REV.	ZONE	ECO #	REVISION	APPD
00			PRE-RELEASE (sk4046)	
A		P225	Initial Release	[illegible] 8/9
B		P247	Reversed wire colors on sheet 8 of 9 retyped sheets 2-4, added sheet 1	[illegible]
C		P344	Added sheet 5, and stainles steel callout for thrust bearing and washer, change leadscrew headtype to slothead	[illegible]

TOLERANCES
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES.

DECIMALS .X ± ____
.XX ± ____
.XXX ± ____
ANGLES XX.X ± ____
FRACTIONS ± ____
DIMENSIONS IN PARENTHESIS ARE IN MILLIMETERS.

DRAWN BY J.Frederick	DATE 8/6/82
CHECKED BY P. Hummel	DATE 8/82
APPROVED BY Howard [illegible]	DATE 8/7/82
RELEASED BY [illegible]	DATE [illegible]

MATERIAL: ____

FINISH: ____

NEXT ASSY.

apple computer inc.

TITLE
MOTOR,
LINEAR ACTUATOR,
TWIGGY

SIZE	DRAWING NUMBER
A	880-0009-C

SCALE: ____ SHEET 1 OF 10

DRAWING NUMBER 880-0009-C SH 1 OF 10

1.0 SCOPE:

This specification establishes the performance criteria and acceptance requirements for the linear actuator.

2.0 ITEM IDENTIFICATION:

The linear actuator motor is a four-phase permanent magnet inductor type motor with unipolar windings. Application of electrical power to the coils in the proper sequence provides discreet linear motion of the output shaft.

3.0 REQUIREMENTS:

3.1 Voltage: Actuator must operate at 11 ± .5 VDC under normal conditions.

3.2 Resistance per phase - 20 ± 10% Ω

3.3 Inductance per phase - 5.0 mH

3.4 Insulation resistance - 20 M Ω

3.5 Coil switching sequence - See Fig. 1B

3.6 Step Size - .0020 + .0005" non-accumulating over .736" a step is defined as the linear distance moved during one succesive pulse.

3.7 Step Accuracy -	See Section 5.5
3.8 Step Rate Max. -	500 pps with 8 oz. load 350 pps with 20 oz. load 50% phase overlap. See Fig. 1B
3.9 Required Travel -	1.250 ± .020 inch
3.10 Holding Force Unenergized-	16 Oz. min.
3.11 Bearing -	Single radial ball bearing Radial or Thrust bearings and washers must be stainless steel for preload (8 oz.)
3.12 Operating Temperature -	5 degrees C-55 degrees C
3.13 Storage Temperature -	-40 degrees C-75 degrees C

4.0 PHYSICAL CONFIGURATION SEE FIGURE 1

5.0 QUALIFICATION

5.1 Environment

All tests will be performed at normal room temperature and 10.5 VDC unless otherwise specified.

5.2 Direction of Travel

When energized in the sequence show in Fig. 1B, the leadscrew must move in the direct shown.

5.3 Step Rate vs Load

The actuator must be able to reach 500 pps with an 8 oz. load, an 350 pps with a 20 oz. load. The speed profiles are indicated below.

	20 OZ. LOAD		8 OZ. LOAD	
PHASE	PPS	M SEC	PPS	M SEC
0 1	113	8.8	126	7.9
0 2	206	4.8	256	3.9
0 3	280	3.6	400	2.5
0 4	350	2.9	500	2.0
.	.	.	.	.
ON-3	350	2.9	500	2.0
ON-2	280	3.6	400	2.5
ON-1	206	4.8	256	3.9
ON	113	8.8	126	7.9

5.4 Minimum Life

The actuator must pass the accuracy qualification test described in Section 5.5 after completing the following life test.

The test fixture such as shown in Figure 4 will be used to exercise the actuators. A random move will be supplied by Apple such that the actuator will move back and forth in random-size moves at 500 pps and after every one-hundered moves, will make one full excursion at 350 pps. The fixture is arranged such that during the 500 pps moves, the motor will have 8 oz. load and at 350 pps, the load will be increased to 20 oz. This will be continued until the actuator has moved 3×10^6 total moves.

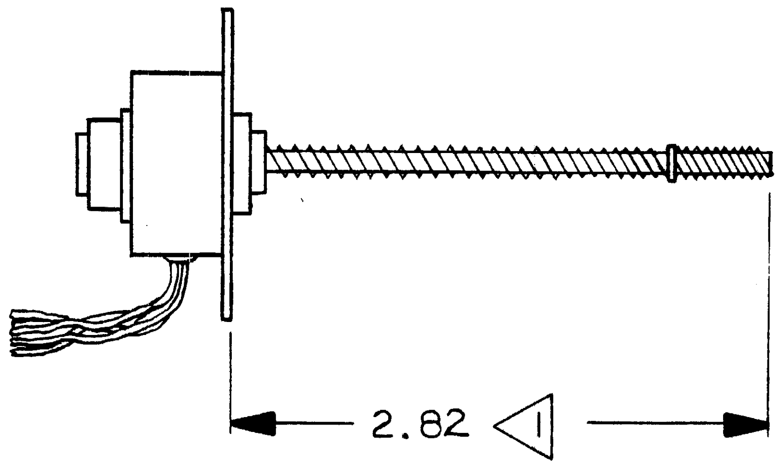
5.5 Step Accuracy

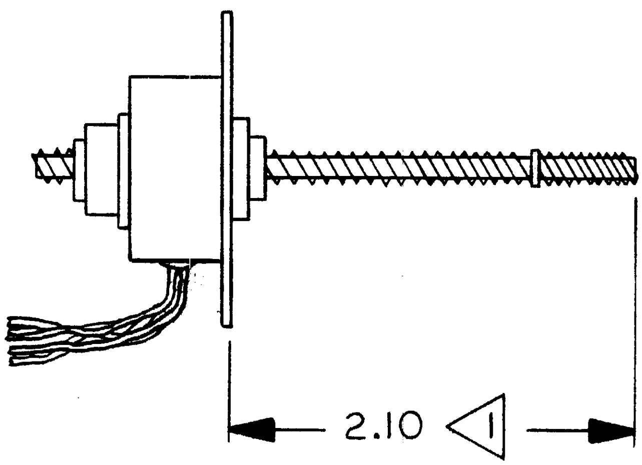
Using a test fixture as indicated in Figure 4, the actuator is positioned approximately 4 steps (.008") back from the maximum extended position. This is defined in Figure 5. This point becomes reference zero for all subsequent position measurements. The actuator is then driven 24 steps (1 full revolution of the motor) toward the retracted position in 8-step increments. The relative position is measured after each move with a high resolution (50 microinch) linear encoder (SONY MAGNASCALE D6-2025SA) and the position error is calculated. The position error defined as the difference between measured position and the theoretical position (number of steps x steps size). This procedure moving 8 steps is repeated through the accuracy range shown in Figure 5. The position error will be displayed on monitor of an Apple II. The neccessary interface cards and test software will be supplied by Apple.

The actuator is rejected if over this .720" of travel, any value of the position error has an excess of .001" deviation from any other.

NOTES:

◁1 ACCURACY WILL BE TESTED IN THIS RANGE FROM 2.82 IN. TO 2.10 IN. AS DEFINED.





apple computer inc.	SIZE A	DRAWING NUMBER 880-0009-C
	SCALE: ______	SHEET 5 OF 10

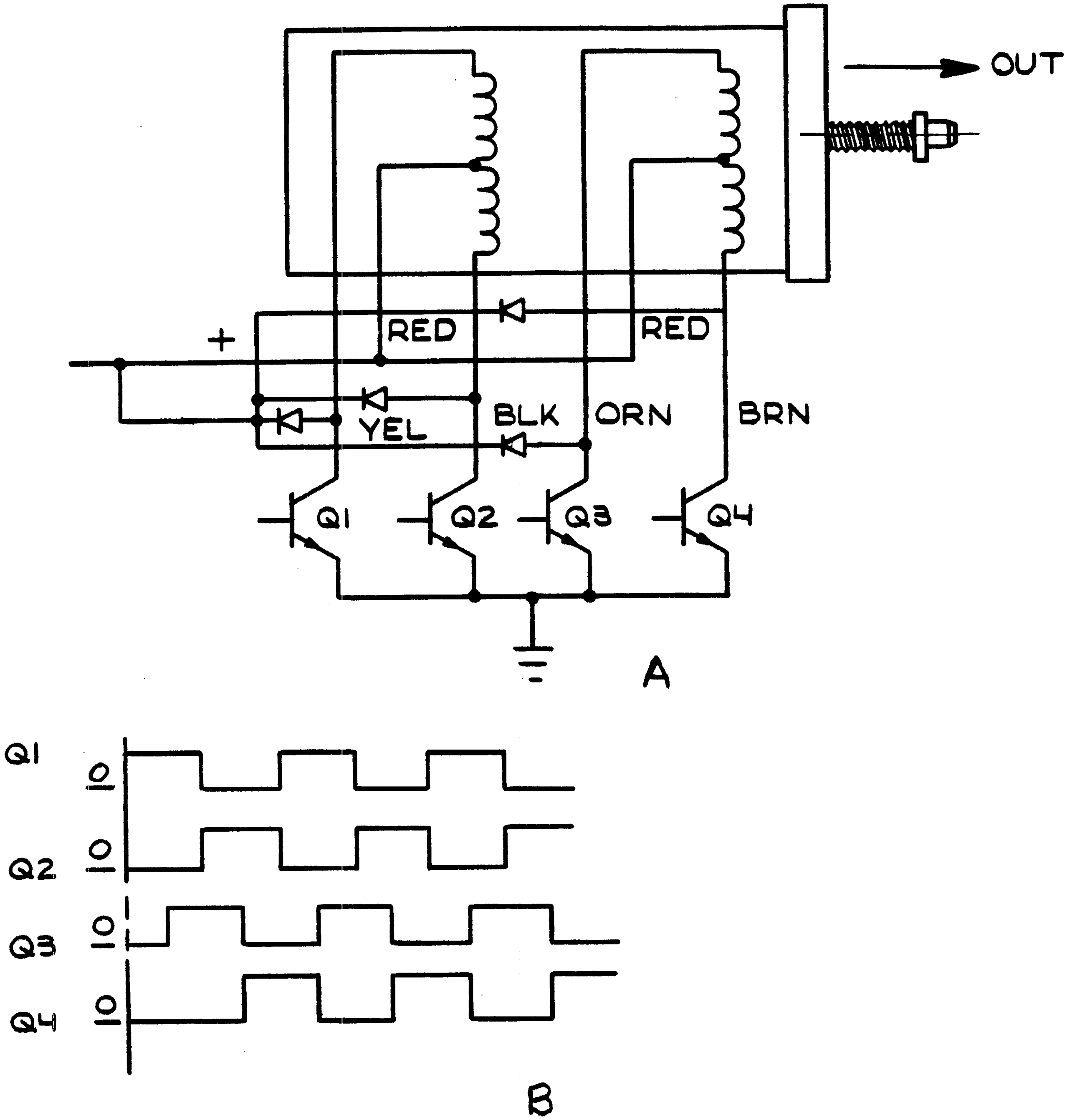


FIG 1

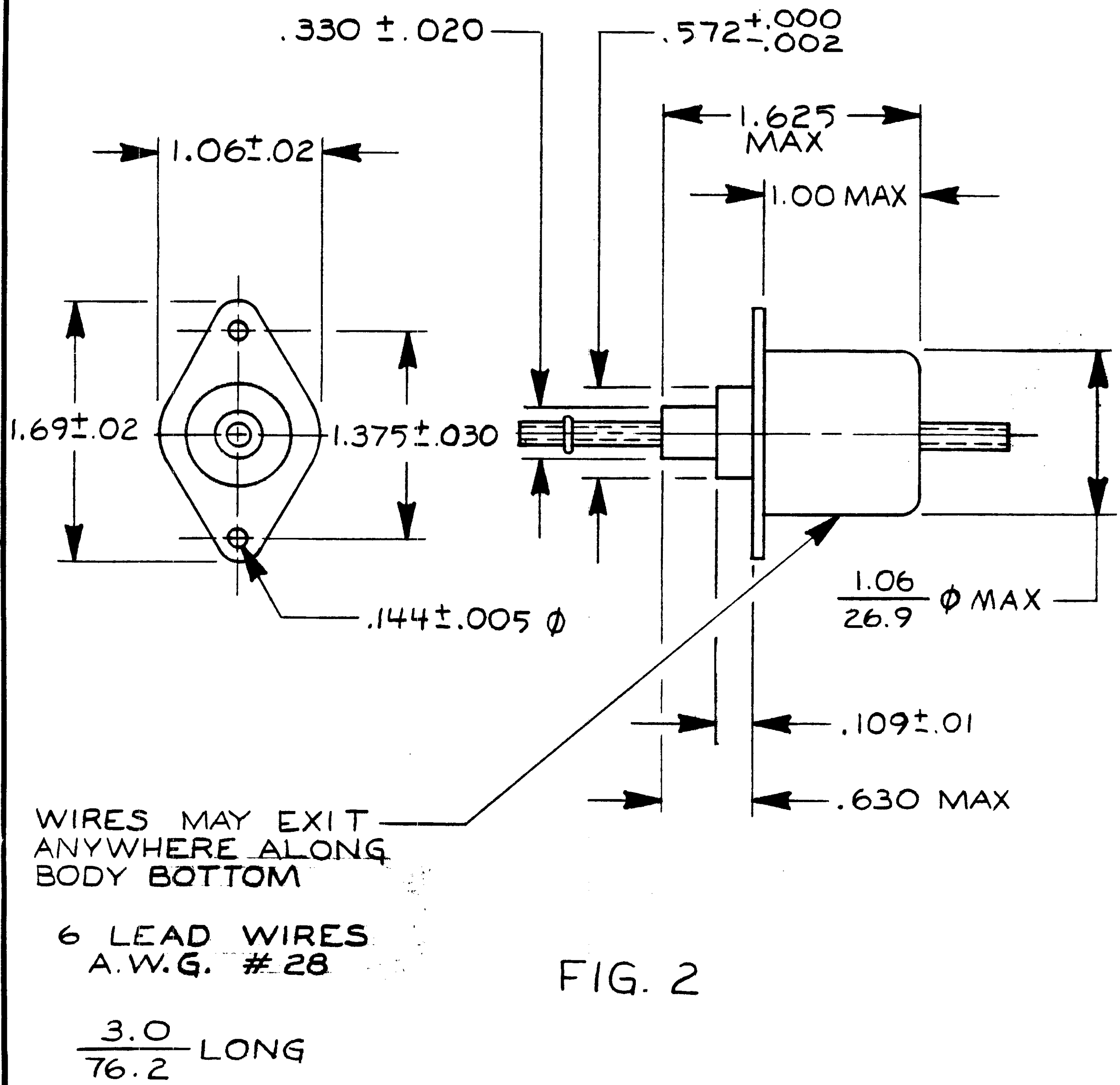


FIG. 2

apple computer inc.	SIZE A	DRAWING NUMBER 880-0009-C
	SCALE: 1/1	SHEET 7 OF 10

NOTES:

