REV.	ZONE	ECO #	REVISION	APPD	DATE
A		F083	INITIAL RELEASE		
A		F185	PAGE 9: ADDED WET BULB TEMP. PAGE 29: ADDED DATE LABEL SHAPE, SIZE, MONTH AND YEAR. REMOVED REFERENCE TO FIGURE 4.3. PAGE 31: ADDED APPLE TO PART NUMBER 1.0 HIGH.	RJC	12/83
A		F207	PRODUCTION RELEASE	for Charles	4/11/84

SPECIFICATION FOR 3.5 INCH SINGLE SIDED DISK DRIVE

APPLE PART NUMBER 699-0285

SHEET 39 is E SIZE DRAWING

DRAWING NUMBER 699-0285-A

SHT 1 / 39

METRIC

DIMENSIONS ARE IN MILLIMETERS
TOLERANCES
X ± ____ XXDs ____
XX ± ____ ANGLES ± ____
DO NOT SCALE DRAWING

MATERIAL:		FINISH:	
DRFT		DRFT CK	GLC 10/83
ENG APPVL	11/83	MFG APPVL	11/83
RELEASE		ENG DIV	MAC
DESIGNER		SCALE	

apple computer inc.

TITLE: DISK DRIVE. 3 1/2 INCH

SIZE	DRAWING NUMBER	SHT
A	699-0285-A	1 / 39

CONTENTS

1.0 Description

This specification defines a single sided 3.5 inch Micro-Floppy disk Drive, Apple part number 699-0285.

2.0 Specification

The drive shall satisfy the following specifications when a diskette meeting the Apple disk specification, specification number 003-0001, is used.

2.1 Configuration

The drive consists of a read/write head, head positioning mechanism, disk motor, interface logic circuit, read/ write circuit, and auto 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. 154-1983 requirements for safety.

2.2 Mechanical Dimensions

The mounting holes are shown in Figure 2.2, and the complete mechanical dimensions are shown in Apple drawing number 699-0285 page 39, which is an addendum to this specification available on request.

2.3 Performance

2.3.1 Capacity and Encoding Method - see Appendix B

2.3.2 Transfer Rate

Detected flux transistions shall occur not less than 1.89 usec nor more than 6.36 usec apart.

2.3.3 Access Time

a. Track to track slew rate : 12 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
d. Motor start time : 400 msec Max
(These times are satisfied when the motor speed has settled to within +/- 1% of its final average rpm.)

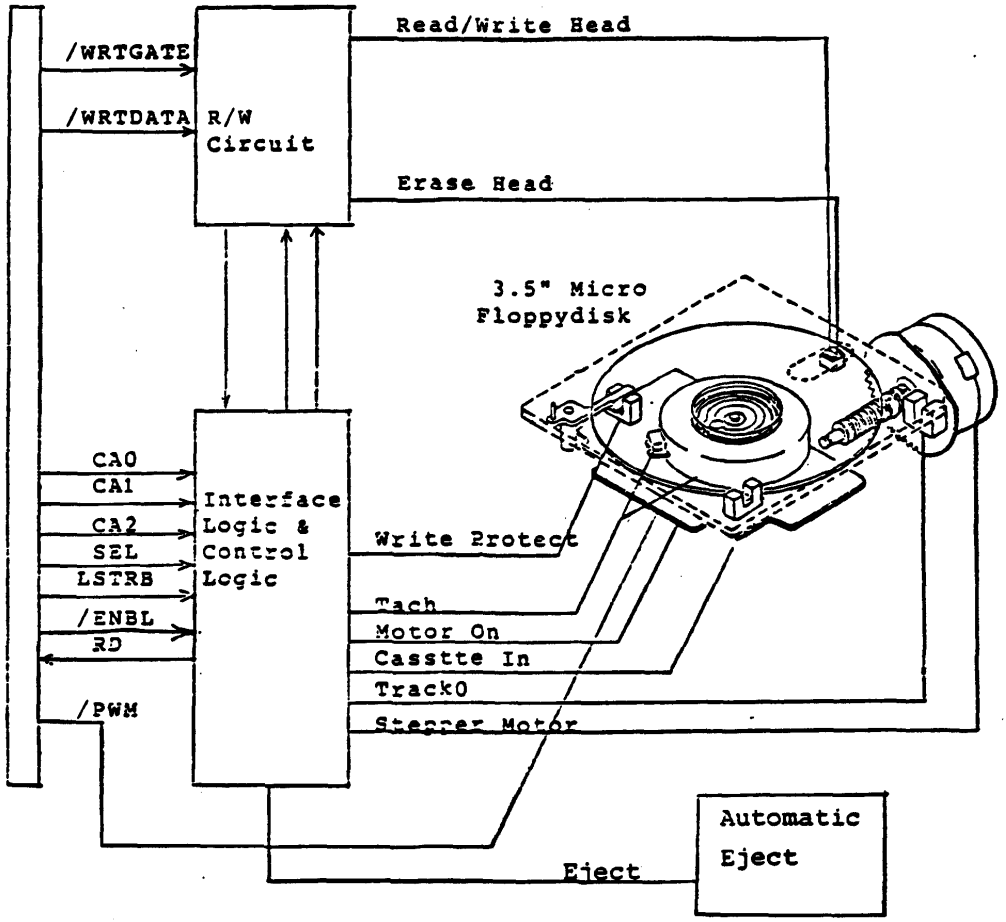
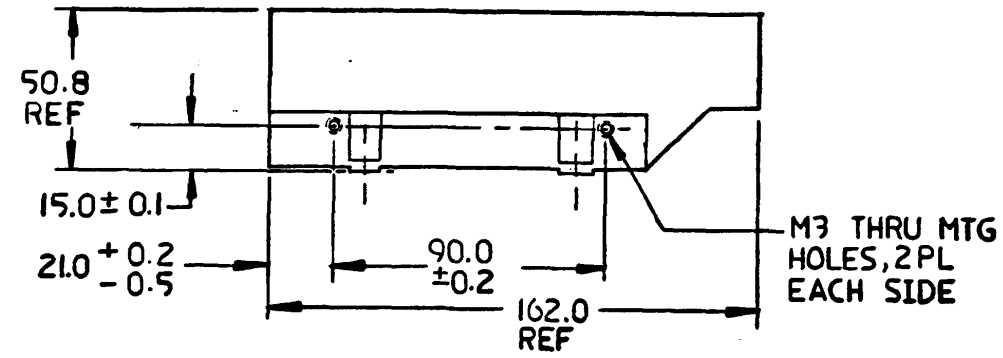
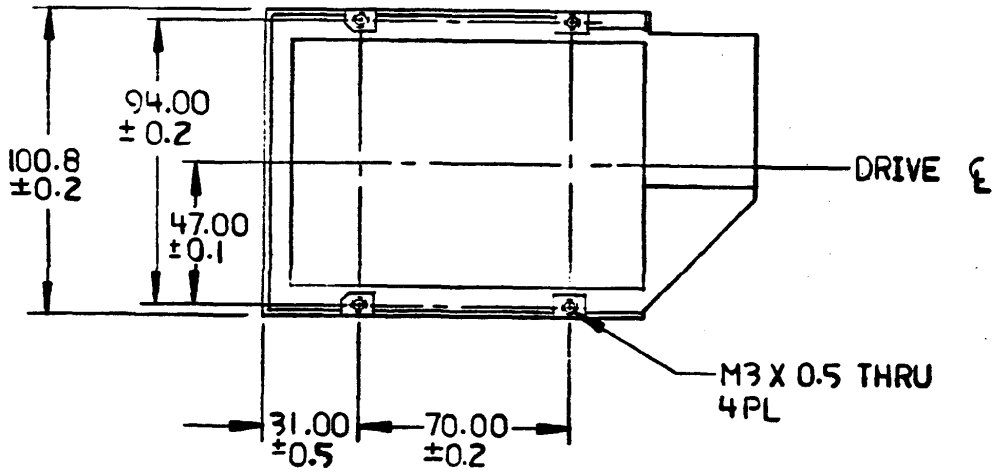


Figure 2.1 Configuration of Disk Drive

apple computer inc.	SIZE A	DRAWING NUMBER 699-0285-A
	SCALE:	SHEET 6 OF 39



RIGHT SIDE VIEW



BOTTOM VIEW

Figure 2.2 Mounting Hole Dimensions

apple computer inc.

