
16-31	2	11	429
32-47	3	10	472
48-63	4	9	525
64-79	5	8	590

This format is derived by limiting the sectors per track for the drive according to the smaller radius of the opposite-side track. This format yields a total of 800 sectors or blocks per side. Block numbering goes from 0 to 1599: block 0 is sector 0 on track 0 and block 1599 is sector 7 on track 79 of side 1 (sectors are numbered from 0). These blocks are to be interleaved with side 0 blocks in a cylinder fashion (blocks 0-11 will be on side 0, track 0, blocks 12-23 will be on side 1 track 0, etc).

Sectors are typically interleaved 2:1 because of the write recover time. As an example, the sector sequencing for 2:1 interleave is:

Speed group 1: 0-6-7-2-8-3-9-4-10-5-11
Speed group 2: 0-6-1-7-3-8-3-9-4-10-5
Speed group 3: 0-5-1-6-2-7-3-8-4-9
Speed group 4: 0-5-1-6-2-7-3-8-4
Speed group 5: 0-4-1-5-2-6-3-7

Sector Format

A sector can be divided into four major sections. These are the header sync field, the header field, the data sync field and data field. These fields combined add up to 733.5 code bytes minimum.

Header Sync Field (6.25 bytes + sync overhead)

5 bit slip FF's minimum (FF, 3F, Cf, F3, FC, FF)

The header sync field contains a pattern of one and zeros that synchronizes the hardware state machine with the data on the disk. The header sync and header fields are written only when the diskette is formatted. The formatter should make this field as large as possible since this field buffers expansion of the previous sector's data field due to speed variation of the drive.

Header Field (11 bytes)

D5 AA 96 Trk Sect Side Fmt ChkSum DE AA off

The header field indentifies the sector. The sub-fields are:

D5 AA 96	address marks: this identifies the fields as a header field.
Track	encoded low 6 bits of track number
Sector	encoded sector number
Side	encoded high 2 bits of track number and side bit: decoded bit 5=0 for side 0, 1 for side 1 decoded bit 0 is the high-order bit of the track number decoded bits 1-4 are reserved and should be 0
Format	encoded format specification: decoded bit 5=0 for single-sided formats decoded bits 0-4 define the format interleave: standard 2:1 interleave formats have a 2 in the field
Checksum	checksum formed by exclusive 'or' in the track, sector side and format fields
DE AA	bit slip marks: this identifies the end of the field
Off	pad byte where the write electronics were turned off

Data Sync Field (6.25 bytes)

5 bit slip FF's (FF, 3F, CF, F3, FC, FF)

The data sync field contains a pattern of ones and zeros than synchronizes the state machine with the data on the disk. This field is written whenever the data field is written.

Data Field (710 bytes)

D5 AA AD Sect <endcoded data> ChkSum DE AA off

The data field contains the actual data in the sector. The sub-fields are:

D5 AA AD	data marks: this identifies the field as a data field.
Sector	encoded sector number
Encoded Data	524 data bytes encoded into 699 code bytes; the first 12 data bytes are typically used as a sector tag by the operating system, and the remaining 512 bytes for actual data
Checksum	a 24-bit checksum encoded into 4 code byte (see below)
DE AA	bit slip marks: this identifies the end of the field
Off	pad byte where the write electronics were turned off

Data Encoding Format

A sector is composed of 524 user data bytes and a 3 byte checksum. These are translated into 6 bit nibbles that are used to look up GCR codewords to be written to the disk. The data is encoded as follows: CSUMA, CSUMB, CSUMC are registers used for accumulating the checksum. BYTEA, BYTEB, BYTEC contain three bytes from the data buffer. GCR is the table of GCR codewords.