1. DEBURR SLOT

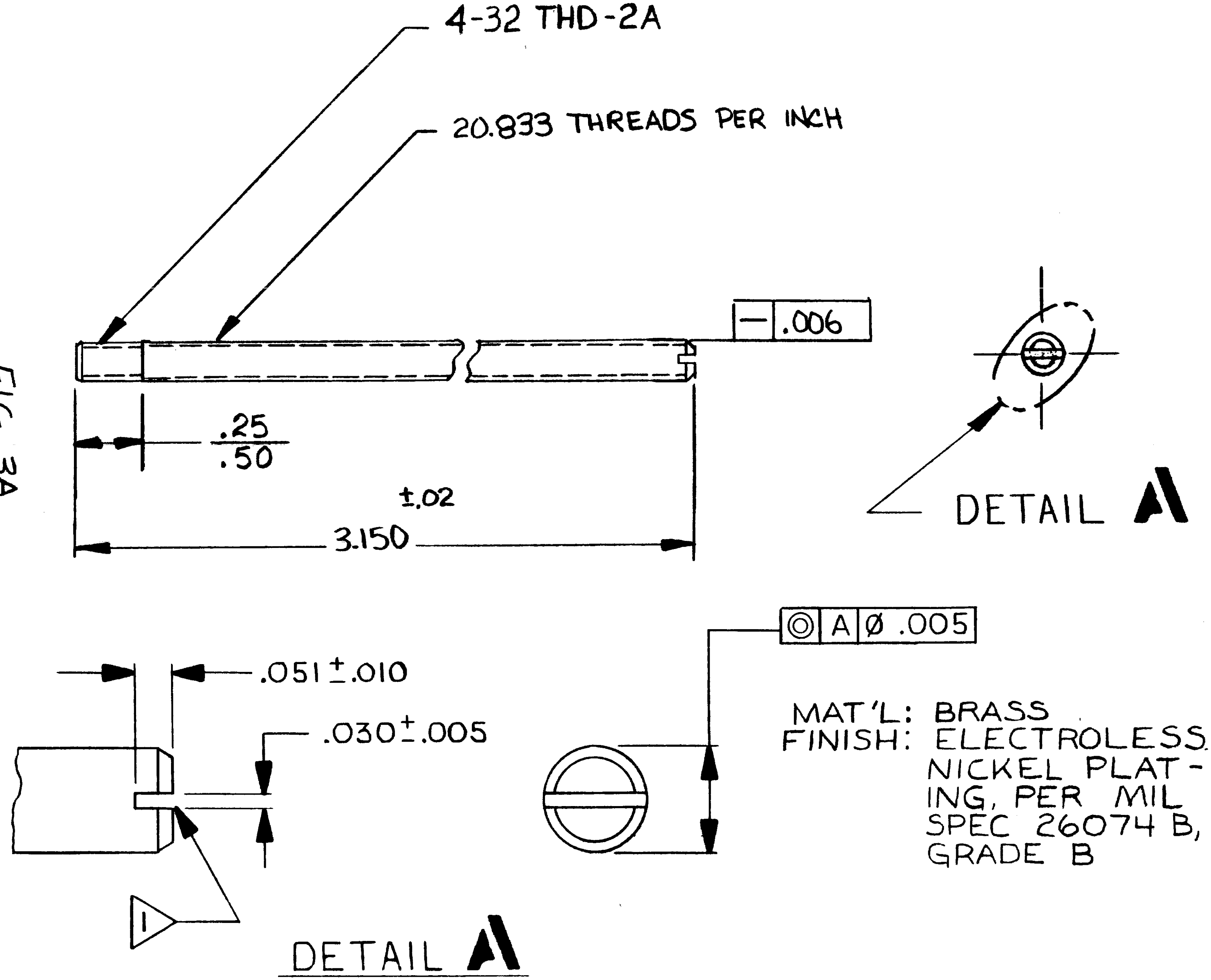
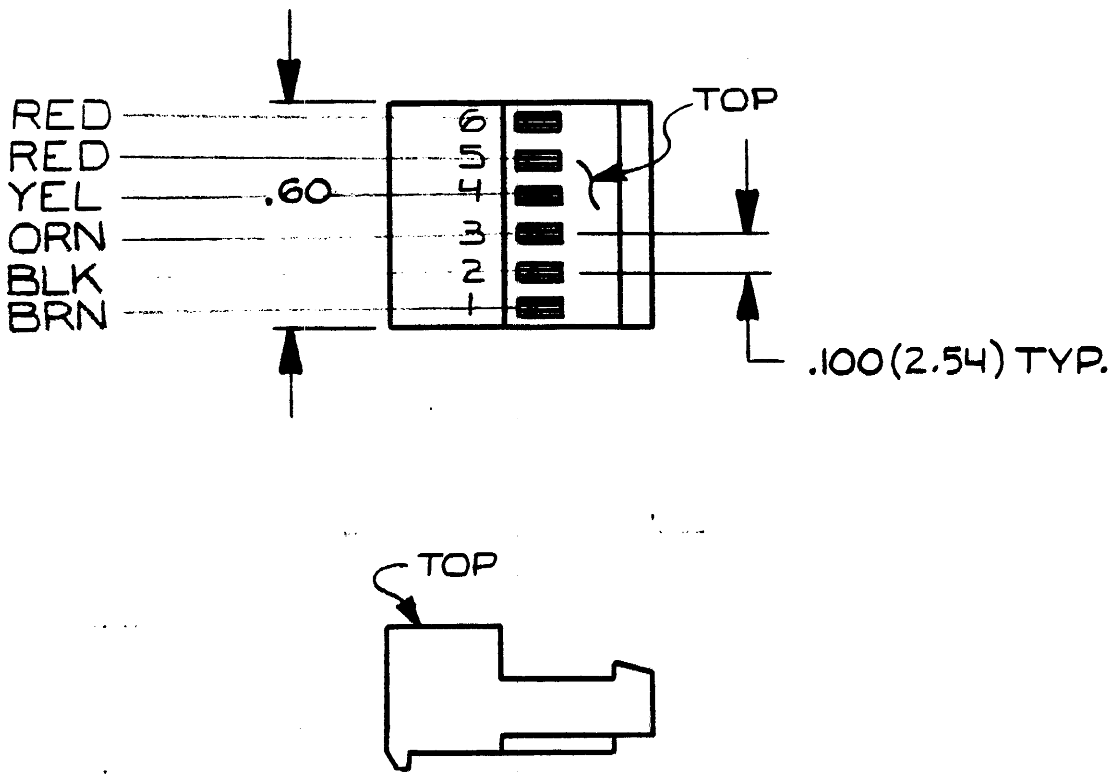


FIG 3A

apple computer inc.	SIZE A	DRAWING NUMBER 880-0009-C
	SCALE: NONE	SHEET 8 OF 10



AMP 640443-6 OR EQUIV.

FIG 3B

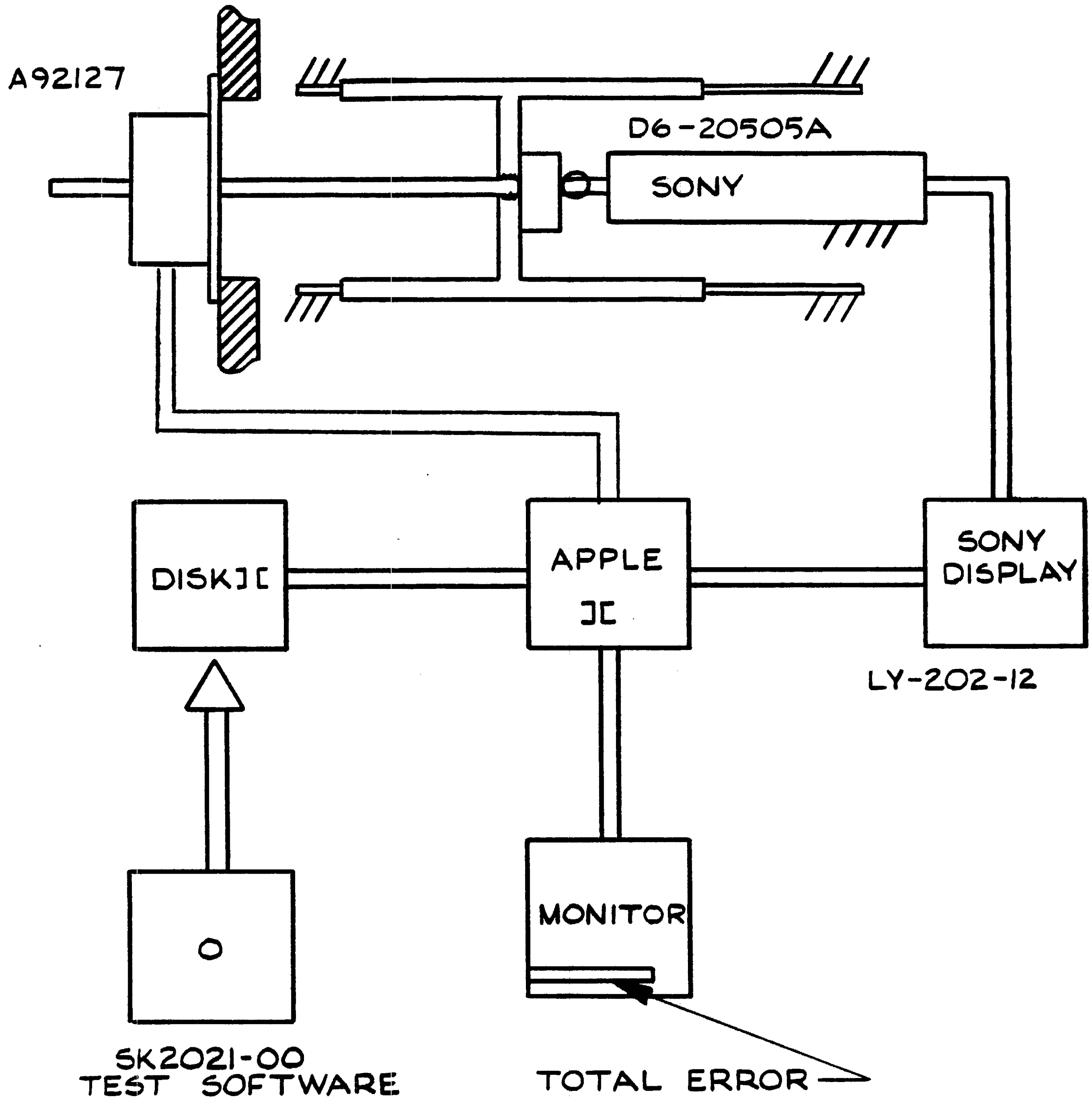


FIG 4

apple computer inc.	SIZE A	DRAWING NUMBER 880-0009-C
	SCALE: NONE	SHEET 10 OF 10

REV.	ZONE	ECO #	REVISION	APPD	DATE
A		P225	Initial Release (SK 4048)		6/82
B		P328	Added sections 2.9, 3.0, 3.1-sheet 2 Added sheet 1 (top sheet), added bushing and radial ball bearing to sheet 4.		12-17-82
C		P438	Sheet 5 add 2 AWG 7/30 wire note. Change connector from AMP #640441-5 to Molex #22-01-2057. Shorten wires from 6" to 5" and from 4" to 3".		3/83
D		P556	Change heading (1.0) to "SCOPE". Add" or AWG 24,7/32.",to note,sht.5 Change dims.,sht.5,to 5.0 +/-.2 (127) and 3.0 +/-.2 (76)	KL	8/82 8-83

DRAWING NUMBER 880-0011-D SH 1 OF 5

TOLERANCES UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES.	
DECIMALS .X ±	
.XX ±	
.XXX ±	
ANGLES XX.X ±	
FRACTIONS ±	
DIMENSIONS IN PARENTHESIS ARE IN MILLIMETERS.	
DRAWN BY	J.Frederick 12/16/82
CHECKED BY	12/82
APPROVED BY	12-82
RELEASED BY	12/82
MATERIAL:	
FINISH:	
NEXT ASSY.	

apple computer inc.

TITLE Motor, Drive, Twiggy

SIZE	DRAWING NUMBER
A	880-0011-D

SCALE: SHEET 1 OF 5

1.0 SCOPE

This specification describes the electrical and mechanical requirements for the Twiggy Spindle Drive Motor.

2.0 MOTOR PERFORMANCE

2.1	Normal Voltage:	12 VDC
2.2	No Load Current:	0.2A Max.
2.3	Torque ('2700 rpm):	.75 in.-oz. Min. (under servo control)
2.4	Rotation:	CCW (looking at pulley)
2.5	Stall torque:	2 in.-oz. '12 VDC
2.6	Stall current:	2.5A '12 VDC Max.
2.7	Dielectric resistance:	10M Min. between all leads and case.
2.8	Temperature Range:	50-140^{o}F continuous duty
2.9	Bearings:	Radial Ball Bearing and Bushing as Shown in figure 2.
2.10	Life Expectancy:	2500 HRS.
2.11	Side Load:	32 oz. Min.