SIZE	DRAWING NUMBER
A	699-0285-A
SCALE:	SHEET 7 OF 39

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 continuously variable from 390 to 605 rpm using a pulse width modulated signal input.

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 minumum density assumes all 6 usec transistions even though the format doesn't allow more than one 6 usec interval to be written at a time.

Maximum	:	8472 FCI
Minimum	:	2365 FCI

c. Track Density : 0.1875mm Track - Track

d. Tracks : 80

e. R/W Head : 1

2.3.5 Weight: 750g Max

2.4 Input Power Requirements

Voltage	Max. Ripple	Current
+12.0V +/-5%	0.1Vpp	Standby 0.15A (motor off) Average 0.3A (motor on) Peak 1.0A (stepping)
+5.0V +/-5%	0.1Vpp	0.5A maximum

2.5 Environmental limits

2.5.1 Temperature

Operating : 5 C to 50 C (40 F to 122 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 : 20% to 80% relative humidity with a wet bulb temperature of 29 C (85 F), with no condensation.

5% to 90% relative humidity with a wet bulb temperature of 37.8 C (100 F) if the track alignment specification (Section 2.11) is relaxed to +/-0.040 mm from +/-0.035 mm, with no condensation.

Non-Operating: 5% to 95% relative humidity with no condensation.

2.5.3 Vibration

Operating : The unit shall perform read/write operation without errors with continuous vibration from 5 to 100 Hz at a maximun of 0.5G along each of the three mutually perpendicular axes.

Non-Operating: The unit shall be able to withstand continuous vibration from 5Hz to 300Hz with a maximun level of 2.0G along each of the three mutually perpendicular axes without any degradation of any characteristics below the performance specification.

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 the three mutually perpendicular axis while performing normal read/write functions without damage or any loss of data.

Non-Operating: The unit when unpacked shall withstand a shock of 60G on any of the three mutually perpendicular axis.

2.6 Noise

Operating : Noise from the drive shall be less than 55 Dba at a point 50cm from the drive.

2.7 Orientation

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

2.8 Reliability

a. Mean Time Between Failure (MTBF): 8000POH
b. Mean Time to Repair (MTTR) : 30 minutes
c. Preventive Maintenance (PM) : Not Required
d. Component life : 5 years
e. Error Rate

1. Soft Read : 1 per 10^{9} bits read
2. Hard Read : 1 per 10^{12} bits read
3. Seek Error : 1 per 10^{6} seeks

2.9 Overwrite Characteristics

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

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):

2F signal level (db) - residual level of 1F (db)

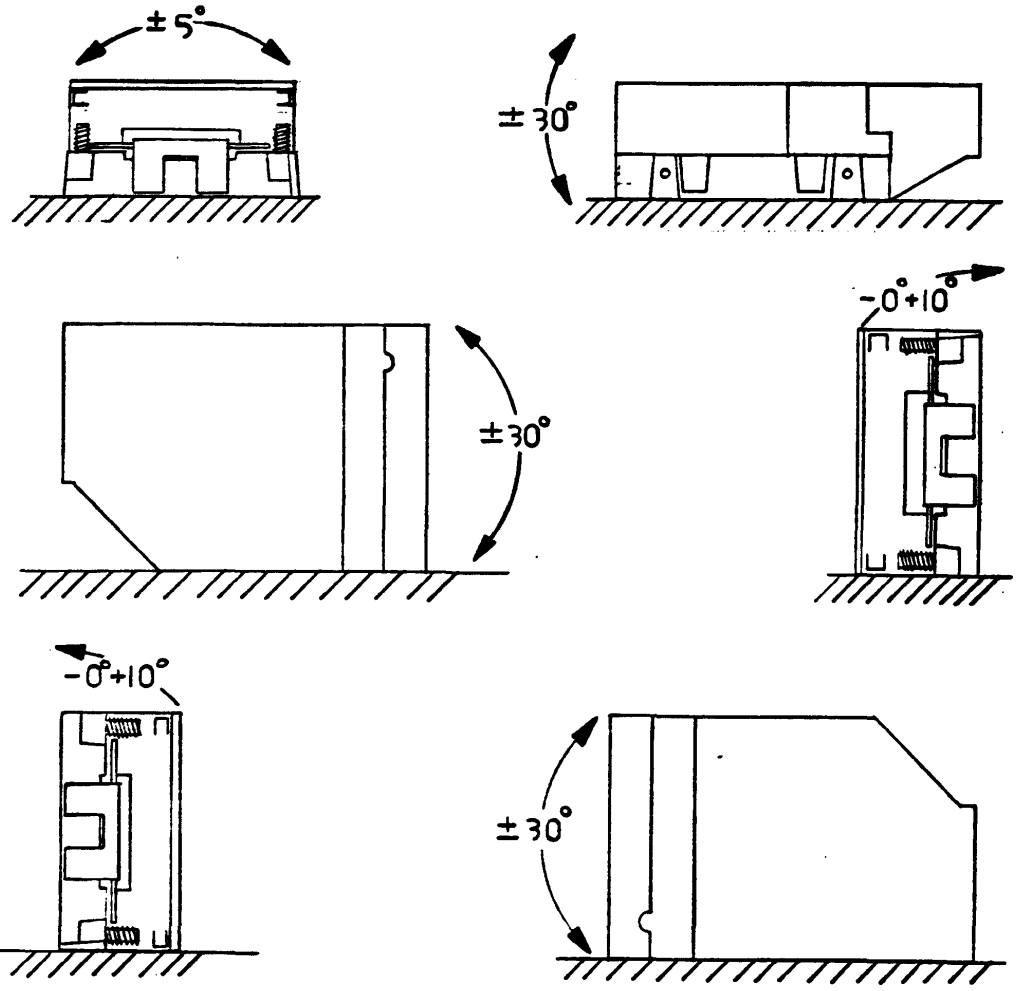


Figure 2.3 Allowable Orientations

2.10 Time Margin

2.10.1 Definition of time margin

Time margin is measured using the Apple jitter generating fixture. This circuit jitters 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 jitter generator, Apple part number 890-2002, is shown in Appendix A.

The data read is comprised of a random pattern of flux changes including all legal combinations of 2, 4, & 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: >300 nS

2.10.3 Off-track Time Margin

The time margin using a reference disk on which random data is written +0.035 mm and -0.035 mm off track shall be >300 ns.

2.11 Alignment Accuracy

Track position is defined by:

RN = 39.5 — 0.1875 x N

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

Alignment Accuracy at track 40 shall be: +/-0.020 mm

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

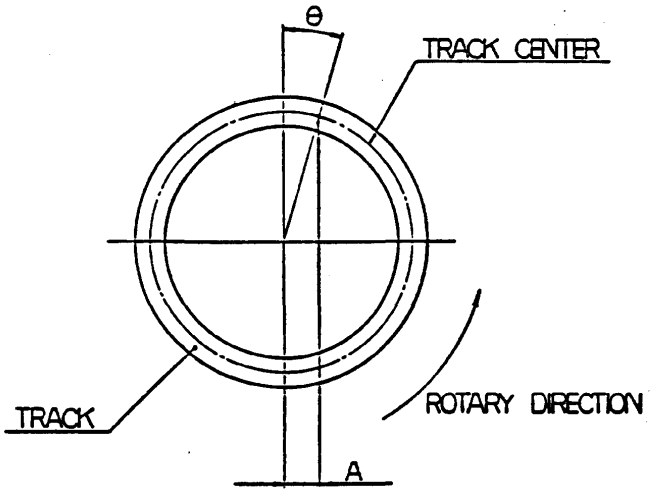
2.12 Azimuth Angle

Azimuth Angle shall be;

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

where : X = 39.5
Y = 0.1875
N = Track number (0 to 79)

Azimuth angle is defined in Figure 2.4.