1. Rotate CSUMC left
   CSUMC [76543210] <-CSUMC [65432107]
   Carry <-CSUMC [7]
2. CSUMA<-CSUMA + BYTEA + carry from step 1
3. BYTEA <-BYTEA xor CSUMC
4. CSUMB <-CSUMB + BYTEB + carry from step 2
5. BYTEB <-BYTEB xor CSUMA
6. CSUMC <-CSUMC + BYTEC + carry from step 4
7. BYTEC <-BYTEC xor CSYMB
8. Convert BYTEA, BYTEB and BYTEC to 6 bit nibbles
   NIBL1 <-A7 A6 B7 B6 C7 C6 High bits of the bytes
   NIBL2 <-A5 A4 A3 A2 A1 A0 Low bits of BYTEA
   NIBL3 <-B5 B4 B3 B2 B1 B0 Low bits of BYTEB
   NIBL4 <-C5 C4 C3 C2 C1 C0 Low bits of BYTEC
9. Write GCR (NIBL1), GCR (NIBL2), GCR (NIBL3) and GCR (NIBL4)

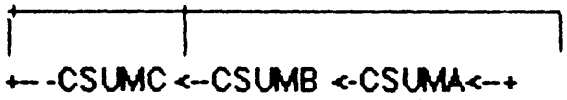


Figure showing carry propagation

GRC Codeword Table (used to convert nibbles to GCR codewords)

```
 0: 96,97,9A,9B,9D,9E,9F,A6
 8: A7,AB,AC,AD,AE,AF,B2,B3
10: B4,B5,B6,B7,B9,BA,BB,BC
18: DB,BE,BF,CB,CD,CE,CF,D3
20: D6,D7,D9,DA,DB,DC,DD,DE
28: DF,E5,E6,E7,E9,EA,EB,EC
30: ED,EE,EF,F2,F3,F4,F5,F6
38: F7,F9,FA,FB,FC,FD,FE,FF
```

Disk Storage Calculations

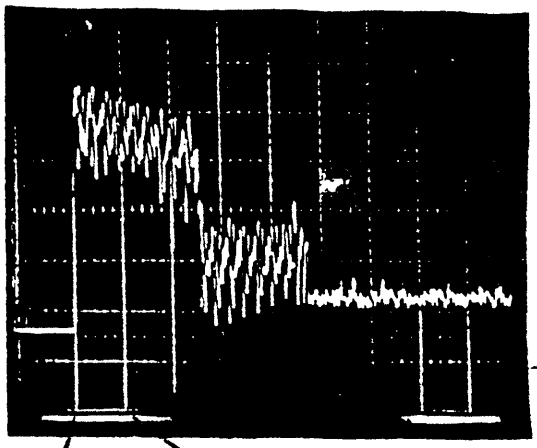
The next page shows how the track classes and speeds were determined. The following formulas were used:

track density:	135.4666 track/inch 0.1875 mm track to track
track 0 radius:	39.5 mm (38.0 mm, side 1)
max data density:	8381 fci = 344.4882 fcmm (8850 fci, side 1)
sync overhead:	6%
bytes/block:	733.5
data speed:	489.6K bits/sec
bytes:	(733.5 * blocks) * 1.06
rpm:	60 sec/min * 489.6kbits/sec (bytes * 8 bits/byte)
fci:	bytes * 8 bits/byte (2*Pi*Radius in inches)