3.0 TACHOMETER

3.1	Frequency:	8 cycles per revolution
3.2	Voltage:	1 volt Min. '1500 rpm into 1K
3.3	Accuracy:	Peaks shall be within 10% of nominal

4.0 INTERCONNECTION

4.1	Wire Length:	Per figure 3
4.2	Connector:	Per figure 3

5.0 MECHANICAL PACKAGE

5.1	Overall dimensions:	Per figure 2
5.2	Pulley detail:	Per figure 1

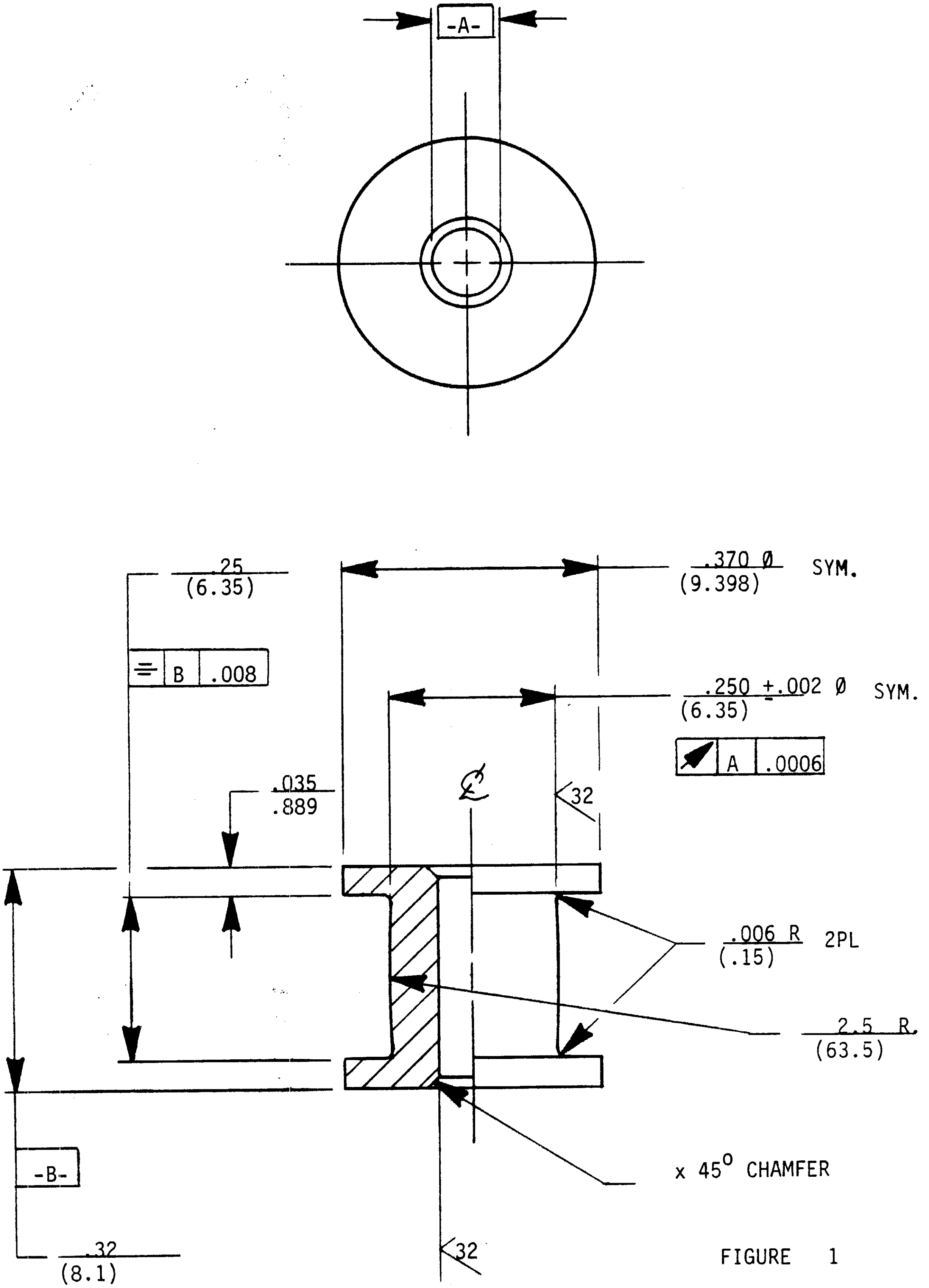


FIGURE 1

apple computer inc.	SIZE A	DRAWING NUMBER 880-0011- D
	SCALE: NONE	SHEET 3 OF 5

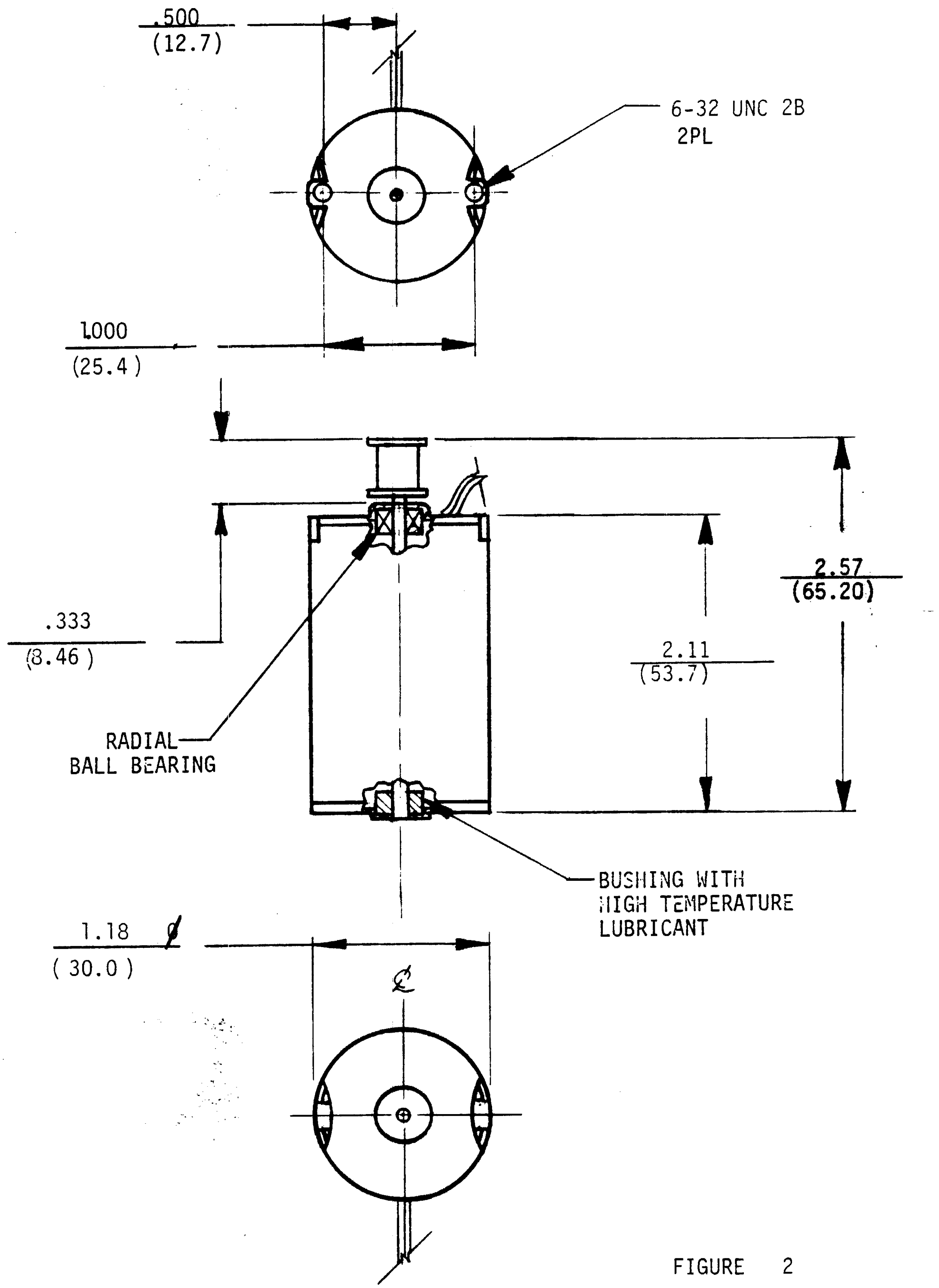


FIGURE 2

apple computer inc.

SIZE	DRAWING NUMBER
A	880-0011-D
SCALE: 1/1	SHEET 4 OF 5

NOTE: Wire to be AWG 22, 7/30, or AWG 24, 7/32.

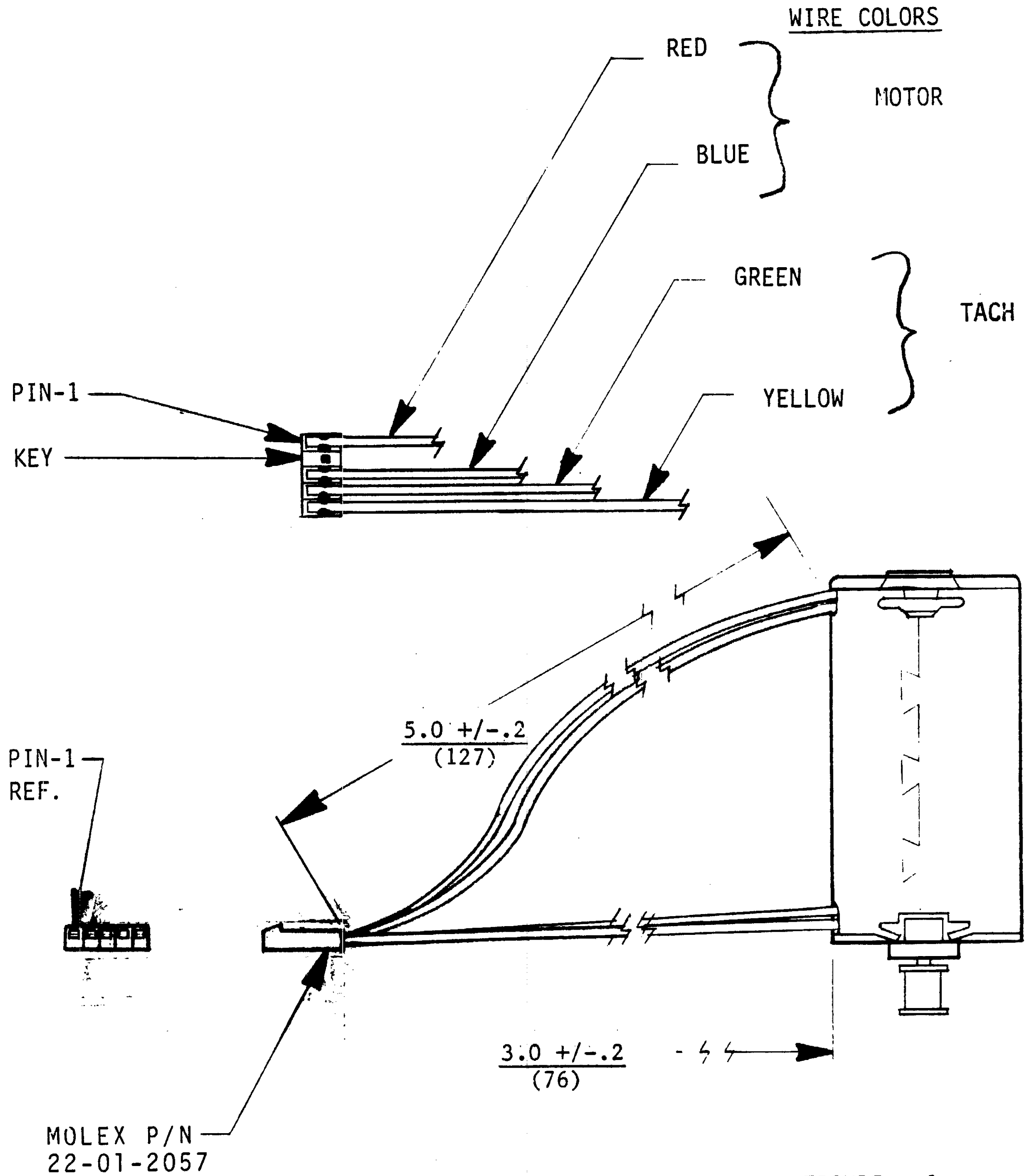


FIGURE 3

SIZE	DRAWING NUMBER
A	880-0011-D
SCALE: 1/1	SHEET 5 OF 5

apple computer inc.

REV.	ZONE	ECO #	REVISION	APPD	DATE

TWIGGY DISK DRIVE SPECIFICATION

CONFIDENTIAL

TOLERANCES UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. DECIMALS .X ± ____ .XX ± ____ .XXX ± ____ ANGLES XX.X ± ____ FRACTIONS ± ____ DIMENSIONS IN PARENTHESIS ARE IN MILLIMETERS.	DRAWN BY [illegible] DATE [illegible] CHECKED BY DATE APPROVED BY DATE RELEASED BY DATE	apple computer inc. TITLE [illegible]
MATERIAL:		SIZE A / DRAWING NUMBER [illegible]
NEXT ASSY.	FINISH:	SCALE: / SHEET OF

1.0 SCOPE

This document describes the 5-1/4-inch minifloppy, double-sided Twiggy Disk Drive for use by Apple Computer. Description of performance parameters, operating criteria, and mechanical/electrical interface requirements are included.

2.0 REFERENCE DOCUMENTS

2.1 062-0107 Head Specification (R/W Head, Twiggy)

2.2 062-0102 Media Specification (2-sided fileware diskette)

2.3 880-0011 Drive Motor Specification

2.4 062-0120 Alignment diskette, high coercivity media

2.5 880-0009 Linear Actuator Motor Specification

2.6 050-5001 Analog Board Schematic

2.7 050-5002 Digital Board Schematic

3.0 GENERAL INFORMATION

3.1 Description

The Twiggy double-sided disk drive is a random access read/write device. Data is transferred to and from a removable rotating flexible diskette via two read/write head assemblies which are mounted on a moving carriage. The media is inserted in the drive by the user and is automatically fixed in position. Drive electronics are contained on two printed circuit boards and control head positioning, multiple drive motor speeds for nearly constant data packing density, and read/write control circuitry.

3.2 Data Parameters

Formatted Capacity	851 KBYTES
Unformatted Capacity	1,334 KBYTES
Transfer Rate	62.5 KBYTES
Data Encoding Method	MGCR
Usable Sides of Diskette	2
Tracks per Inch	62.5
Tracks per Side	46
Data Packing Density	10,000 FTPI (Approx.)