SIDE 0 VIEW

Figure 2.4 Azimuth Angle

2.13 Off Track Error Rate

a. Using the plus-off-tracked disk on which random flux transistions are recorded off-track +35um from the reference position on all tracks, the drive shall meet the error rate specification.

b. Using the minus-off-tracked disk on which random flux transistions recorded off-track -35um from the reference position on all tracks, the drive shall meet the error rate specification.

2.14 Temperature Inside Drive

The temperature rise above ambient at the disk surface inside of the drive shall not exceed 10 degrees C when the drive is used at 50% duty cycle Random Seek with random reads and writes. The drive shall be set in free air at an ambient temperature of 50 degrees C maximum.

2.15 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, and a new drive, move the head to Track 35, then record 2F signal. Measure the output signal level (Lr).

b. Insert another new disk into 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 in (a). Move the head to Track 35, measure the output signal level (Lx).

f. The ratio of Lx over Lr shall be > 80% as follows:

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

2.16 Media Wear

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 track.

2.17 Disk Motor

The disk motor speed shall be controlled by a PWM signal from the host computer. The specifications of the disk motor are as follows:

2.17.1 Speed Control Range

a. Speed at 9.4% duty cycle of PWM with the diskette in place and head at TK0 (measured at 25 +/- 3 degrees C) shall be:

$$305 < V_{low} < 380\text{rpm}$$

b. Speed at 91% duty cycle of PWM with diskette in place and head at TK79 (measured at 25 +/- 3 degrees C) shall be:

$$625 < V_{high} < 780\text{rpm}$$

c. Over the full environmental range as specified in Section 2.5, and with a diskette in place the following speeds must be guaranteed including all jitter and drift effects:

With the head positioned at TK0 and the PWM set to 9.4%, the motor speed must be less than 390 rpm.

With the head positioned at TK79 and the PWM set to 91%, the motor speed must be greater than 605 rpm.

2.17.2 Linearity

Non-linearity of the disk motor speed shall be less than 2.0%.

Linearity is defined as,

$$\text{Linearity} = \left| \frac{Vx - Vr}{Vr} \right| \times 100\%$$

where :

$$Vr = \frac{(Va - Vb)}{81.6} (x - 9.4) + Vb$$

Vx : Measured speed at a PWM duty cycle of x %.
Va : Measured speed at a PWM duty cycle of 91%.
Vb : Measured speed at a PWM duty cycle of 9.4%.

2.17.3 Jitter

Jitter of the disk motor speed shall be less than 1.8% peak - peak when measured at a motor speed of between 390 and 605 RPM. Jitter is defined as:

$$\text{Jitter} = \frac{4\ Sx}{Sm} \times 100\%$$

where : Sx is the standard deviation of the TACH pulse period sampled randomly 100 points and Sm is the mean of Tach pulse period.

2.17.4 Thermal drift

Thermal drift of disk motor speed for any speed between 390 and 605 rpm shall be less than 3%. The definition of the thermal drift:

$$\text{Thermal drift} = \left| \frac{Vx - Vr}{Vr} \right| \times 100\%$$

where : Vr : Disk motor speed at 25 C ambient temperature.

Vx : Disk motor speed between 5 C to 50 C ambient temperature.

2.17.5 Initial drift

Initial drift of disk motor speed shall be less than 1.0%. Initial drift is defined as:

$$\text{Initial drift} = \left| \frac{Vx - Vr}{Vr} \right| \times 100\%$$

where : Vr : Disk motor speed at 1 sec after disk motor is turned on.

Vx : Disk motor speed at 120 sec after disk motor is turned on.

2.17.6 Speed - Torque characteristics

The change of speed with torque is:

Ratio of speed/torque : -0.25% /gram cm

2.18 Eject Mechanism

2.18.1 Eject Timing

From the leading edge of the eject signal which is 750 +/- 25 milliseconds in duration, the total eject time shall be less than 1.5 seconds. Note that the "cassette in" signal is not guaranteed to indicate no cassette in place until the eject operation is complete.

2.18.2 Eject Mechanism Life

The eject mechanism shall be capable of at least 20,000 disk insertions and ejections using the auto eject mechanism without degradation of specifications or failure. Both insertion and ejection shall be smooth and quiet.

2.18.3 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 1.3 Kg.

3.0 Interface

3.1 General Description

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

SEL	CA2	CA1	CA0	Output signal on RD line
0	0	0	0	/DIRTN
0	0	0	1	/STEP
0	0	1	0	/MOTORON
0	0	1	1	(EJECT)
0	1	0	0	RDDATA (Head0)
0	1	1	0	SIDES
0	1	1	1	/DRVIN
1	0	0	0	/CSTIN
1	0	0	1	/WRTROT
1	0	1	0	/TK0
1	0	1	1	/TACH
1	1	0	0	RDDATA (Head1)
1	1	1	0	Reserved
1	1	1	1	Reserved

3.1.2 Sending Control Commands to Drive.

The host system can send four commands: /DIRTN, /STEP, /MOTORON and EJECT. To send one of the control commands to the drive, set CA2 to the value (a zero or a one) to which the host system wishes the command to be set, and then set CA0, CA1 and SEL to the value which selects the desired command. Finally, bring LSTRB first high and then low.

Note 1: EJECT is an unlached output only: EJECT is a signal which cannot be read (it always reads the value one). To eject a disk, set SEL, CA2, CA1 and CA0 as 0111, then hold LSTRB high for 750 msec.

Note 2: CA0, CA1, CA2 and SEL must not change value while LSTRB is high and CA0 and CA1 must be returned to a one level before changing SEL.

3.2 Signal Descriptions

3.2.1 /CSTIN

This signal goes to a zero only when a disk is in the drive.

3.2.2 /WRTPRT

This signal goes to a zero only when a write-protected disk is in the drive, or when no disk is in the drive.

3.2.3 /TK0

This signal goes to a zero only when the head is located at track 0. From the time the /STEP signal is set to a zero, a delay of 12msec is required before TK0 is valid.

3.2.4 /TACH

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

Number of pulses per rotation	: 60
Duty cycle	: 50% +/- 10%
Accuracy of pulse period	: +/- 0.2%

3.2.5 /DIRTN

This signal sets the direction of head motion for stepping from one track to another. A zero sets the direction towards the center of the disk. A one sets the direction towards the outer edge of the disk. When the drive is disabled (/ENBL high), /DIRTN is set to a zero.

3.2.6 /STEP

At falling edge of this signal, the head starts to move to the adjacent track. When the step sequence is complete, /STEP is set to a one by the drive. The direction is determined by /DIRTN. When the drive is disabled (/ENBL high), /STEP is set to a one.

3.2.7 /MOTORON

When this signal is set low, the disk motor is turned on if a disk is in the drive. When the drive is disabled (/ENBL high), /MOTORON is set to a one.

3.2.8 EJECT

Setting EJECT to a one causes the disk to be ejected from the drive. The EJECT must be a one for 750 msec +/-25 msec to eject a disk. When the drive is disabled (/ENBL high), the EJECT is set to a zero.

3.2.9 SIDES

This status bit is read as a zero if the drive is single-sided, or a one if the drive is double-sided.

3.2.10 /DRVIN

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

3.2.11 RDDATA

RDDATA is the actual data read from the disk.

3.2.12 /PWM

The /PWM signal is used by the host computer to adjust the speed of the drive motor. This TTL level signal transmits timing information in the form of a fixed pulse rate of from 20 KHz to 40 KHz. The duty cycle of each pulse is defined as the percentage of time the signal is at a logic zero level. The disk motor speed control is specified to operate at the correct speed for duty cycles between 10% and 90%. One implementation of the speed control uses a PWM rate of 22 KHz, and gains extra resolution by "dithering" the pulse duty cycle such that each set of 10 successive pulses varies in duty cycle. This method increases the resolution by a factor of 10 but also results in decreasing the effective frequency of the control signal to 2.2 KHz.