APPENDEX C

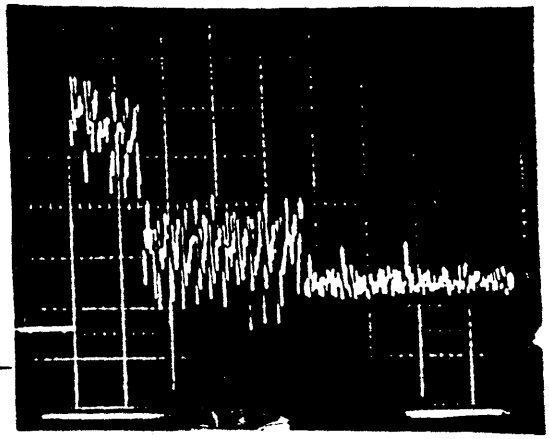
CURRENT WAVE FORMS
REFERENCE ONLY

Motor On and Seek
12 V Tk 0 to 79 100ma/div
100 msec./div

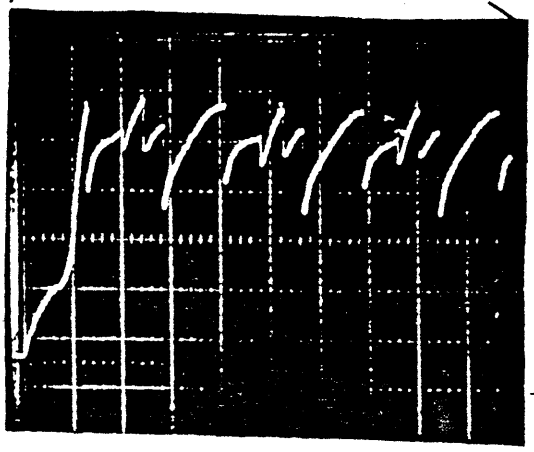


GND

12 V Tk 79 to 0 100 ma/div
100 msec./div

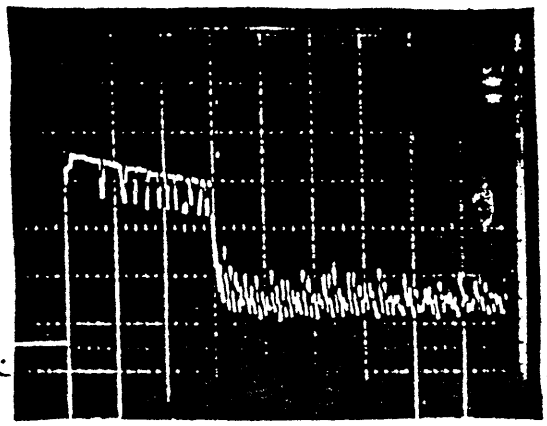


Expanded Motor On and Seek
100 mA/div 2 msec /div



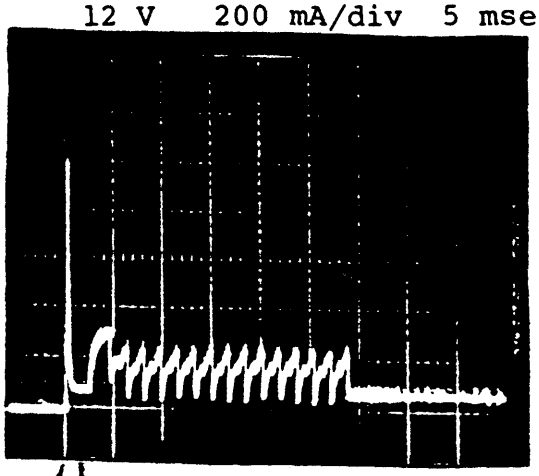
GND

Motor On only
100 mA/div 50 msec/div



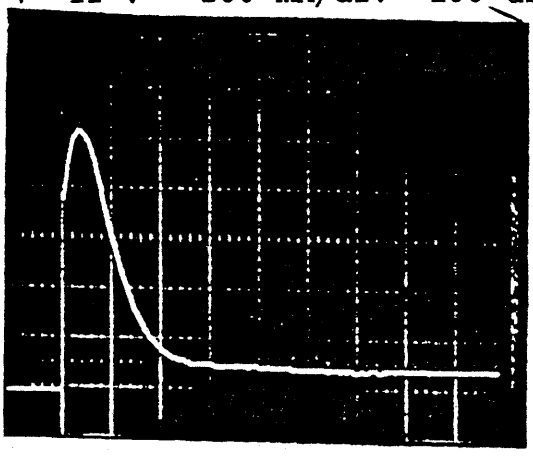
CURRENT WAVE FORMS CONT.