3.3 Media

The diskette used in the drive is a 5-1/4-inch double-sided high coercivity media described in detail in Apple Media Specification #062-0102. The media is enclosed in a special high temperature (60 C) jacket with 2 head access holes and a write protect notch. (See Figure 1.) Data is recorded on both sides between a 1.530- and 2.250-inch radius. The media is capable of storing data at 10,000 FTPI and is certified to be error free per the above mentioned spec. The diskette is supplied with an envelope to protect the media when not in use.

3.4 Interchangeability

The drive design allows for full interchangeability of media with Twiggy-type drives within the environmental operating condition specified in Section 4.4.1.

3.5 Reliability

3.5.1 Definitions

Soft Error is a data error which is recoverable using recommended error recovery techniques. (See Table D.)

Hard Error is a data error which is nonrecoverable.

Seek Error is a positioning error which is recoverable using recommended error recovery techniques. (See Table D.)

3.5.2 Error Rate

The drive and diskette, stabilized to the same environmental conditions for a minimum of 1 hour prior to operation, will perform as follows:

Soft Error	1 Error in 10^8 Bits Read
Hard Error	1 Error in 10^{11} Bits Read
Seek Error	1 Error in 10^6 Seeks Made

3.5.3	MTBF	2,000 drive on hours
3.5.4	MTTR	30 minutes
3.5.5	Preventive Maintenance	Head load pad changes as required
3.5.6	Expected Life	2,000 drive on hours at 25% duty cycle over 5 years
3.5.7	Component Life	5 years

4.0 DETAILED DESCRIPTION

4.1 Drive Dimensions and Mounting Configuration (See Figure 2.)

4.2 Diskette Positioning and Package Interface (See Figure 3.)

4.3 Weight

Installed	2.8 lb
Shipping	3.2 lb

4.4 Environmental

4.4.1 Temperature and Humidity

Operating Limits (drive with media)

Temperature	10° C to 60° C
Relative Humidity	8% to 80%
Max. Wet Bulb Temperature	29.4° C

Shipping Limits (drive only)

Temperature	-40° C to 60° C
Relative Humidity	1% to 90%
Max. Wet Bulb Temperature	No condensation

Storage Limits (drive only)

Temperature	-22° C to 60° C
Relative Humidity	1% to 95%
Max. Wet Bulb Temperature	No condensation

4.4.2 Vibration

Non-operating: The drive shall withstand vibration within the range of 3 Hz to 200 Hz at a constant input of 0.5 G's acceleration in the three major axis.

Shipping: The drive, when packed for shipment, shall withstand a random vibration spectrum from 3 Hz to 50 Hz at an input of 0.5 G's acceleration.

4.4.3 Shock

Non-operating: The drive will withstand a 4-inch free fall drop on the three major axis.

Shipping: The drive, when packed for shipment, shall withstand a 30 G acceleration.

4.5 Mechanical Tolerancing

Drive Thermal Coefficient	10 microinch/inch/degrees F
Actuator Positioning Accuracy	Track Nominal Position +/- 0.0007 inch
Media Clamping Accuracy (with media center hole tolerance of +/- 0.001)	0.0027 inch TIR
Head Azimuth Error	0 degrees +/- 9 minutes
Head Alignment Accuracy	0.001 inch
Head Load	Rear Hd - 20 grams +/- 2 grams Front Hd - 23 grams +/- 2 grams
Penetration	0.008 +/- 0.004 inch

4.6 Power Requirement

+12 Volt Supply	12.0 Vdc +/- 5% @ 1.6A (120 mV p-p Ripple)
+5 Volt Supply	5.0 Vdc +/- 5% @ 0.4A (50 mV p-p Ripple)
-5 Volt Supply	-5.0 Vdc +/- 5% @ 0.2A (50 mV p-p Ripple)

4.7 Functional Requirements

4.7.1 Operator Controls

No indicators are provided. Diskette ejection is controlled by the disk eject switch mounted on the top circuit board. See Figure 3 for physical location.

4.7.2 Data Recording/Addressing

Data is represented on the diskette by 8-bit encoded bytes, written with the high-order bit (bit 7) first and proceeding to the low-order bit (bit 0). The presence of a magnetic flux transition represents a binary one. The encoded bytes are derived from the raw data bytes according to an 8-bit to 6-bit conversion followed by a modified group code (MGCR) representing each 6-bit value, called a nibble. The MGCR code table is shown on Table A. Due to the 8-bit to 6-bit conversion, each raw data byte occupies 1-1/3 code bytes on the diskette. Thus 512 data bytes, for example, require 683 code bytes.

The data format on the diskette is determined by the controller program invoked whenever the user executes a format via the operating system. There are a variable number of sectors per track depending on the rotational speed for that track. There are 46 tracks per side (92 tracks total) with 8-speed groupings. Table B shows the sectors per track for each track speed class, and track radial location.

The sector format, detailed on Table C, shows how each sector is divided into sections for sync, header, and data areas.

5.0 INTERFACE

5.1 Signal Interface

5.1.1 Disk in Place

The 'Disk in Place' signal is active when a diskette is inserted into the drive. It provides a 'high' level to the Digital Board which can then be sensed by the controller via a multiplexer controlled by ØA and HEADSEL. No 'Disk in Place' produces a low level to the Digital Board. The Signal is output to the SENSE line when the controller sets ØA and HEADSEL to a 'high' level, with $\overline{\text{DE}}$ set low.

5.1.2 Write Protect

The 'Write Protect' signal is active when the diskette has the write protect tab covered. It is active 'high' and output to the SENSE line when the controller sets ØA, HEADSEL and $\overline{\text{DE}}$ all 'low'.

5.1.3 Eject Button

The Eject Button, when pressed, produces a 'high' signal level at the digital board. This 'Eject' signal sets a latch which is output to the controller when ØA is 'low' and HEADSEL is 'high' with $\overline{\text{DE}}$ 'low'.

5.1.4 Motor Speed

The motor speed is controlled by an 8-bit digital to analog converter which provides the input to a servo control circuit. The servo, located on the Digital Board, drives the motor and receives feedback from a tachometer. The digital to analog converter is loaded by the controller using the ØA line as the data and the MCLK line as clock.

5.1.5 Head/Carriage Position

The positioner is controlled by a stepper motor which is driven by ØA, ØB, ØC, and ØD from the controller. Each of the ØA, ØB, ØC, and ØD signals controls a stepper motor phase. There are eight phase steps per track. A sequence of ØA-ØB-ØC-ØD-ØA-... (one pulse per phase) moves the carriage out away from the spindle, and the reverse sequence, ØD-ØC-ØB-ØA-ØD-... moves the carriage in. For this direction, the controller moves the carriage a half track (four phases) beyond the desired track and then out (reverse direction) to the track location. This is done to minimize the hysteresis caused by approaching a track from different directions.

5.1.6 Optical Calibration

Calibration of the head/carriage assembly is controlled by an optical sensor which defines track 0 location. This calibration is accomplished by positioning the head at track -1/4 and -3/8, and setting the sensor so that the output voltage of the sensor is < 1.8V at track - 1/4, and > 2.5V at track -3/8.

5.2 Power and Interface PIN Connection

The interface connector used is a 26-pin (3M-3429 or equivalent) Apple P/N 515-0111. Pin assignments are as follows:

PIN	SIGNAL	PIN #	SIGNAL
1	+12V	14	Read Data
2	ØA	15	GND
3	+12V	16	Drive Enable ($\overline{DE}$)
4	ØB	17	N.C.
5	+12V	18	Head Sel
6	ØC	19	N.C.
7	+12V	20	Sense
8	ØD	21	+5V
9	GND	22	MCLK
10	W Data	23	+5V
11	GND	24	N.C.
12	W Req	25	-5V
13	GND	26	N.C.

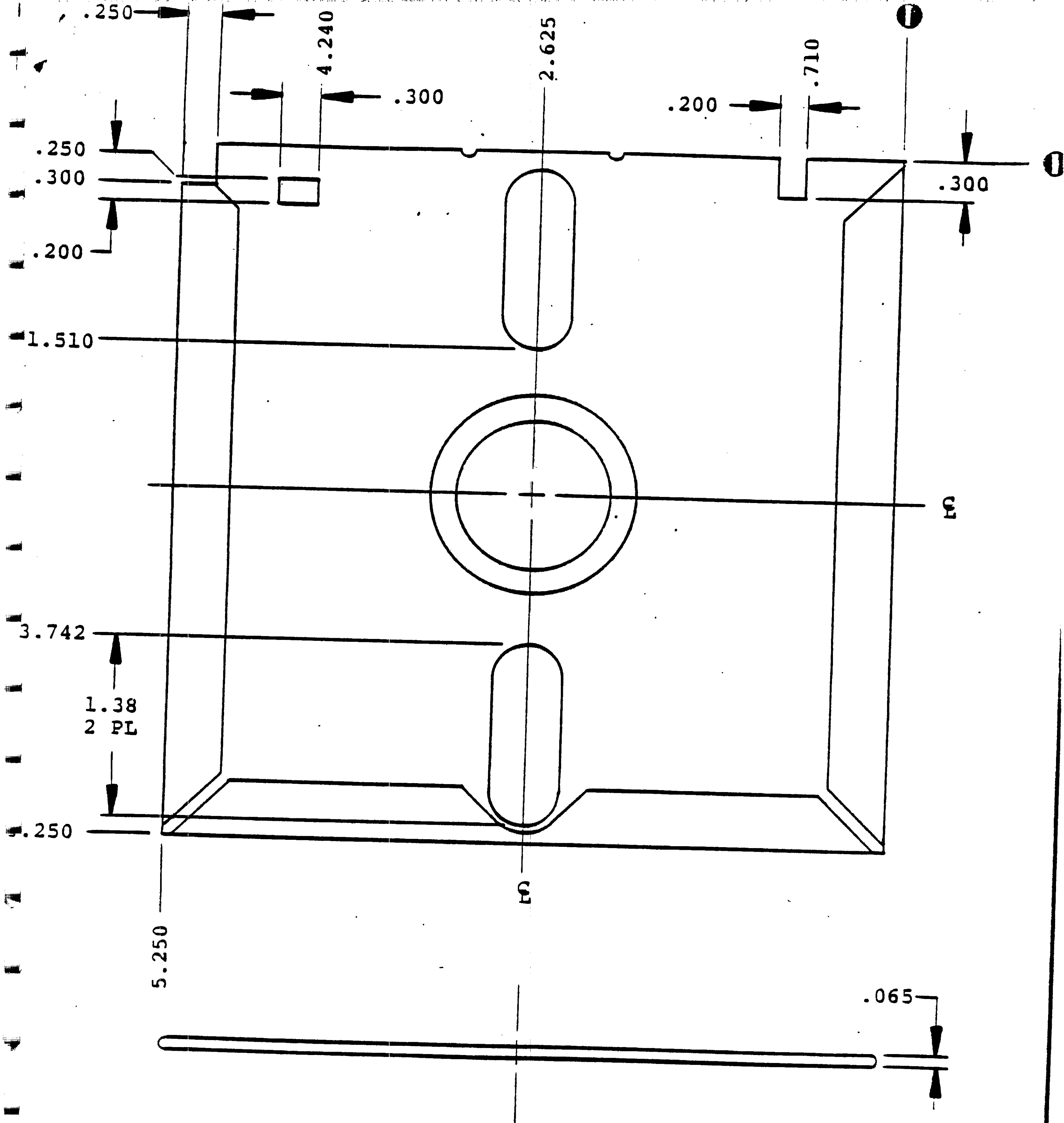


FIG. 1

DISKETTE OUTLAY

SIZE	DRAWING NUMBER	
A		
SCALE: FULL		SHEET 1 OF 4

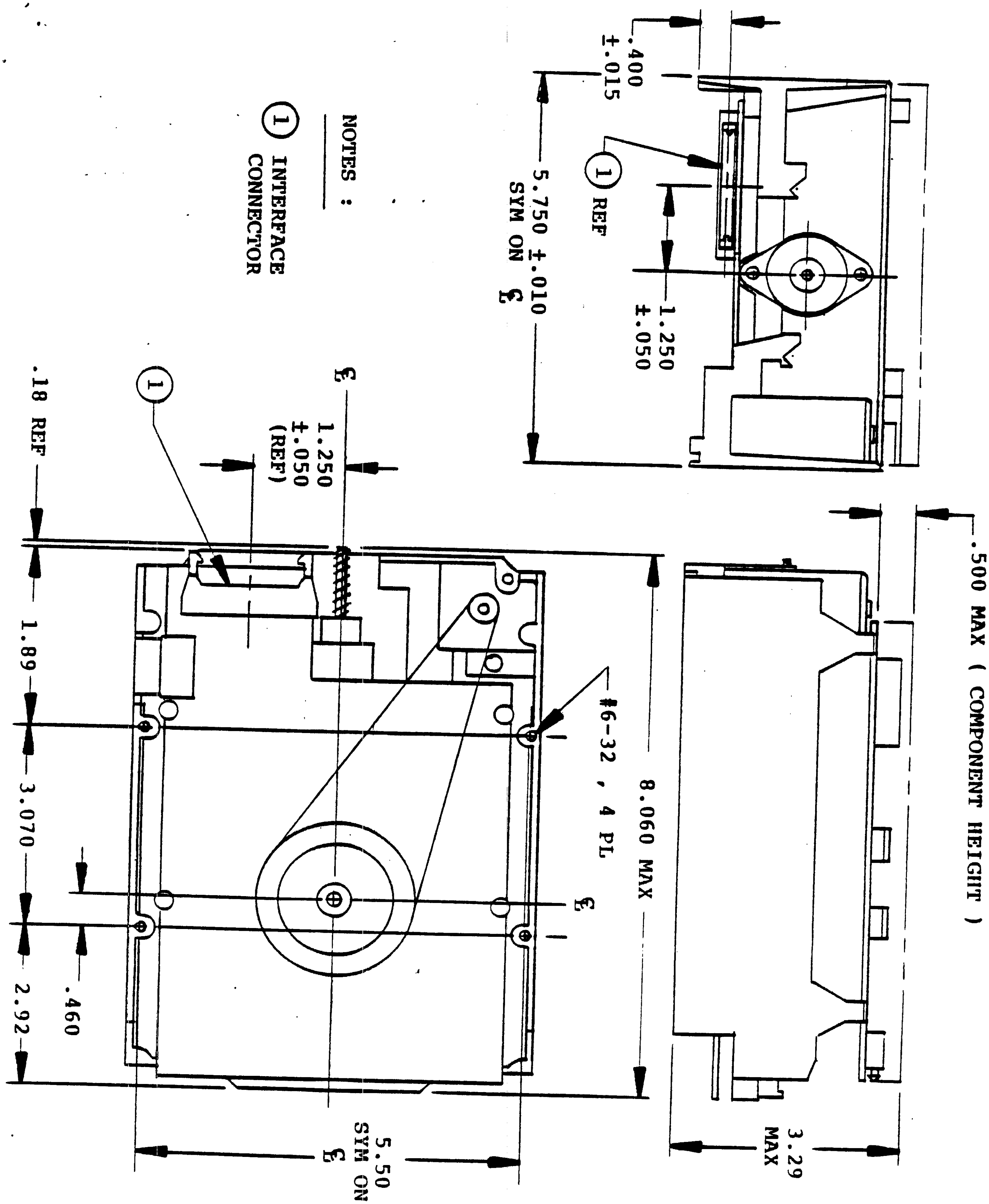


FIG. 2

DRIVE DIMENTIONS

apple computer inc.	SIZE A	DRAWING NUMBER
	SCALE: 1/2 X	SHEET 2 OF 4

NOTES :