3.2.13 CA0, CA1, CA2, SEL

These signals are used to multiplex inputs from the drive to the RD line during a read operation. During a command write operation these signals select addressable latches in the drive (except for EJECT). CA2 serves the special purpose of selecting a one or a zero to be set into the addressable latches during a write. SEL is used as "Head Select" for a double sided drive during a read.

3.2.14 /ENBL

This line enables all communication with the drive. When /ENBL is high (drive disabled), the RD output goes into a high impedance state, and the control latches in the drive are preset to their inactive states.

3.2.15 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 and then low.

3.2.16 RD

This line is the only output line from the drive. It is multiplexed by the control lines and allows the host to read disk status information as well as data.

3.2.17 WRTDATA

This line is used for data that is to be written on the disk. The magnetized pattern on the disk is same as the level of WRTDATA. Each change in the level of WRTDATA causes a flux transistion to be written on the disk. WRTDATA is allowed to record on the disk only when /WRTGATE is a zero.

3.2.18 /WRTGATE

This signal enables data to be written on the disk and turns on the erase head.

3.3 DC Characteristics of Interface Signals

3.3.1 Output Drive

Name	Output Current (milliamps) IOH	IOL	Output Voltage (volts) VOH	VOL
RD*	-1.0	6.5	2.4	0.5

3.3.2 Input Loading

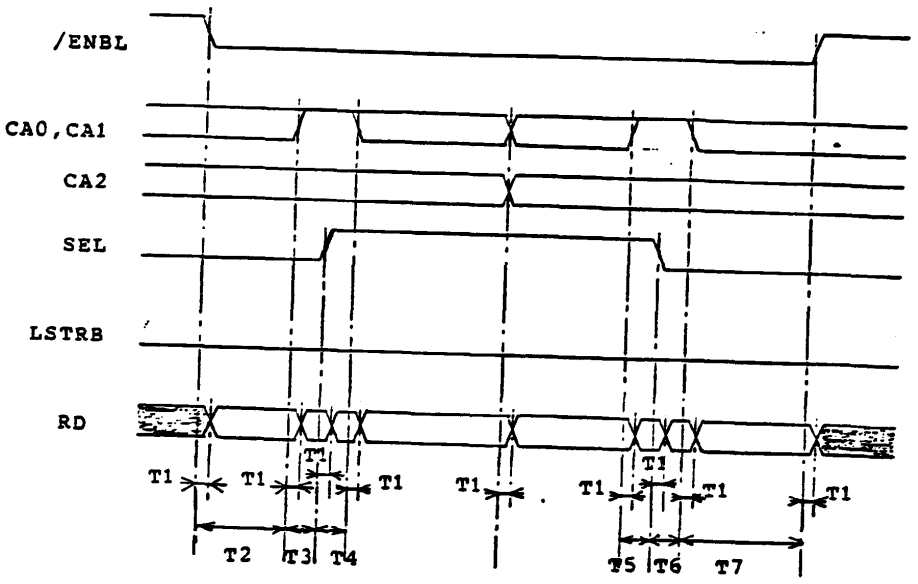
Name	Input Current (milliamps) VIN=2.4V IIH	VIN=0.4V IIL	Input Voltage threshold (volts) VIH	VIL
WRTDATA*, /WRTGATE*	-0.9	-1.5	2.0	0.8
CA0-CA2, LSTRB, SEL	0.1	-0.25	2.0	0.8
/ENBL	0.125	-0.75	2.2	0.8
/PWM	0.01	-0.04	2.0	0.8

*These signal lines include a 3.3K pull-up resistor to +5v.

3.4 Timing Requirements

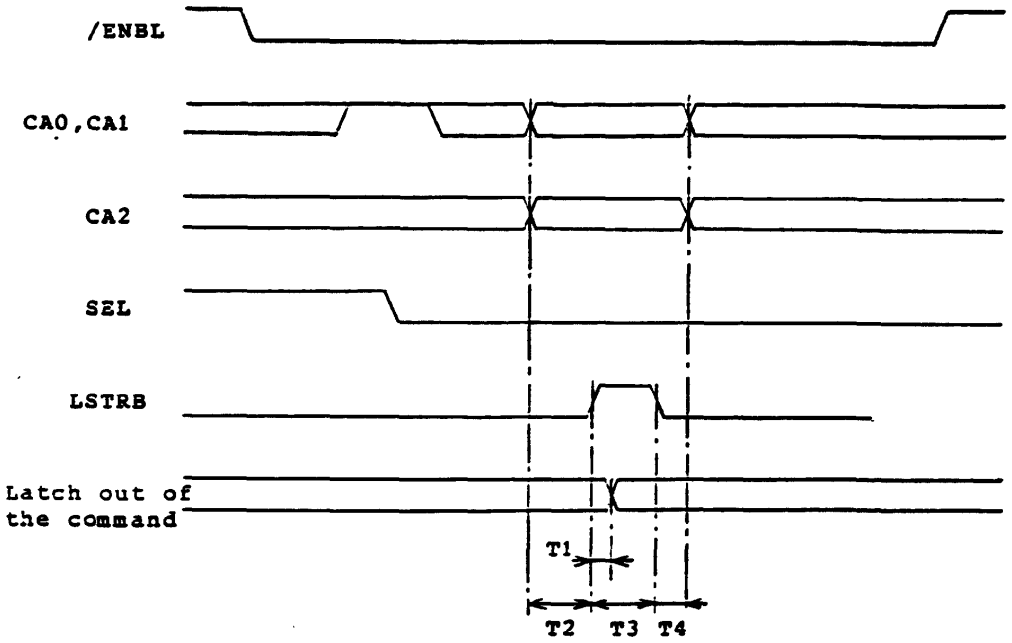
The following sections contain timing diagrams which show the relationship between the input and output signals.

3.4.1 Reading one of the status signals



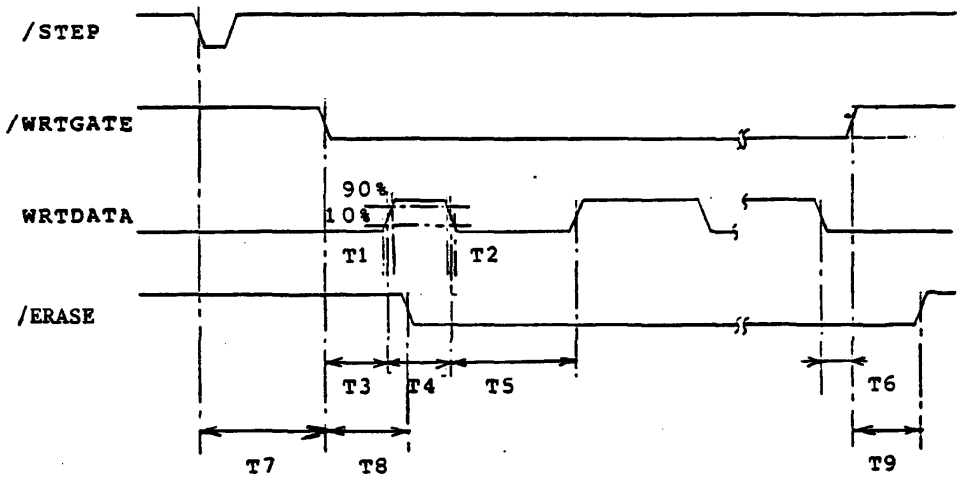
T1 : 0.5 us Max
T2 : 0.5 us Min
T3 : 0.5 us Min
T4 : 0.5 us Min
T5 : 0.5 us Min
T6 : 0.5 us Min
T7 : 1 us Min

3.4.2 Sending one of the control commands



T1 : 1 us
T2 : 0.5 us
T3 : 1 us Min except for EJECT
0.75 s for EJECT
T4 : 0.5 us