/ENBL ON
12 V 200 mA/div 5 msec/div



GND

12 V 200 mA/div 100 usec/div

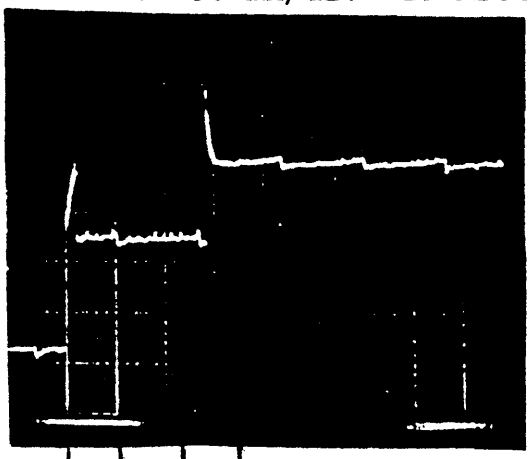


GND

CURRENT WAVE FORMS CONT.

/ENBL ON

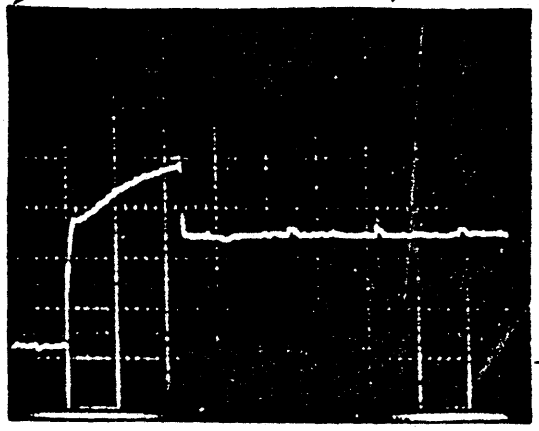
5 V 50 mA/div 10 msec/div



GND

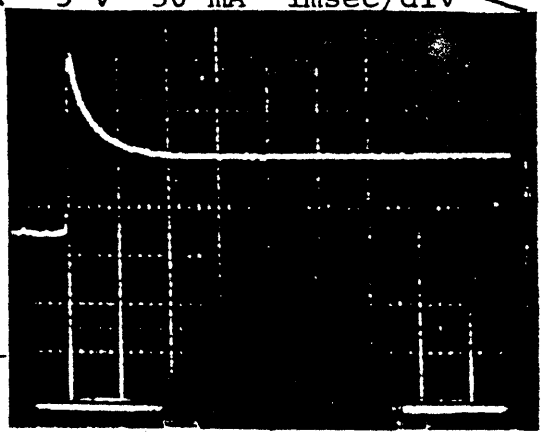
/ENBL ON

5 V 50 mA 1 msec/div



/ENBL ON

5 V 50 mA 1msec/div

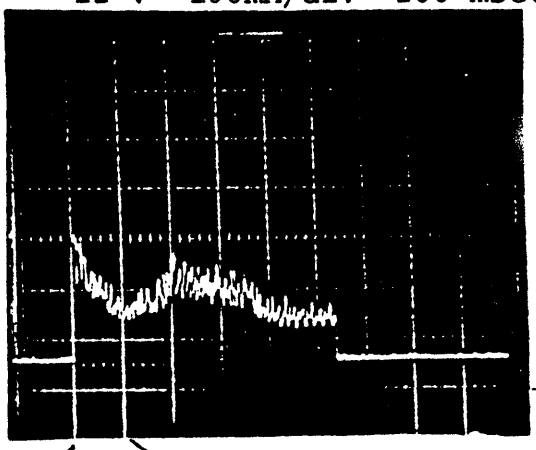


GND

CURRENT WAVE FORMS CONT.

CARTRIDGE EJECT MOTOR
(SPINDLE MOTOR OFF)

12 V 100mA/div 200 msec/div



100 mA/div 20 msec/div