(1) EJECT BUTTON

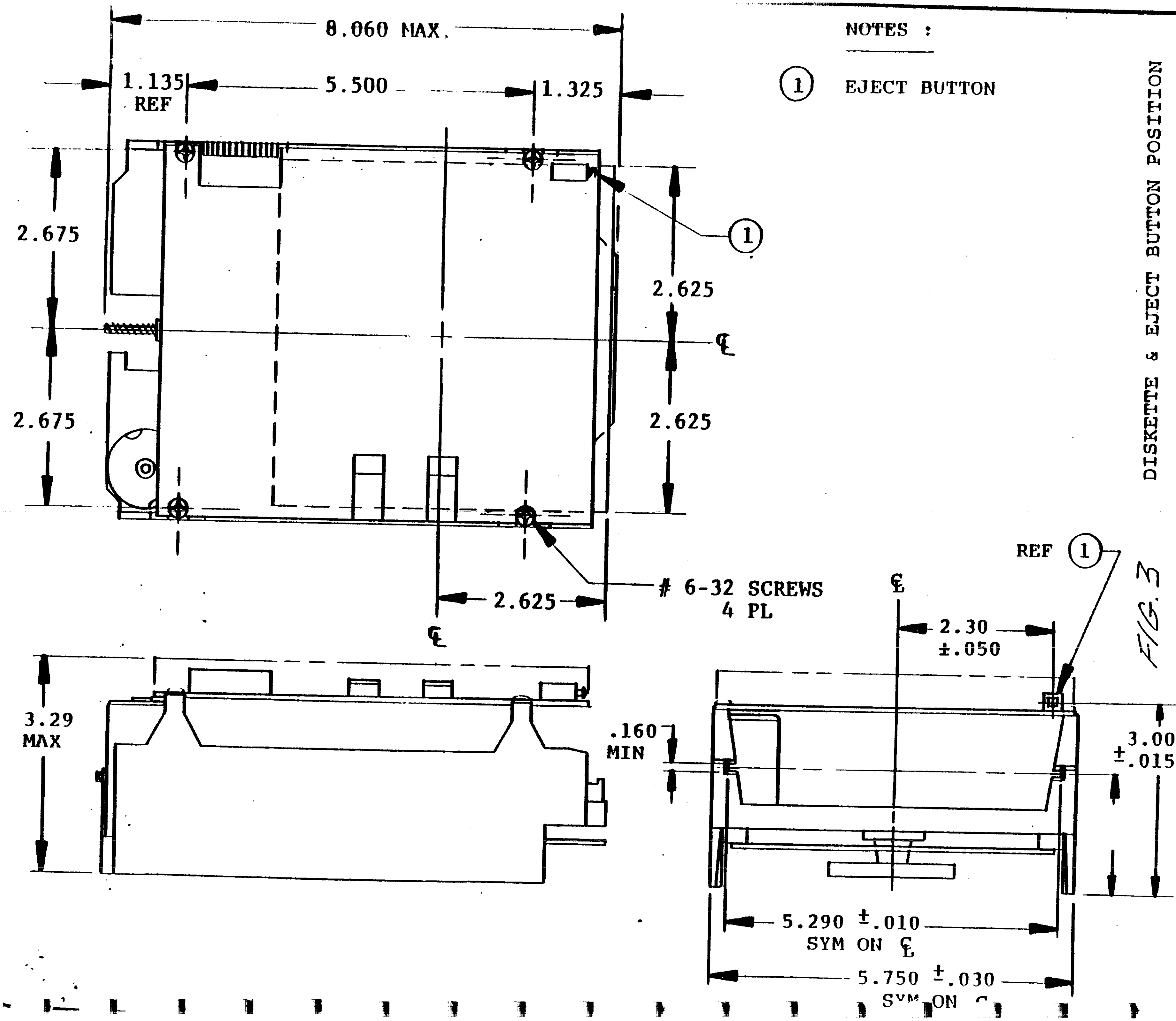


FIG. 3

DISKETTE & EJECT BUTTON POSITION

apple computer inc.

SIZE	DRAWING NUMBER
A	
SCALE: 1/2 X	SHEET 3 OF 4

TABLE A

MGCR CODEWORD TABLE

This is the table used to convert nibbles to MGCR codewords.

o:	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

TABLE B

TRACK	RADIUS	POSSIBLE BYTES	SYNC BYTES	USER BYTES	ACTUAL BLOCKS	USABLE BLOCKS	RPM	ACTUAL BYTES	ACTUAL RPM	BPI	CLASS	CODE
0	2.25	17671.46	1070.29	16601.17	22.63	22	212.21	17177.66	218.31	9720.57		
1	2.23	17545.79	1062.75	16483.05	22.47	22	213.73	17177.66	218.31	9790.19		
2	2.22	17420.13	1055.21	16364.92	22.31	22	215.27	17177.66	218.31	9860.81		
3	2.20	17294.47	1047.67	16246.80	22.15	22	216.83	17177.66	218.31	9932.46	1	DC
4	2.19	17168.80	1040.13	16128.68	21.99	21	218.42	16397.34	228.70	9550.66		
5	2.17	17043.14	1032.59	16010.55	21.83	21	220.03	16397.34	228.70	9621.08		
6	2.15	16917.48	1025.05	15892.43	21.67	21	221.66	16397.34	228.70	9692.55		
7	2.14	16791.81	1017.51	15774.30	21.51	21	223.32	16397.34	228.70	9765.08		
8	2.12	16666.15	1009.97	15656.18	21.34	21	225.01	16397.34	228.70	9838.71		
9	2.11	16540.49	1002.43	15538.06	21.18	21	226.72	16397.34	228.70	9913.46		
10	2.09	16414.82	994.89	15419.93	21.02	21	228.45	16397.34	228.70	9989.35	2	CC
11	2.07	16289.16	987.35	15301.81	20.86	20	230.21	15617.02	240.12	9587.37		
12	2.06	16163.49	979.81	15183.68	20.70	20	232.00	15617.02	240.12	9661.91		
13	2.04	16037.83	972.27	15065.56	20.54	20	233.82	15617.02	240.12	9737.61		
14	2.03	15912.17	964.73	14947.44	20.38	20	235.67	15617.02	240.12	9814.52		
15	2.01	15786.50	957.19	14829.31	20.22	20	237.54	15617.02	240.12	9892.64		
16	1.99	15660.84	949.65	14711.19	20.06	20	239.45	15617.02	240.12	9972.02	3	B8
17	1.98	15535.18	942.11	14593.07	19.90	19	241.39	14836.70	252.75	9550.39		
18	1.96	15409.51	934.57	14474.94	19.73	19	243.36	14836.70	252.75	9628.28		
19	1.95	15283.85	927.03	14356.82	19.57	19	254.36	14836.70	252.75	9707.44		
20	1.93	15158.18	919.49	14238.69	19.41	19	247.39	14836.70	252.75	9787.91		
21	1.91	15032.52	911.95	14120.57	19.25	19	249.46	14836.70	252.75	9869.74		
22	1.90	14906.86	904.41	14002.45	19.09	19	251.56	14836.70	252.75	9952.94	4	A4
23	1.88	14781.19	896.87	13884.32	18.93	18	253.70	14056.38	266.78	9509.64		
24	1.87	14655.53	899.33	13766.20	18.77	18	255.88	14056.38	266.78	9591.18		
25	1.85	14529.87	881.79	13648.07	18.61	18	258.09	14056.38	266.78	9674.13		
26	1.83	14404.20	874.25	13529.95	18.45	18	260.34	14056.38	266.78	9758.53		
27	1.82	14278.54	866.71	13411.83	18.28	18	262.63	14056.38	266.78	9844.41		
28	1.80	14152.87	859.17	13293.70	18.12	18	264.96	14056.28	266.78	9931.82	5	8E
29	1.79	14027.21	851.63	13175.58	17.96	17	267.34	13276.06	282.46	9464.51		
30	1.77	13901.55	844.09	13057.45	17.80	17	269.75	13276.06	282.46	9550.06		
31	1.75	13775.88	836.55	12939.33	17.64	17	272.21	13276.06	282.46	9637.18		
32	1.74	13650.22	826.01	12821.21	17.48	17	274.72	13276.06	282.46	9725.90		
33	1.72	13524.56	821.47	12703.08	17.32	17	277.27	13276.06	282.46	9816.27		
34	1.71	13398.89	813.93	12584.96	17.16	17	279.87	13276.06	282.46	9908.33	6	75
35	1.69	13273.23	806.39	12466.84	17.00	16	282.52	12495.74	300.10	9414.25		
36	1.67	13147.57	798.85	12348.71	16.84	16	285.22	12495.74	300.10	9504.23		
37	1.66	13021.90	791.31	12230.59	16.67	16	287.98	12495.74	300.10	9595.94		
38	1.64	12896.24	783.77	12112.46	16.51	16	290.78	12495.74	300.10	9689.45		
39	1.63	12770.57	776.23	11994.34	16.35	16	293.64	12495.74	300.10	9784.79		
40	1.61	12644.91	768.69	11876.22	16.19	16	296.56	12495.74	300.10	9882.03		
41	1.59	12519.25	761.15	11758.09	16.03	16	299.54	12495.74	300.10	9981.23	7	59
42	1.58	12393.58	753.61	11639.97	15.87	15	302.58	11715.43	320.09	9452.82		
43	1.56	12267.92	746.08	11521.84	15.71	15	305.68	11715.43	320.09	9549.64		
44	1.55	12142.26	738.54	11403.72	15.55	15	308.84	11715.43	320.09	9648.48		
45	1.53	12016.59	731.00	11285.60	15.39	15	312.07	11715.43	320.09	9749.37	8	38
					TOTAL:	851						

TABLE C

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.

HEADER SYNC FIELD

5 bit slip FFs   6.25 bytes

The header sync field contains a pattern of ones and zeros that synchronize the state machine with the data on the disk. The formatter should make this field as large as possible.

HEADER FIELD

D5 AA 96 TRACK SECTOR SIDE VOLUME CHECKSUM DE AA OFF   11 bytes

The header field identifies the sector. The track, sector, side, spare, and checksum are written in 16 sector format.

D5 AA 96	Address marks. This identifies the field as a header field.
TRACK	Track number
SECTOR	Sector number
SIDE	Side number: 0 or 1.
VOLUME	Identifies which machine formatted the disk: 0 = Apple II or Apple ///. 1 = Lisa 2 = Macintosh
CHECKSUM	Checksum formed by exclusive oring the track, sector, side and volume.
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

5 bit slip FFs   6.25 bytes

The data sync field is similar to the header sync field.

DATA FIELD

D5 AA AD SECTOR ENCODED DATA CHECKSUM DE AA OFF   710 bytes

The data field contains the actual data in the sector.

D5 AA AD	Data marks. This identifies the field as a data field.
SECTOR	Sector number
ENCODED DATA	The 524 user data bytes. 699 codewords.
CHECKSUM	A 24 bit checksum. Four codewords.
DE AA	Bit slip marks. This identifies the end of the field.
OFF	Pad byte at the end of the field.

TABLE D

DATA RECOVERY ALGORITHMS FOR TWIGGY

A. Offtrack Stepping

1. When a diskette is first inserted in a drive:

   a. Seek to track -1 on front head

   b. Step away from the nominal track center at 2 mil (1/8 track) increments and read a full track of data.

   c. If more than 25% of headers and/or data fields are read with checksum or bit slip errors, stop and record this position.

   d. Repeat 1.b. and 1.c. for the opposite direction from track center.

   e. Take the average of the two cutoff points (greater than 25% errors) as the new nominal track center position for all seeks.

2. When a sector cannot be read after 100 attempts, nontarget sectors on the track are also counted in the 100 tries. (Note: This condition also causes a recalibrate.)

   a. Repeat 1.a. through 1.e.

   b. Retain the new nominal track center position obtained in 2.a. for subsequent seeks.

3. The maximum number of offtrack microsteps will be three (6 mils on either side of 'nominal').

B. Speed Control

The same conditions that cause the microstepping algorithm to be invoked also cause a speed calibration to be performed, initially on track -1 and subsequently on the track exhibiting the read errors.

C. Seek errors are recoverable by performing a drive recalibration.

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6. DRAWINGS

1. GENERAL DESCRIPTION

The Analog Floppy Tester (AFT) is a device that is designed to comprehensively test the double-sided, double density magnetic storage media used in the Apple Twiggy Floppy Disk Drive.

The AFT includes a digital control board, an analog board, an index detector board, a buffer board, and a media/tester interface board. These circuit boards are referred to as the AFT electronics. In addition, there are four Twiggy boards; the deglitch board, the Twiggy digital board, the Twiggy analog board, and the Twiggy controller board. All of these boards except the media test interface board and Twiggy controller are located physically on the AFT chassis. Both the Twiggy digital board and the Twiggy analog board have been extensively modified for the tester application. An external Twiggy mechanism is clamped to the top of the AFT and is used as the test station for the magnetic storage media.