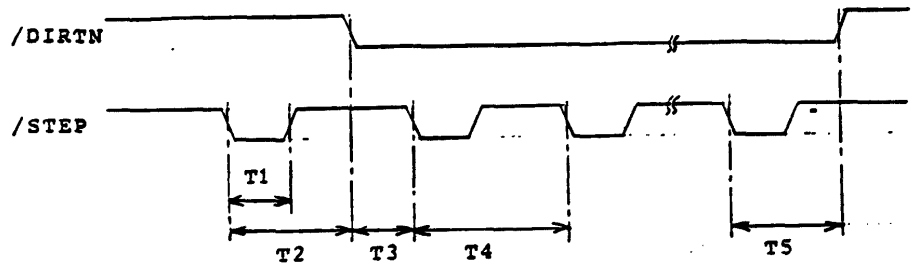
3.4.3 /WRTGATE, WRTDATA and /ERASE Timing



T1 : 100 ns Max
T2 : 100 ns Max
T3 : 1.8 us
T4 : 2 us +/- 0.05 us for 2 usec period*
: 4 us +/- 0.05 us for 4 usec period*
: 6 us +/- 0.05 us for 6 usec period*
T5 : 2 us -/+ 0.05 us for 2 usec period*
: 4 us -/+ 0.05 us for 4 usec period*
: 6 us -/+ 0.05 us for 6 usec period*
T6 : 2us
T7 : 12 ms + 30 ms Min
T8 : 250 us +/- 6 us
T9 : 884 us +/- 5 us

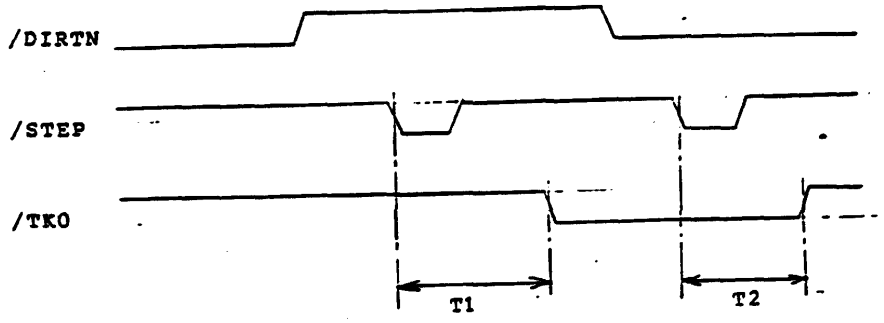
*These numbers will be different if the system clock frequency is different, however, since the disk controller controls both read and write frequency, no decrease in time margin is experienced due to this effect. For disks recorded on different systems to be interchangeable, the data density on the disk must be the same.

3.4.4 /DIRTN and /STEP Timing



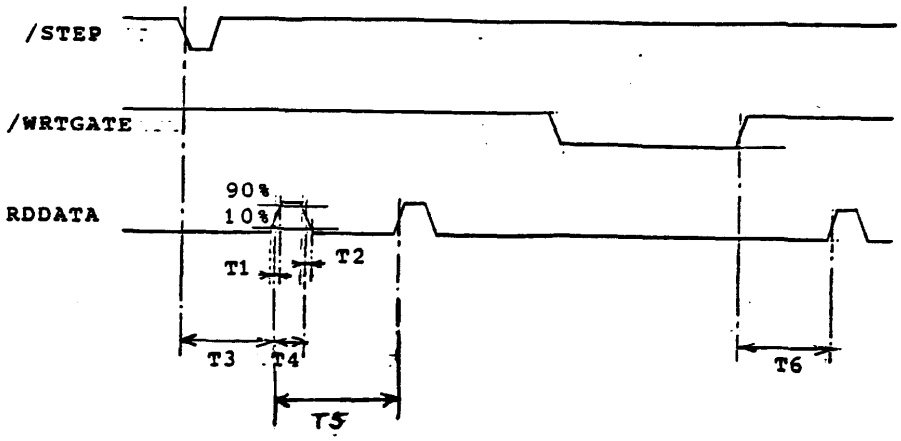
T1 : 10 us Min 12 ms Max
T2 : 10 ms Min
T3 : 2 us Min
T4 : 12 ms Min
T5 : 11 us Min

3.4.5 /TKO Timing



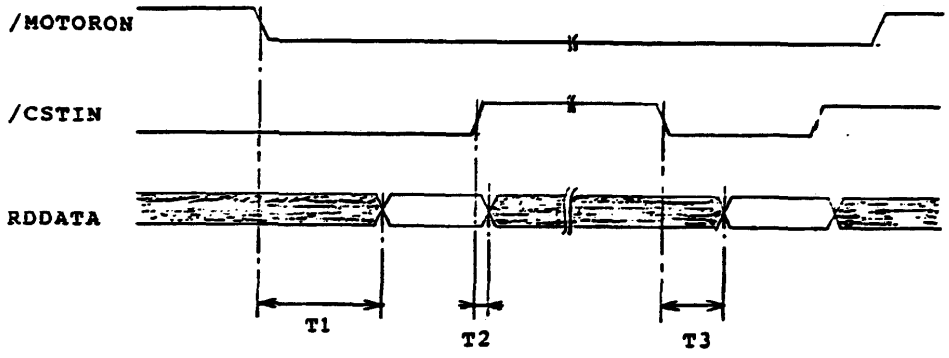
T1 : 12 ms Max
T2 : 12 ms Max

3.4.6 RDDATA VALID TIMING - CONDITION 1



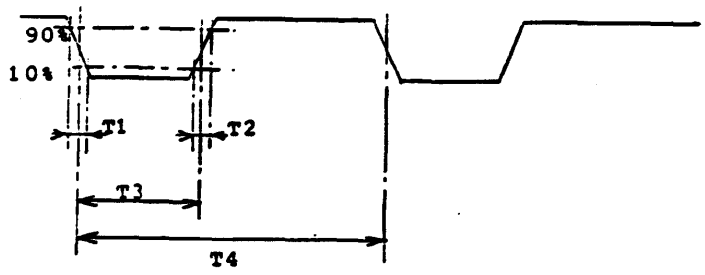
T1 : 100 ns Max
T2 : 100 ns Max
T3 : 12 ms STEP + 30 ms HEAD SETTLING
T4 : 400 ns Min 800 ns Max
T5 : 2 us, 4 us, or 6 us
T6 : 10 us (data error may occur when ERASE goes off)

3.4.7 RDDATA VALID TIMING - CONDITION 2



T1 : 400 ms Max
T2 : No Requirement
T3 : 1 second Max

3.4.8 /PWM WAVEFORM



T1 : 50 ns
T2 : 50 ns
T3 : 10% to 90% of T4
T4 : 25 us to 50 us

3.5 Power On and Power 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 100 milliseconds. That is there shall be no ringing on the supplies during turn on or turn off which causes them to rise above and 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%).

At 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.

3.6 Interface Connector and Pin Assignment

The interface connector shall be a 20 pin connector, 3M J3428-5202 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 Labelling

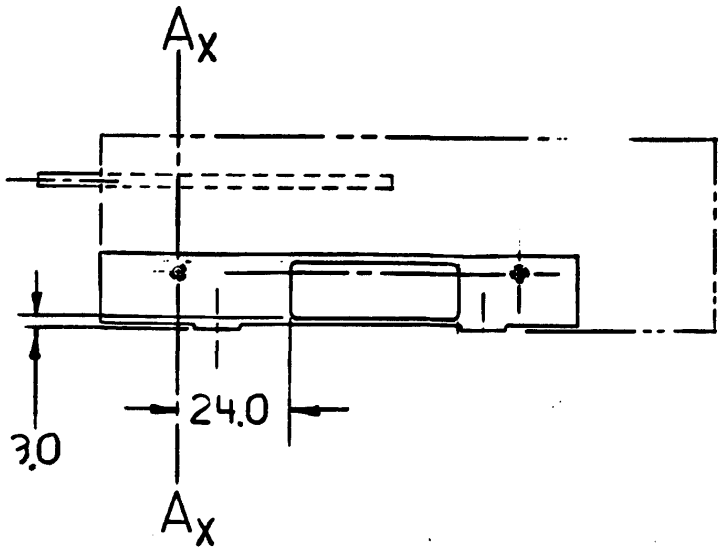
The drive shall have two labels attached when it is shipped to Apple.