2. SYSTEM CONFIGURATION

Figure 1 is a block diagram showing the tester installed in a system configuration. In addition to the tester, the system requires an Apple III computer with at least 128K memory and integral floppy disk drive, a CRT monitor, and a printer (usually an Apple Silentype). The interface with the Apple III is via two boards; the standard Twiggy controller board which is installed in slot 4 of the Apple III and the media tester interface board which is installed in slot 2.

The purpose of the media tester interface is to transfer data and control signals between the computer and the tester to control the read/write functions of the tester electronics. The purpose of the Twiggy controller interface is to provide track stepping and speed control for the Twiggy drive mechanism.

3. FUNCTIONAL OPERATIONS

The testing of the Twiggy media is controlled by the program disk that you insert into the Apple III's built-in drive. The tests can be completed on every track, or on specific tracks, depending upon the program being used. In any case, the tracks to be tested are identified by the controller starting at the outside track on head 0.

Using the Twiggy Disk Specification as a reference, the AFT is capable of testing the Twiggy media for the following criteria:

- Track Average Amplitude (TAA)
- TAA Deviation
- Modulation
- Resolution
- Resolution Deviation
- Overwrite
- Missing Pulse
- Extra Pulse
- Write Current
- Self Test

Refer to Section 5 for a brief description of each of these tests.

3.1 TEST FLOW

It takes six complete revolutions of the disk to completely test each track on the disk. However, the AFT Quick Test completes all six revolutions only on tracks 0 and 95.

During the first revolution, a frequency of 1F (125 kHz) is written on the track. During the second revolution, the signal is read back, peak detected, and sent to the computer where its track average amplitude (TAA) is compared to predetermined limits.

A frequency of 2F (250 kHz) is written on the track during the third revolution and read back during the fourth revolution. Many tests are performed during the fourth revolution. First, the 2F signal is read back, peak detected, and sent to the computer where its TAA is also compared to predetermined limits. Secondly, any missing pulse errors or modulation errors detected by the AFT are sent to the computer. During the fourth revolution, an overwrite test is also performed. This test checks to see if any residual 1F signal is left over after writing over the track with a 2F signal. If the overwrite value drops below a preset limit, it is considered an error. Finally, resolution is checked and compared to preset limits. Resolution is the ratio of 2F TAA to 1F TAA.

During the fifth revolution, any data that was previously recorded on the track is DC erased. Then the track is read back on the sixth revolution and the resulting signal is compared to a reference level. An extra pulse error is indicated if the signal exceeds the reference level.

The following table summarizes the functions and tests that occur during each of the six revolutions of the disk:

Disk Revolution	Function	Test
1	Write 1F	1F TAA
2	Read Back 1F	
3	Write 2F	
4	Read Back	2F TAA Missing Pulse Modulation Overwrite Resolution
5	DC Erase	
6	Read Back	Extra Pulse

3.2 COMMAND FUNCTIONS

The computer specifies the test being performed by issuing command words to the AFT controller logic via a peripheral interface adaptor (PIA). The four-bit command word is placed on the first four bits of PIA5, Port A and a command strobe is placed on the fifth bit of PIA5, Port A. The command strobe signals the AFT control logic that a command word is on line. The computer can send out a command word and a command strobe whenever it polls the AFT and finds a signal called pre-index active on the eighth bit of PIA4, Port B. The command word is sent to the control logic where it is decoded, latched, and processed when the next index pulse occurs.

The four-bit command words are decoded to provide the following functions:

Command Words	Function
0	Write
1	Erase
2	Measure TAA
3	Detect MP and MOD
4	Detect XP
5	Measure TAA and Detect MP and Mod

The following paragraphs provide a brief description of each command function.

3.2.1 WRITE

This command will cause a signal to be written on the selected track for one revolution at either 1F (125 kHz) or 2F (250 kHz). The frequency is dependent upon the status of the Select.2F/1F control signal from the computer.

3.2.2 ERASE

This command causes a DC signal to be written for one revolution of the disk, thus effecting a DC erase.

3.2.3 MEASURE TAA

This command will measure Track Average Amplitude (TAA) and latch it into a 12-bit register. It will also cause Residual 1F TAA to be measured and latched into a 12-bit register. The tri-state outputs of these two registers will appear at PIA4, PA 0-7, and PB 0-3. Two select lines, Select Residual 1F TAA or Select TAA, will determine which register is connected to the PIA.

3.2.4 DETECT MP AND MOD

This command will enable the Missing Pulse Detector and the Modulation Detector circuits on the AFT Control Logic board. Two counters on the AFT Analog and Detection Circuit board, one for MP and one for MOD, will count the number of errors detected for one revolution of the disk. The MP error count will be available on PIA1, PB 0-7. The MOD error count will be available on PIA3, PB 0-7.

3.2.5 DETECT XP

This command will enable the Extra Pulse Detector circuit on the Analog and Detector circuit board. Then a counter on the Control Logic board will count the number of extra pulses detected during one revolution. The XP error count will be available on PIA2, PBO-7.

3.2.6 MEASURE TAA AND DETECT MP AND MOD

This command will do the same as the commands previously described in paragraphs 3.2.3 and 3.2.4, but will cause all measurement and detection to be accomplished in the same revolution.

4. CIRCUIT DESCRIPTIONS

4.1 MEDIA TESTER INTERFACE

The media tester interface board plugs into slot 2 of the Apple III computer. Its function is to transfer data and control signals between the computer and tester to control the read/write functions of the tester electronics. The most important components on this board are five peripheral interface adaptors (PIAs)

and the associated logic that allows each PIA to be separately selected. The input and output signals are exchanged between the PIAs and the tester via two 50-pin connectors and two 40-pin connectors. Tables 1 through 4 list the signals found on the pins of each connector.

Table 1. J1, Connector Pin Assignments (40-pin)

PIN #	SIGNAL TYPE	DESCRIPTION
2	input	bit 0 lsb, LS byte of TAA or residual 1F TAA
4	"	" 1 "
6	"	" 2 "
8	"	" 3 "
10	"	" 4 "
12	"	" 5 "
14	"	" 6 "
16	"	bit 7 msb, LS byte of TAA or residual 1F TAA
26	input	bit 0 lsb, MS byte of TAA or residual 1F TAA
28	"	" 1 "
30	"	" 2 "
32	"	" 3 msb, MS byte of TAA or residual 1F TAA
40	input	Pre-index mark

TABLE 2. J2, CONNECTOR PIN ASSIGNMENTS (40-PIN)

PIN #	SIGNAL TYPE	DESCRIPTION
2	output	bit 0 lsb Command Word
4	"	" 1 "
6	"	" 2 "
8	"	bit 3 msb Command Word
10	output	Command Strobe
12	output	bit 0 lsb Select Functions

PIN #	SIGNAL TYPE	DESCRIPTION
14	output	bit 1 lsb Select Functions
16	"	bit 2 msb Select Functions
26	output	Select 2F/1F
28	"	bit 0 lsb Write Current
30	"	" 1 "
32	"	" 2 "
34	"	" 3 "
36	"	" 4 "
38	"	" 5 "
40	"	bit 6 msb Write Current

Table 3. J3, Connector Pin Assignments (50-pin)

PIN #	SIGNAL TYPE	DESCRIPTION
2	output	bit 0 lsb MP% Reference Level
4	"	" 1 "
6	"	" 2 "
8	"	" 3 "
10	"	" 4 "
12	"	" 5 "
14	"	" 6 "
16	"	bit 7 msb MP% Reference Level
18	input	bit 0 lsb MP Error Count
20	"	" 1 "
22	"	" 2 "
24	"	" 3 "
26	"	" 4 "
28	"	" 5 "
30	"	" 6 "
32	"	bit 7 msb MP Error Count
34	output	bit 0 lsb XP% Reference Level
36	"	" 1 "
38	"	" 2 "
40	"	" 3 "
42	"	" 4 "
44	"	" 5 "
46	"	" 6 "
48	"	bit 7 msb XP% Reference Level

Table 4. J4, Connector Pin Assignments (50-pin)

PIN #	SIGNAL TYPE	DESCRIPTION
2	input	bit 0 lsb XP Error Count
4	"	" 1 "
6	"	" 2 "
8	"	" 3 "
10	"	" 4 "
12	"	" 5 "
14	"	" 6 "
16	"	bit k7 msb XP Error Count
18	output	bit 0 lsb MOD% Reference Level
20	"	" 1 "
22	"	" 2 "
24	"	" 3 "
26	"	" 4 "
28	"	" 5 "
30	"	" 6 "
32	"	bit 7 msb MOD% Reference Level
34	input	bit 0 lsb MOD Error Count
36	"	" 1 "
38	"	" 2 "
40	"	" 3 "
42	"	" 4 "
44	"	" 5 "
46	"	" 6 "
48	"	bit 7 msb MOD Error Count

4.2 CONTROL LOGIC

For this discussion, refer to the simplified block diagram of the control logic functions (Figure 2) and the control logic schematic diagram.

The first function to be discussed is index. This signal is applied to the control logic board at J5, pin 8 (see sheet 1 of the control logic diagram). Index is the clocking mechanism for the major functions of the tester. The index detector is physically mounted near the top of the tester. A reflective tape attached to the drive spindle is detected by the index detector each time the disk spindle makes a complete revolution. The mechanical index is actually an unshaped pulse that is shaped, delayed, and made into a 64-microsecond pulse that is referred to as pre-index. The pre-index pulse is shaped and delayed 100 microseconds to produce the positive index pulse that is used to synchronize all commands sent to the tester.

Probably the most important function of the control logic is command decode. The Apple III computer sends commands to the tester electronics by putting a 4-bit command word on the first four bits of PIA5, Port A. The fifth bit of PIA5, Port A is used as a command strobe. When the computer detects the pre-index signal on the eighth bit of PIA4, Port B, it sends the command word and command strobe to the tester. A low-to-high transition of the command strobe (J2,pin 10) tells the control logic that a command word is on line. This command word is latched into the control logic and processed when the next index pulse is detected. U1 is the command decoder chip. In addition to index, this chip is gated by the 125/250 kHz oscillator to initiate the specific test and measurement sequences called for by the computer command word.

Also shown on sheet 1 of the control logic schematic is the clock generator circuit. Y1 is a MHz crystal oscillator. Its output is divided by four to produce a 2F (250 kHz) signal at U49, pin 5. The 2F signal is also divided by two to produce a 1F (125 kHz) signal at U51, pin 5. The computer sends a select signal on the first bit of PIA5, Port B, to determine whether the frequency of the write data will be 1F or 2F. A low on this signal line indicates 1F; a high indicates 2F. The write data will only be sent to the Twiggy digital board when the write enable signal is high as the result of the command decoder decoding the incoming command as a write.

Sheet 2 of the control logic schematic contains three 0 to 255 bit counter circuits. These counters are used to count missing bit errors, modulation errors, and extra bit errors when such errors are detected by the threshold comparators on the analog board. The counters are enabled by the appropriate command from the command decode logic (sheet 1) and will count the number of errors detected for one revolution of the disk. For example, if command word #3 (Detect MP and MOD) is decoded, signal DMME will go high and enable the missing pulse and the modulation counters. The outputs of the error counters are buffered and sent back to the computer via the PIA board. The modulation error count is placed on PIA1, PB 0-7; the missing pulse error count on PIA1, PBB 0-7; and the extra pulse error count on PIA2, PB 0-7.

Sheet 3 of the control logic schematic contains the 12-bit analog to digital (A/D) converter that converts the track average amplitude (TAA) 1F or 2F signal or the residual TAA (1F) signal to a digital output that is stored in MC14174 buffered latches for sampling by the computer via the PIA board. If the select TAA signal is active (high), the switch circuit controlling the input to the A/D converter will allow the conversion of TAA (1F or 2F), however, if the select residual 1F TAA signal is high, then the residual 1F TAA signal will be converted to digital.

The 7-bit digital to analog converter (DAC) U4 on sheet 3 receives programmable digitized write current inputs from the computer and converts them to an analog signal that is adjusted for 3-1/2 ma. peak using R5. The output of the DAC goes through a current amplifier consisting of U3 and transistors Q1 and Q2, and is sent to the write current sync circuit on the Twiggy digital board.

4.3 ANALOG AND DETECTION LOGIC

For this discussion, refer to the simplified block diagram of the main analog functions (Figure 3) and the analog and detection schematic diagram.

Sheet 1 of the schematic diagram contains the DACs and threshold comparators for detecting missing pulse, extra pulse, and modulation errors. These inputs are controlled by the computer program and are set for specific threshold levels.

Following is a description of how a missing pulse error is generated. For example, assume that the missing pulse input from the computer to DAC U5 is set to a specific reference threshold level of 50%. The output of the DAC is converted to a voltage level and applied as the minus reference voltage input to comparator U2, pin 9 and as the plus reference voltage input to comparator U2, pin 4. The nonpeak detected TAA signals (raw 1F/2F, and 1F residual) are applied to U2, pin 10 and the same signals 180 degrees out of phase are applied to U2, pin 5. (By using two comparators, the possibility of detecting errors resulting from baseline shift is eliminated.) If these signals drop below the 50 per cent reference voltage threshold level, the outputs of the comparators will go low and trigger one-shots whose outputs are ANDed to produce the missing pulse error signal. The pulse width of the error signal is determined by the duration of the one-shots.

The extra pulse circuit operates in a similar manner except that if the raw TAA signal exceeds the reference voltage threshold level, an extra pulse error signal is generated.

The modulation error circuit is slightly different. It requires only one comparator that is used to compare a modulation reference threshold against the peak detected TAA signal.

Any errors that are detected by these circuits are sent to the error counters shown on sheet 2 of the control logic schematic diagram.

The DC power supply is shown on the bottom of sheet 1. This circuit rectifies the AC input voltage down to a raw +18 Vdc that is then regulated to plus and minus 12 Vdc and 5 Vdc. These are the only voltages required to operate the tester.

Sheet 2 of the analog and detection circuit schematic contains the self test logic and the circuits for separating the raw 1F/2F TAA signal from the Twiggy via the Twiggy analog board into TAA and residual TAA signals. The raw 1F/2F TAA signal is amplified by U29 and is fed to power amplifiers U26 and U27. The differential output of these amplifiers follows two paths; the normal TAA path and the residual TAA path.