4.1 Label Position

The serial number label shall be attached to the right side, and the date label to the left side of the chassis 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 4.2. The date label shape and size may be picked by the drive manufacturer, but must include the month and year of manufacture and be clearly legible.



SCALE : NONE

TOL. : XX.X ± 0.4

Figure 4.1 Label Position

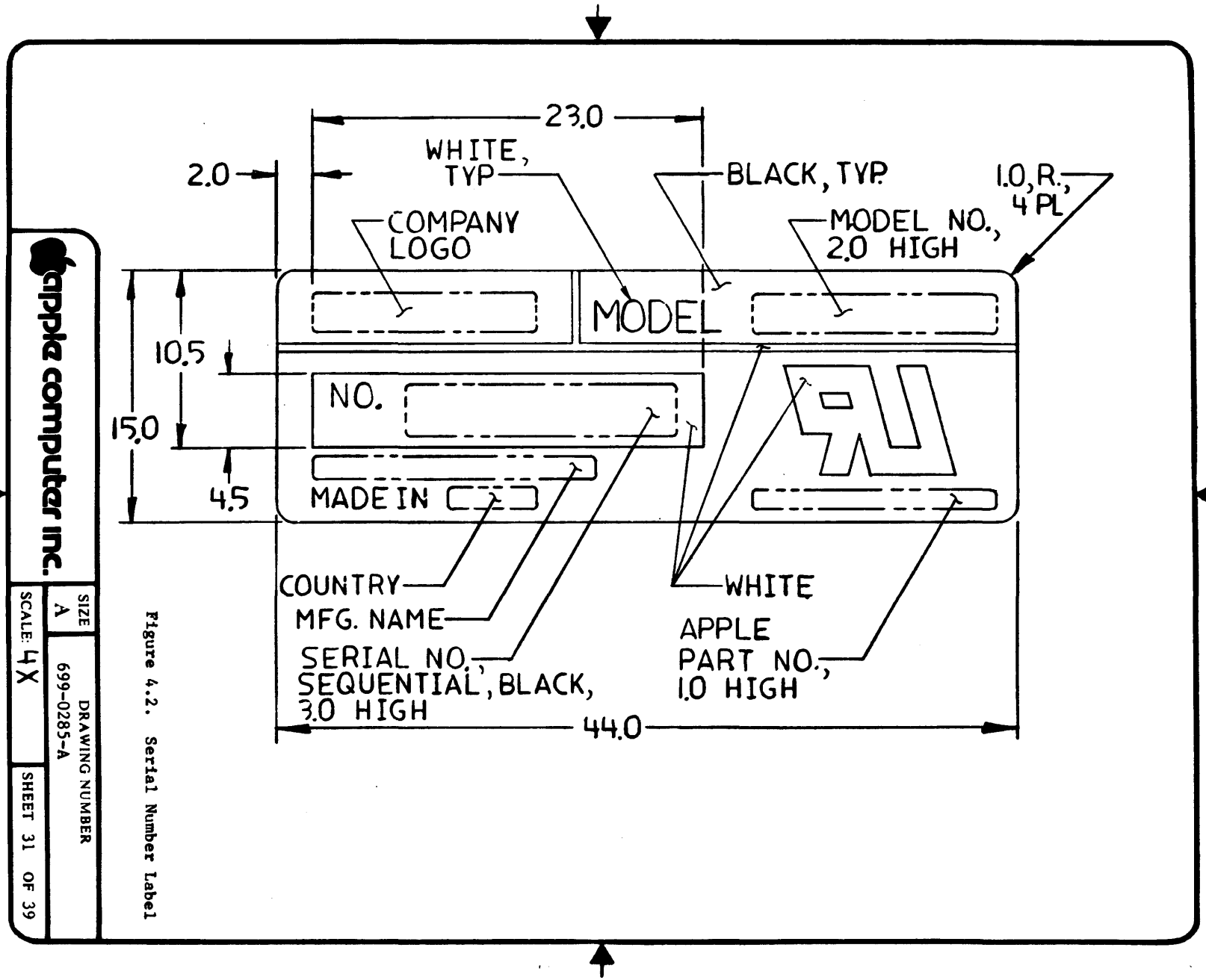
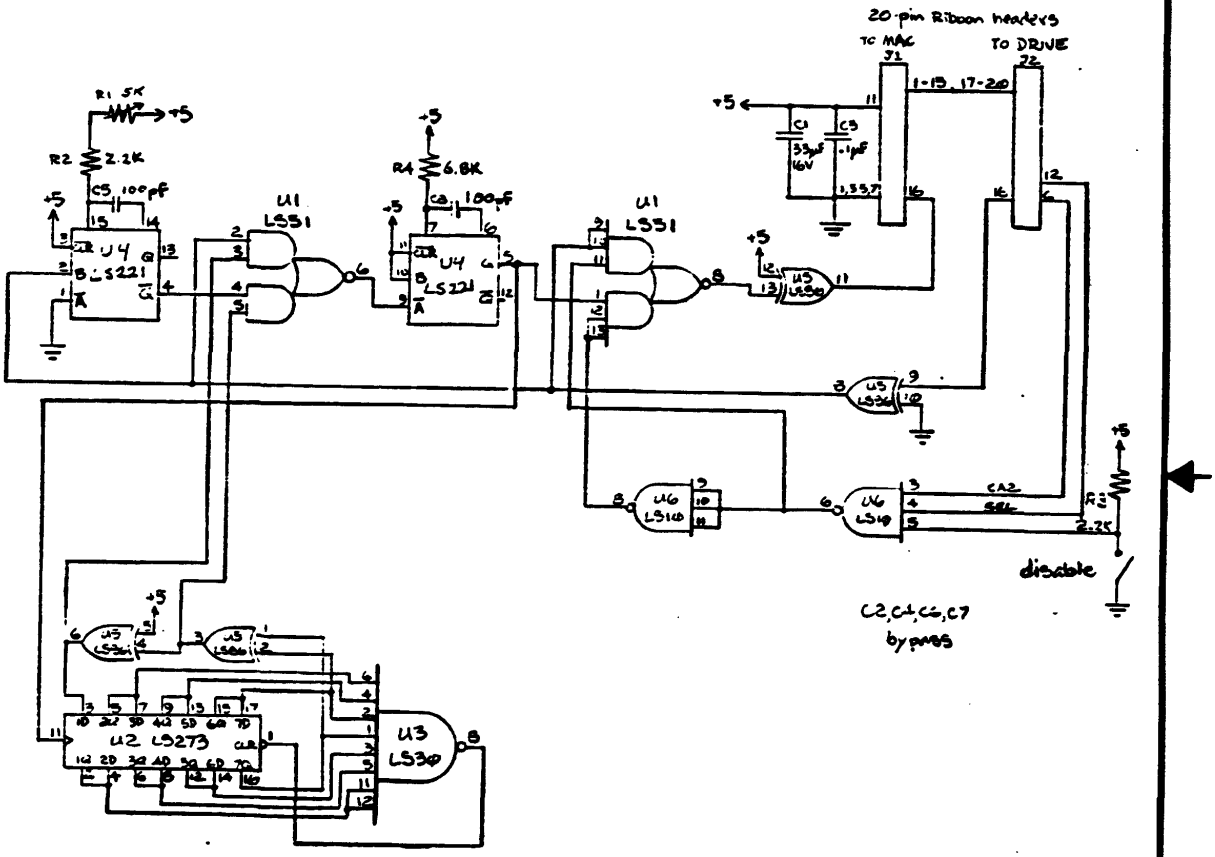


Figure 4.2. Serial Number Label

apple computer inc.