The normal TAA path is through U21, a preamplifier and double-to-single ended converter/buffer. The overall gain of this circuit is about 10,. The outputs of U21, pin 7 and U21, pin 1 are fed to the missing pulse and extra pulse error comparators on sheet 1. The TAA signal from U21, pin 1 is also fed to the TL810 peak detector on sheet 3. The output of the peak detector (about 1-1/2 volts peak) is amplified by three-stage amplifier U17. The signal from the junction of R41 and R44 is fed back to the modulation error comparator on sheet 1. The TAA signal from U17, pin 8 is sent to the AFT control logic (sheet 3 of the control logic schematic) where it is converted to a digital signal for subsequent sampling by the computer.

The residual TAA path is through a low pass notch filter network on sheet 2. The purpose of this path is to measure the amount of 1F TAA that remains following an overwrite test. The filter is peaked at 125 kHz and notched at 250 kHz. It provides a difference between 1F and 2F of 80 Db. Six capacitors (C76, C80, C83, C86, and C87) must be trimmed to obtain the desired signal. The 1F filtered output is fed to an amplifier (sheet 3) with a gain of about 26 Db. The signal is then peak detected and filtered to provide a small DC voltage level at U19, pin 8. The residual 1F TAA is sent to the AFT control logic via J6, pin 4 whenever the test sequence causes the incoming signal on J6, pin 10 to be low. The U19 amplifiers are zeroed out whenever the signal on J6, pin 14 is high.

Another function found on the analog and detection circuit board is self-test (see sheet 2). The self-test consists of an external plug-in circuit board that uses IC connectors U6 and U7. The MC 14093 chip in U7 must be removed and replaced with the test board. The self-test PCB connector plugs into U6. The purpose of the test board is to generate known error signals for extra bit, missing bit, and modulation, check the signal amplitude, and verify that the AFT circuitry is in calibration. When the self-test board is installed, it simulates the signals that are expected from the Twiggy drive during normal test mode.

4.4 TWIGGY CONTROLLER

The Twiggy controller (Figure 4) provides the interface between the Apple III and the Twiggy electronics. Its function is to control head selection, track positioning, and rotational speed variations of the Twiggy drive used on the AFT. The controller also performs supervisory and error recovery functions to increase the reliability of the drive.

The controller used in the AFT configuration does not control the read/write functions of the Twiggy drive. Instead, these functions are controlled by the AFT control logic via commands sent from the computer.

4.5 TWIGGY DIGITAL BOARD

For this discussion, refer to the Twiggy block diagram (Figure 4) and the schematic diagram of the Twiggy digital board. The digital board can be broken down into four function areas. These are:

- Head actuator control
- Spindle drive motor speed control
- Sense circuits
- Read/write control circuits

4.5.1 Head Actuator Control

When drive enable is low, transistor Q1 turns on the plus voltage supply to the stepper motor. The four phase signals ØA, ØB, ØC, and ØD generated by the Twiggy controller are buffered for high current drive and provided to the stepper motor to position the heads.

4.5.2 Spindle Drive Motor Speed Control

The Twiggy controller sends the motor speed code to the digital board using two lines. The code data is sent as an 8-bit serial word over the phase A (0A) line (J1, pin 2). This code word is clocked into a shift register by the motor clock signal (MCLK) from the controller (J1, pin 22). The outputs of the shift register are summed together through a resistive ladder network to produce a reference voltage. This reference is supplied to the non-inverting comparator input of a frequency to voltage converter. An AC signal generated by the tachometer in the spindle motor is full wave rectified and fed to the input of the same frequency to voltage converter. The output of the converter is then compared with the reference and the resulting signal is used to drive the motor. The motor is turned off when the motor clock signal goes low and the inverting input to the comparator is forced to +12 volts thus stopping the current supply to the motor.

4.5.3 Sense Circuits

The sense circuits provide information to the Twiggy controller about the status of the drive. Three signals are multiplexed onto a sense line (J1, pin 20) by a 74LS253 Data Selector/Multiplexer. WRITE PROTECT and DISK IN PLACE are signals from optical sensors that indicate the status of the disk. The remaining line on the multiplexer monitors the state of a latch that is set by the EJECT signal generated when the EJECT button on the front of the drive is pressed. In addition, DISK IN PLACE or EJECT cause an interrupt signal to be asserted and sent to the Apple III.

4.5.4 Read/Write Control Circuits

The read-write circuits are primarily for generating the signals needed by the Twiggy Analog board. However, these circuits have been modified so that the write data comes from the AFT control logic board via J5, pin 1 and the programmable write current for the Twiggy Analog board comes from the DAC on the AFT control logic board, to the Twiggy Digital board via J5, pin 3. To more easily understand the operation of these circuits, refer to the circuit description of the Twiggy analog board in the following paragraphs.

4.6 TWIGGY ANALOG BOARD

For this discussion, refer to the Twiggy block diagram (Figure 4) and the Twiggy analog board schematic diagram. The analog board can be broken down into three functional areas. These are:

- Head selection circuits
- Read circuits
- Write circuits

4.6.1 Head Selection

Before a write or read operation can take place, the appropriate read/write head must be selected. Either of two signals from the Twiggy digital board, MUX A and MUX B, must be on to allow head selection during a read operation. MUX A selects the lower head when HEAD SEL is high and -WREQ is inactive (high). Both MUX signals must be off during a write operation. Two FET switch pairs on the analog board receive the MUX signals. The signals first pass through level shifters that provide the correct operating voltages to the FET switches.

Head selection for a write operation is accomplished as follows. Either a WRITE A or a WRITE B signal is routed to the analog board from the Twiggy digital board by gating HEAD SEL and -WREQ. If HEAD SEL is high, the WRITE A signal goes high and allows the lower head to be selected. Conversely, if the HEAD SEL signal is low, the WRITE B signal goes high and allows the upper head to be selected. Data is routed to the selected head by a 74LS157 data selector on the Twiggy digital board. This circuit receives write data (W DATA) from the AFT control logic board (J5, pin 1) and depending on the logic level of the HEAD SEL signal, routes the data to the A or B write drivers on the Twiggy analog board.

4.6.2 Write Circuits

The head erase coil of the selected head is supplied with 12 volts by the active state of either WRITE A or WRITE B. The impedance of the erase coil is low enough, compared with a 200 ohm resistor to ground, that the center tap of the read/write coil is also at 12 volts. The path through which current flows in the read/write head is determined by a transistor pair in the CA3146 transistor array. These transistors switch back and forth and change the direction of current flow through the head in accordance with the write data signal.

4.6.3 Read Circuits

In the read mode, one of the heads is selected, the erase circuit is open, and the head's center tap is essentially grounded through a 200 ohm resistor. The read signal coming from the head is amplified by a differential amplifier and filtered by a low pass filter. The resulting read signal (raw 1F/2F TAA) passes through a buffer amplifier and is routed to the AFT analog and detection circuit board (J2, pins 1 and 3).

5. TEST CRITERIA

5.1 TRACK AVERAGE AMPLITUDE

After writing a complete revolution of the disk with the recording current specified in Section 5.7 of the Twiggy Disk Specification, the read-back signal will be peak detected and averaged. The time constant used is t /5 where t is the period of one revolution. The following frequencies will be written:

1F (250 KFTPS) 125 kHz
2F (500 KFTPS) 250 kHz

The TAA value for the 1F frequency will be compared to a limit. If the TAA value exceeds the limit, it will be reported as an error.

5.2 MODULATION

The F read-back signal will be peak detected with a peak detector with a time constant of 1/2 x 200 seconds. This will allow modulation at a rate lower than 200 Hz to be detected with full amplitude. A counter will count the number of modulation errors per track. Maximum count will be 256. The reference level is calculated as follows:

Modulation Reference Level = 2FTAA x % Modulation Error Limit

5.3 RESOLUTION

The ratio of the 2FTAA to the 1FTAA is defined as the resolution of the disk. It is reported as a percentage.

Resolution = (2FTAA / 1FTAA) %

This resolution will be compared to a limit, and if the resolution falls below this limit, it will be reported as an error.

5.4 OVERWRITE

The residual amplitude of the 1F signal remaining after the signal has been overwritten with a 2F signal is compared to the 1FTAA. This ratio, reported as a value in dB's, is defined as overwrite.

Overwrite = 20 log Residual 1FTAA / 1FTAA

This overwrite value will be compared to a limit. If its value drops below that limit, this will be reported as an overwrite error.

5.5 MISSING PULSE

The 2F read-back signal will be compared to a reference level; if any pulse drops below the reference level, it will be considered as a missing pulse. A counter will count the number of missing pulse errors per track. The maximum count will be 256. The reference level is calculated as follows:

MP Reference Level = 2FTAA x % MP Error Limit

5.6 EXTRA PULSE

After a DC erase, the resulting read-back signal will be compared to a reference level, and if the signal exceeds this reference level, an extra pulse error will be reported. A counter will count the number of extra pulses per track. The maximum count will be 256. The reference level is calculated as follows:

XP Reference Level = 2FTAA x % XP Error Limit

5.7 WRITE CURRENT

Write current will be programmable via a 7-bit DAC, the full scale current being 10 mA base-to-peak.

5.8 SELF-TEST

An external board generator will be used to generate known error signals for extra bit, missing bit, and modulation. Amplitude of the signal is also tested. The amplitude reported should be approximately 5 mV. This signal is switched into the circuit in place of the signal from the Twiggy.

5.8.1 Missing Bit and Modulation Error Signal

The modulation frequency is 61 Hz. During pre-index, the amplitude of this signal is reduced to 50% of its original amplitude, thus producing a modulation error signal if the missing bit threshold is set above 40%. The missing bit count is 1 and modulation count is 17.

5.8.2 Extra Bit Error Signal

During pre-index, a burst of 2F frequency is produced with a level of 35% of the original amplitude, thus producing an extra bit error if the extra bit threshold is set to a value below 35%. The count for this error signal should be 136.

6. DRAWINGS

This section contains simplified block diagrams and schematic diagrams of the tester's circuit boards.

ANALOG FLOPPY TESTER (AFT) SELF-CALIBRATION TEST PROCEDURE

OBJECTIVE:

The objective of this procedure is to supplement the AFT calibration procedure to insure correlation between all AFT electronics.

EQUIPMENT NECESSARY:

1. AIII/MIII System
2. Twiggy Media
3. Analog Floppy Test
4. AFT UTILITIES test disk
5. Analog Floppy Tester (AFT)

TEST PROCEDURE:

1. Remove the cover to the AFT and remove IC U17 on the AFT Analog PCB.
2. Insert the Self Test PCB.
3. Boot up the Apple III with the AFT UTILITIES test disk.
4. Apply power to the AFT unit.
5. From the MEDIA TESTER UTILITIES menu, type '3' to select the "Marginalize self-tests" option.
6. From the "SELF TEST MARGINALIZATION" menu, type '3' to select the "Amplitude test" mode. Insert Twiggy media and type <RTN>.
   Type '5'<RTN> for desired signal amplitude.
   Also, type '1'<RTN> for desired percentage of accuracy.
   The signal amplitude should be 5.00 mV (+/-) 1%. Adjust R91 on the AFT Analog PCB if out of limits. Type <RTN> to return to the "SELF TEST MARGINALIZATION" menu.
7. Type '1'<RTN> to select the "Marginalize missing bits and modulation" test mode. Check to insure that the following limits are observed for the AFT units:
   a. MISSING BITS = 39% (+/-) 1%
   b. MODULATION = 110% (+/-) 1%.
   Type <RTN> to return to the 'SELF TEST MARGINALIZATION' menu.
8. Type '2'<RTN> to select the "Marginalize extra bits" test mode. Check to insure that the following limits are observed for the AFT units:
   EXTRA BITS = 34% (+/-) 1%.
   Type <RTN> to return to the "SELF TEST MARGINALIZATION" menu.,
9. If out of specification, make the necessary corrections to the AFT units off line.
10. Power OFF the AFT unit. Remove the Self Test PCB and install IC U7. Close cover to the AFT unit.

AFT QUALIFICATION/CORRELATION PROCEDURE

OBJECTIVE:

The intent of this procedure is to achieve reasonable correlation between all Analog Floppy Testers (AFT). The goal is to have all readings within 10% for all testers/medium and within 20% overall.

EQUIPMENT NECESSARY:

1. AIII/MIII system
2. Silentype PRINTER
3. CERTIFIED Twiggy reference media - 3 each
4. Analog Floppy Testers
5. AFT QUICKTESTSB REV. B disk
6. AFT HEADTESTS disk

Oscilloscope - TEK 465b or equivalent.

GOLD STANDARD MEDIUM SPECIFICATIONS:

TRK44,HDO/1	
1FTAA = 5.00 mV	RESOLUTION = 77%
2FTAA = 3.85 mV	OVERWRITE = -38 dB*

*Overwrite is defined for the silver disk as residual 1F/1FTAA.

MEDIA SCAN, SINGLE STEP TEST SPECIFICATIONS:

ALL TRKS,HDO/1	
1FTAA = 3.0 mV to 6.0 mV	RESOLUTION = >70%
2FTAA = 3.0 mV to 6.0 mV	OVERWRITE = <-35 dB
Missing bit errors = 0	Modulation errors = 0
Extra bit errors = 0	

PROCEDURE:

Insure that the AIII and Analog Floppy Tester (AFT) is powered OFF!
Insure that the silentype is connected to the AIII.

Install the Twiggy Controller PCB and the VIA PCB into the AIII. Attach appropriate cables carefully by observing connector polarities.

1. MEDIA SCAN TEST -- A quick test to scan the ref. media for missing bits and modulation errors. Check 1FTAA, 2FTAA, resolution, writeover, and extra bits on both surfaces for the outer and inner tracks only.

   a. Boot up the AIII with the AFT QUICKTESTB disk. Apply power to the AFT.
   b. Type in the date, AFT #, employee initials, and media #. Type <RTN> and the silentype should print the heading and parametric limits.
   c. A two-option menu will be displayed, from which you must select '2' <RTN> for error reporting.

d. At this time, you will be asked to enter the ref. disk correction factors as written on the ref. disk for both sides.
e. Having done step 1.d, insert ref. disk into Twiggy drive and type <RTN>.
f. The AFT will test TRK45, both sides, then eject the ref. disk. This will be repeated twice, head correction factors averaged, then printed out. If any correction factor is out of its acceptable range, an error message will be printed out at the end of that surface and the program will abort. If this happens, call maintenance.
g. Type in the ref. disk #, then <RTN>.
h. Insert the first ref. media, then type <RTN>. The media scan test will sequence automatically starting with TRK00/HD0 and ending with TRK95/HD1.
i. The silentype will print out a summary of the tested medium/AFT.
j. The monitor will indicate whether the medium/AFT PASSED or FAILED.