SIZE	DRAWING NUMBER
A	699-0285-A
SCALE: 4X	SHEET 31 OF 39

Appendix A. Jitter Generator Schematic

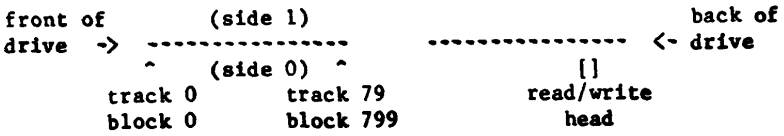


apple computer inc.	SIZE A	DRAWING NUMBER 699-0285-A
	SCALE:	SHEET 32 OF 39

Appendix B. Sector Format

This document describes the sector format used for single-sided 3-1/2 inch diskettes; provision is made for eventual expansion to double-sided diskettes.

The current drive has a single read/write head located on the bottom of the drive at the back (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, side 1, will be used on future double-sided disk drives.

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 1 represents a data transfer rate of 489.6 K bits/sec. Speed 2 is for 500 K 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 1	Speed 2
0 - 15	1	12	394	402
16 - 31	2	11	429	438
32 - 47	3	10	472	482
48 - 63	4	9	525	536
64 - 79	5	8	590	603

This format is derived by limiting the sectors per track for the single-sided drive according to the smaller radius of the opposite-side track of the future double-sided drive. This format yields a total of 800 sectors or blocks. Block numbering goes from 0 to 799: block 0 is sector 0 on track 0 and block 799 is sector 7 on track 79 (sectors are numbered from 0). Future double-sided disks will have an additional 800 blocks on side 1; these blocks will 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 recovery time. As an example, the sector sequencing for 2:1 interleave is:

speed group 1: 0-6-1-7-2-8-3-9-4-10-5-11
speed group 2: 0-6-1-7-2-8-3-9-4-10-5
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 the data field. These fields combined add up to 733.5 code bytes minimum.

Header Sync Field (6.25 bytes + sync overhead)

```
------------------------------------------
5 bit slip FFs minimum (FF,3F,CF,F3,FC,FF)
------------------------------------------
```

The header sync field contains a pattern of ones and zeroes 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 identifies the sector. The sub-fields are:

D5 AA 96	address marks: this identifies the field 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 this field
Checksum	checksum formed by exclusive 'or'ing 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 FFs (FF,3F,CF,F3,FC,FF)
------------------------------------------
```

The data sync field contains a pattern of ones and zeroes that 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 <encoded 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 bytes (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 CSUMB
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)

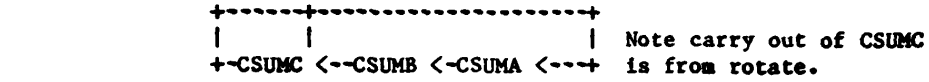


Figure showing carry propagation

GCR 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:	BD,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

Speed Control

Disk speed is controlled via a PWM signal from the host computer. The duty cycle of this signal is set by software in the host computer; the appropriate value is determined by measuring the length of pulses on the tach sense line from the disk drive. The disk speed should be checked when a diskette is first inserted and periodically thereafter to allow adjustment for thermal drifting of disk speed. The speed should also be checked at the position on the diskette which corresponds to the actual speed group to compensate for torque loading of the motor.

Disk Storage Calculations

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

track density:	135.4666 tracks/inch 0.1875 mm track to track
track 0 radius:	39.5 mm
max data density:	8750 fci = 344.4882 fcmm
sync overhead:	6%
bytes/block	733.5
data speed:	500 kbits/sec
bytes:	(733.5 * blocks) * 1.06
rpm:	60 sec/min * 500kbits/sec /(bytes*8bits/byte)
fci:	bytes*8bits/byte/(2*Pi*Radius in inches)

The actual RPM values for Macintosh are adjusted for a bit rate of 489.6 kbits/sec and are slightly lower (e.g., 394 rpm instead of 402 rpm on the outside tracks).

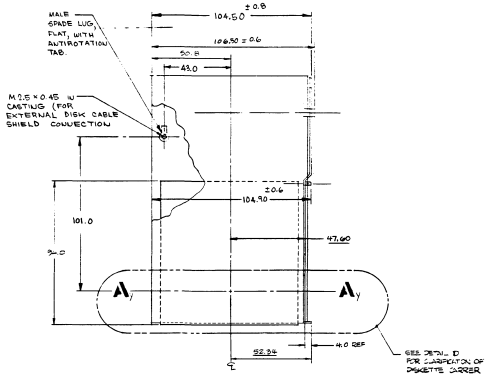
TRACK	RADIUS (side0)	RADIUS (side1)	BLOCKS	BYTES	RPM	FCI (side0)	FCI (side1)
0	39.5	38	12	9330.12	401.9241	7638.955	7940.493
1	39.3125	37.8125	12	9330.12	401.9241	7675,389	7979.867
2	39.125	37.625	12	9330.12	401.9241	7712.172	8019.634
3	38.9375	37.4375	12	9330.12	401.9241	7749.309	8059.799
4	38.75	37.25	12	9330.12	401.9241	7786.806	8100.369
5	38.5625	37.0625	12	9330.12	401.9241	7824.667	8141.349
6	38.375	36.875	12	9330.12	401.9241	7862.899	8182.745
7	38.1875	36.6875	12	9330.12	401.9241	7901.505	8224.565
8	38	36.5	12	9330.12	401.9241	7940.493	8266.815
9	37.8125	36.3125	12	9330.12	401.9241	7979.867	8309.500
10	37.625	36.125	12	9330.12	401.9241	8019.634	8352.629
11	37.4375	35.9375	12	9330.12	401.9241	8059.799	8396.208
12	37.25	35.75	12	9330.12	401.9241	8100.369	8440.244
13	37.0625	35.5625	12	9330.12	401.9241	8141.349	8484.745
14	36.875	35.375	12	9330.12	401.9241	8182.745	8529.717
15	36.6875	35.1875	12	9330.12	401.9241	8224.565	8575.168
16	36.5	35	11	8552.61	438.4626	7577.913	7902.681
17	36.3125	34.8125	11	8552.61	438.4626	7617.042	7945.245
18	36.125	34.625	11	8552.61	438.4626	7656.577	7988.270
19	35.9375	34.4375	11	8552.61	438.4626	7696.524	8031.763
20	35.75	34.25	11	8552.61	438.4626	7736.891	8075.733
21	35.5625	34.0625	11	8552.61	438.4626	7777.683	8120.186
22	35.375	33.875	11	8552.61	438.4626	7818.907	8165.132
23	35.1875	33.6875	11	8552.61	438.4626	7860.571	8210.578
24	35	33.5	11	8552.61	438.4626	7902.681	8256.533
25	34.8125	33.3125	11	8552.61	438.4626	7945.245	8303.005
26	34.625	33.125	11	8552.61	438.4626	7988.270	8350.003
27	34.4375	32.9375	11	8552.61	438.4626	8031.763	8397.536
28	34.25	32.75	11	8552.61	438.4626	8075.733	8445.613
29	34.0625	32.5625	11	8552.61	438.4626	8120.186	8494.245
30	33.875	32.375	11	8552.61	438.4626	8165.132	8543.439
31	33.6875	32.1875	11	8552.61	438.4626	8210.578	8593.207
32	33.5	32	10	7775.1	482.3089	7505.939	7857.780
33	33.3125	31.8125	10	7775.1	482.3089	7548.186	7904.093
34	33.125	31.625	10	7775.1	482.3089	7590.912	7950.955
35	32.9375	31.4375	10	7775.1	482.3089	7634.124	7998.376
36	32.75	31.25	10	7775.1	482.3089	7677.830	8046.366
37	32.5625	31.0625	10	7775.1	482.3089	7722.041	8094.936
38	32.375	30.875	10	7775.1	482.3089	7766.763	8144.095
39	32.1875	30.6875	10	7775.1	482.3089	7812.006	8193.856
40	32	30.5	10	7775.1	482.3089	7857.780	8244.228
41	31.8125	30.3125	10	7775.1	482.3089	7904.093	8295.223
42	31.625	30.125	10	7775.1	482.3089	7950.955	8346.853
43	31.4375	29.9375	10	7775.1	482.3089	7998.376	8399.130
44	31.25	29.75	10	7775.1	482.3089	8046.366	8452.065
45	31.0625	29.5625	10	7775.1	482.3089	8094.936	8505.673
46	30.875	29.375	10	7775.1	482.3089	8144.095	8559.964
47	30.6875	29.1875	10	7775.1	482.3089	8193.856	8614.953

TRACK	RADIUS (side0)	RADIUS (side1)	BLOCKS	BYTES	RPM	FCI (side0)	FCI (side1)
48	30.5	29	9	6997.59	535.8988	7419.805	7803.588
49	30.3125	28.8125	9	6997.59	535.8988	7465.701	7854.371
50	30.125	28.625	9	6997.59	535.8988	7512.168	7905.818
51	29.9375	28.4375	9	6997.59	535.8988	7559.217	7957.945
52	29.75	28.25	9	6997.59	535.8988	7606.859	8010.763
53	29.5625	28.0625	9	6997.59	535.8988	7655.105	8064.287
54	29.375	27.875	9	6997.59	535.8988	7703.968	8118.531
55	29.1875	27.6875	9	6997.59	535.8988	7753.458	8173.510
56	29	27.5	9	6997.59	535.8988	7803.588	8229.238
57	28.8125	27.3125	9	6997.59	535.8988	7854.371	8285.732
58	28.625	27.125	9	6997.59	535.8988	7905.818	8343.006
59	28.4375	26.9375	9	6997.59	535.8988	7957.945	8401.078
60	28.25	26.75	9	6997.59	535.8988	8010.763	8459.965
61	28.0625	26.5625	9	6997.59	535.8988	8064.287	8519.682
62	27.875	26.375	9	6997.59	535.8988	8118.531	8580.248
63	27.6875	26.1875	9	6997.59	535.8988	8173.510	8641.682
64	27.5	26	8	6220.08	602.8861	7314.878	7736.891
65	27.3125	25.8125	8	6220.08	602.8861	7365.095	7793.091
66	27.125	25.625	8	6220.08	602.8861	7416.006	7850.113
67	26.9375	25.4375	8	6220.08	602.8861	7467.625	7907.977
68	26.75	25.25	8	6220.08	602.8861	7519.968	7966.699
69	26.5625	25.0625	8	6220.08	602.8861	7573.051	8026.301
70	26.375	24.875	8	6220.08	602.8861	7626.887	8086.800
71	26.1875	24.6875	8	6220.08	602.8861	7681.495	8148.219
72	26	24.5	8	6220.08	602.8861	7736.891	8210.578
73	25.8125	24.3125	8	6220.08	602.8861	7793.091	8273.898
74	25.625	24.125	8	6220.08	602.8861	7850.113	8338.203
75	25.4375	23.9375	8	6220.08	602.8861	7907.977	8403.516
76	25.25	23.75	8	6220.08	602.8861	7966.699	8469.859
77	25.0625	23.5625	8	6220.08	602.8861	8026.301	8537.259
78	24.875	23.375	8	6220.08	602.8861	8086.800	8605.739
79	24.6875	23.1875	8	6220.08	602.8861	8148.219	8675.328

side 0	blocks	800	max fci side 0 8224.565
side 1	blocks	800	max fci side 1 8675.328
total	blocks	1600	min fci side 0 7314.878
total	bytes	819200	min fci side 1 7736.891

NOTE: UNLESS OTHERWISE SPECIFIED

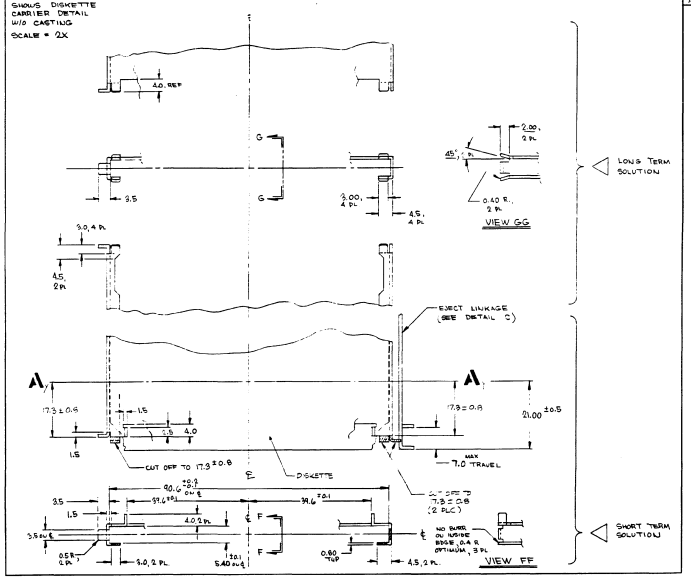
REV	ZONE	ECO #	DESCRIPTION	APPD
A		FORM	INITIAL RELEASE	
A		FISH	SEE SHEET	

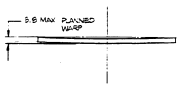


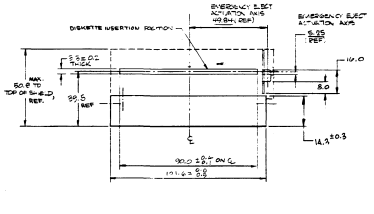
DETAIL D

SINGLE DISKETTE CARRIER DETAIL W/O CASTING

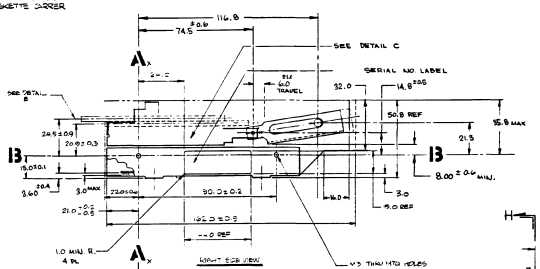
SCALE = 2X

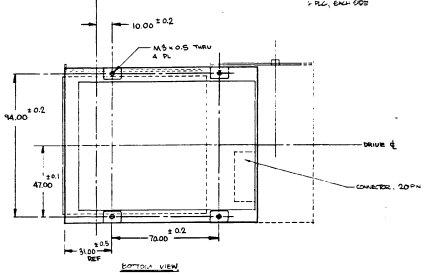


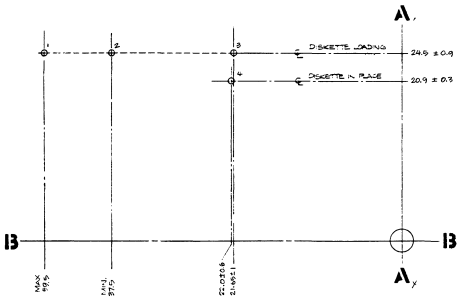




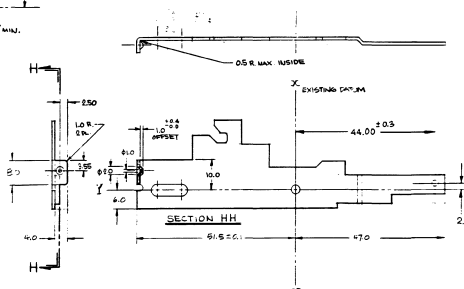
FRONT VIEW







ZONE E
DISKETTE LOWER CARRIER ZONE



ZONE C (EJECT LINKAGE)

SCALE : 2X

SHEETS 1 THRU 38 ARE "A" SIZE

METRIC		apple computer inc.	
N.A.			
MAC		DISK DRIVE, 3 1/2"	
MANOCH	PLL	E 699-0285-A	99/99

V-5821-669