2. SATURATION CURVE TEST -- This test increments the write current in 5.0 mAp steps for the range from 1.0 mAp to 5.0 mAp. It reports the 1FTAA, 2FTAA, resolution, and writeover readings for each write current increment for both heads at TRK45.

a. Boot up the AIII with the AFT HEADTESTB disk.
b. Enter the correction factors as written on the ref. disk, then RTN.
c. From the displayed menu, select speed test by typing '5'. Verify RPM is within limits and pre-index is okay. Type <RTN> to return to main menu.
d. Type '3', then '45'<RTN> to select track 45. Verify lower head is also selected.
e. Type '7' to select saturation curve testing. Values will be output to both console and silentype. Type <RTN> to exit to main menu.
f. Type '2' to select head 1-upper surface. Wait until display indicates surface has changed to proceed.
g. Type '7' to select perform sat. curve testing for upper surface.

3. SINGLE TRACK TEST -- This test reports the results of both heads at three track locations (TRK00,45,&90). The measured parameters are 1FTAA, 2FTAA, resolution, writeover.

a. Type '2' to select lower surface -head 0. Verify track is TRK 0.
b. Type '3', then '0'<RTN> to select TRK0 if not selected.
c. Type '6' to perform single step testing. After measured parameters are displayed, type 'P' to output to silentype. Type <RTN> to exit to main menu.
d. Type '3', then '45'<RTN> to select TRK45,HD0. Type '6' to execute test, then 'P' and <RTN> to print results and exit to main menu.
e. Type '3', then '90'<RTN> to select TRK90,HD0. Type '6' to execute test, then 'P' and <RTN> to print results and exit to main menu.

f. Type '2' to select upper surface, then '3' and '0' to select TRK0,HD1. Type '6' to execute test, then 'P' and <RTN> to print results and exit to main menu.

g. Type '3', then '45'<RTN> to select TRK45,HD1. Type '6' to execute test, then 'P' and <RTN> to print results and exit to main menu.

h. Type '3', then '90'<RTN> to select TRK90,HD1. Type '6' to execute test, then 'P' and <RTN> to print results and exit to main menu.

i. Verify that the corrected values measured above meet MEDIA SCAN, SINGLE STEP TEST SPECIFICATIONS. If not, drive does not qualify as a reference drive for use on AFT.

j. Type '4'<RTN> to eject disk. Type 'N'<RTN> in response to query, "IS DISK BEING CHANGED?" This retains this disk correction values. Reinsert disk and type <RTN>.

k. Repeat 3.a through 3.j two times.

4. Insert next ref. medium and repeat steps 1 through 3 for each of the remaining ref. medium for correlation. Use at least three each ref. media for the test correlation. Recommend a ref. media sample lot of five each. Save and file the recorded data set per tester. Correlate and summarize the test results.

AFT MEDIA CERTIFICATION PROCEDURE OPERATOR'S MANUAL

OBJECTIVE:

The objective of this procedure is to provide a test documentation for media certification.

EQUIPMENT NECESSARY:

1. AIII/MIII SYSTEM (128K)
2. Silentype
3. Analog Floppy Tester
4. AFT QUICKTESTB, REV>B test disk
5. Silver disk with correction factors as a reference medium.
6. Twiggy media for testing

SPECIFICATIONS:

1.	Maximum 1KF TAA:	6.00 mV
2.	Minimum 2F TAA:	3.00 mV
3.	Minimum resolution:	70%
4.	Maximum overwrite:	-35 dB
5.	Missing bit threshold:	40% of 2F TAA
6.	Modulation threshold:	115% of 2F TAA
7.	Extra bit threshold:	30% of 2KF TAA
8.	Read retries:	2

PROCEDURE:

Insure that the AIII and the Analog Floppy Tester (AFT) are powered OFF!
Insure that the Silentype is connected to the AIII (port A).
Also, insure that the Twiggy Controller PCB is installed into slot 4, and the VIA PCB is installed into slot 2 of the AIII peripheral slots.

1. Boot up the AIII with the AFT QUICKTESTB test disk.
2. Wait until the boot process is over, then apply power to AFT unit.
3. Type in the date, AFT #, employee initials, and the media lot #.
4. Type <RTN> and the silentype should print the heading and test parametric limits.
5. A two-option menu will be displayed on the monitor, from which you must select '1' for Media Certifying, otherwise type '2' <RTN> for error reporting.
6. At this time, you will be asked to enter the silver disk correction factors for both sides.
7. Having done step 6, insert silver disk into Twiggy drive and type <RTN>.
8. The AFT will test TRK 45, both surfaces, then eject the silver disk. This will be repeated two times and averaged, then disk and head correction factors will be printed out. If any Head correction factor is out of an acceptable range, an error message will be printed and the program will end. If this happens, call line maintenance.
9. Type in the disk # you wish to begin with, then <RTN>.

10. Insert the first Twiggy disk and type <RTN>. The media scan test should sequence automatically, starting with TRK00/HD0 and end the TRK95/HD1.
11. The disk will be ejected on the first error detected, or, if no errors are detected, continue until TRK95-HD1 and eject the disk.
12. The monitor will indicate whether a tested medium has PASSED or FAILED.
13. The Silentype will print out a summary of the tested medium.
14. Insert next Twiggy medium to be tested into the Twiggy drive and type '1' <RTN>. The AFT should print the next serial number for the media and begin the media scan test automatically.
15. On completion of media certifying, type '2' <RTN>. A summary of tested media results will be printed.

HELPFUL HINTS"

1. Maintain a "silver diskette" medium at each AFT station. This should aid in determining if the AFT or Twiggy drive has gone sour.
2. If excessive missing bits and modulation errors start to occur, install the "known good" Twiggy medium. If excessive errors continue to occur with the "known good" Twiggy medium, replace both load pads on the Twiggy drive as a corrective action.
3. If undetermined errors continue to occur after changing Twiggy drive load pads, turn OFF power to both the AIII and AFT units and ca-1 Test Engineering for assistance.
4. If "Drive Error" occurs, insure that the AFT is powered ON , and the "DC POWER" switch is on the ON position. If problem continues to occur, call Test Engineering for assistance.

PROGRAM: QUICKTESTB

PURPOSE: Program Description of AFT Media Certification Procedure

Intended user(s): Diskette duplication and manufacturing

Equipment needed: AFT tester, rev. B
Apple /// with 128K or more of memory
Monitor
Silentyper
Silver Diskette generated with 'Head.disk' program

(Note: Silver diskette MUST have been generated by the latest procedures. Old silver diskettes were generated using residual 1F to 2F for the overwrite measurements. All rev. B software uses and expects residual 1F to 1F for the overwrite measurements.)

DESCRIPTION OF OPERATION:

With AFT tester OFF, boot program diskette. When prompted, enter date, test station number, employee number, and media lot number. Turn AFT tester on, and allow it to warm up, if necessary.

The next prompt will ask how errors are to be handled. Enter '1' to reject disk on the first error and not print individual disk information. Enter '2' to print individual results on bad surfaces. If option 2 is chosen, disks with errors will not be rejected until the end of the first bad surface.

When prompted, enter the correction factors from the silver diskette labe. (See note under equipment list, above.) Then, as prompted, put the silver diskette in the tester and press RETURN. This will be repeated 2 more times, and the head correction factors averaged. If any single correction factor reading is out of acceptable ranges after one retry, an error message will be printed, and the program will end. If this happens, the tester drive must be checked.

After correction factors are computed, enter the starting diskette number. This number will be automatically incremented for each diskette. To start the test process, insert the diskette in the tester, and press RETURN. When the diskette has been tested, it will be ejected, and 'PASS DISKETTE' or 'FAIL DISKETTE' will be printed on the screen.

To continue testing, enter'1' when prompted. Insert the next diskette and press RETURN. To end the program, enter '2' to quit. The summary of errors and the number of diskettes passed and failed will be printed.

AFT REFERENCE DISK GENERATION PROCEDURE OPERATOR'S MANUAL

OBJECTIVE:

The objective of this procedure is to provide the documentation for the generation of reference media with correction factors, tracable to Primary standards. Reference media is to be used in head/HAC test, media certification, and reference drive qualification.

INTENDED USER: Quality Assurance

EQUIPMENT NECESSARY:

1. AIII/MIII System with minimum 128K
2. Silentype printer
3. Test disk -- HEAD/DISK CORRECTION FACTORS
4. AFT with silver Twiggy drive
5. Silver reference disk with correction factors
6. Certified Twiggy media

GOLD STANDARD HEAD/MEDIUM SPECIFICATIONS:

TRK45,HDS 0/1,1w = 3.5 mA
1FTAA = 5.00 mV RESOLUTION = 77%
1FTAA = 3.85 mV OVERWRITE = 38 dB* 20 LOG|1F RES TAA/1FTAA|

PROCEDURE:

1. Insure AIII/MIII and AFT are turned off.
2. Boot up the AIII with test disk HEAD/DISK CORRECTION FACTORS.
3. On completion of boot up, turn on power to AFT.
4. A four-option menu will be displayed. Type '2'<RTN> to select "calculate head correction factors". This will both 'normalize' the silver drive and allow verification of silver drive quality.
5. Enter disk correction factors, as prompted, from silver disk label.
6. Insert silver disk into AFT silver drive and type <RTN>.
7. The first of ten raw readings will be taken, displayed, and printed. The disk will then be ejected.
8. Reinsert silver disk and type <RTN> as prompted. Repeat nine times.
9. Entered disk and calculated head correction factors will now be displayed. Verify that all silver head correction factors are within 10% of nominal (0.9 to 1.1). Type '3'<RTN> to print factors.
10. Type '1'<RTN> to select "calculate Disk correction factors".
11. Insert silver disk and type <RTN>. Repeat ten times as prompted.
12. Calculated disk correction factors are now displayed. Type '3'<RTN> to print factors. Verify, as a system control, that these correction factors are within 2% of factors on silver disk label.
13. Remove silver disk and insert first certified media to be tested for reference media qualification. Type <RTN>. to start testing.

14. At end of test, calculated disk correction factors will be displayed. Type '3'<RTN> to print. To qualify as reference medium, all factors must be within the range of 0.9 to 1.1.
15. Remove disk, sort as to pass/fail, and then log correction factors on disk label if qualified as a pass.
16. Insert next disk and type <RTN>.
17. Repeat steps 14 through 16 for all media to be qualified. Type 'escape' to end testing.

PROGRAM: HEAD.DISK

PURPOSE: Program Description of AFT Ref. Disk Generation Procedure

Intended user(s): Quality Assurance

Equipment needed: AFT Tester, Rev. B
Apple /// computer with 128K or more of memory
Monitor
Silentype
Silver diskette with known correction factors, if head correction factors are unknown or need to be recomputed.

(Note: Be sure that silver diskette or known head correction factors have overwrite computed as residual 1F to 1F. KA11 rev. B software uses and expects this instead of residual 1F. to 2F.)

DESCRIPTION OF OPERATION:

With AFT tester OFF, boot program diskette. When test has booted and menu is displayed, turn the tester on and let it warm up if necessary. The menu will offer the following four choices:

1. Read and compute silver diskette correction factors.

   If head correction factors have been previously entered or computed, the program will ask if these values are to be used. If the answer is no, or no head correction factors exist yet, the program will prompt for head correction factors. (See NOTE, above.)

   The diskette will be clamped and raw values read ten times, so that correction factors can be averaged. As prompted, insert the disk and hit RETURN. Raw values will be displayed at the end of each reading, and printed on the Silentype. To return to the menu instead of continuing the readings, hit ESCAPE.

   At the end of ten readings, the correction factors are computed and displayed. They may be printed to the Silentype and/or reread.

2. Read and compute head correction factors from silver disk.

   Procedure is identical to disk correction factor computation, except that disk correction factors are required at the beginning instead of head correction factors.

3. Change track.

   Default track is track 45.

4. Quit.

ANALOG FLOPPY TESTER (AFT) CALIBRATION PROCEDURE

OBJECTIVE:

The purpose of this procedure is to supplement the current Adelphi calibration procedure. This includes the writeover filter trim procedure.

EQUIPMENT NECESSARY:

1. Digital Multimeter -- Fluke model 8010A, or equivalent
2. Spectrum Analyzer -- Hewlett Packard model 3585A, or equivalent
3. 5 MHz Signal Generator -- Wavetek model 184, or equivalent
4. Synthesizer/Function Generator -- Hewlett Packard model 3325A, or equivalent
5. Twiggy Attenuator, 40 dB, 50 -p/n
6. Writeover Signal Attenuator, -p/n
7. Write Current Adapter, -p/n
8. Associated BNC cables
9. Analog Floppy Tester (AFT), including AIII, MIII, VIA PCB, and ribbon cables.
10. AFT UTILITIES rev. A1 test disk
11. Oscilloscope -- Tektronix 465B, or equivalent.

CALIBRATION PROCEDURE:

Note: All of the adjustments are located on either the Control Logic PCB or the Analog and Detection Circuit PCB of the Analog Floppy Tester (AFT).

Boot up the AIII system with the AFT UTILITIES test disk. The "MEDIA TESTER UTILTIES" should be displayed. Apply power to the AFT and proceed as follows:

1. A/D CONVERTER +5V SUPPLY ADJUSTMENT -- (Control Logic PCB)

   a. Preset the DMM to the 20 Vdc range.
   b. Connect digital voltmeter to TP5 and TP6 (gnd).
   c. Adjust pot R10 to 5.00 V (+/-) 0.01V.

2. INDEX PERIOD ADJUSTMENT

   a. Connect a probe from TP1 on the AFT Control Logic PCB to CH1 on the oscilloscope (5V/div and 50 ms/div).
   b. From the "MEDIA TESTER UTILITIES", type '2' to select the "1FTAA, 2FTAA, overwrite" mode.
   c. Type '2' to select the "Change track and/or head" option. Type '45' to select TRK45, and type <RTN> to maintain HD0. The index period should change to about 240 ms. Adjust KR45 on the Twiggy Digital PCB for an index period of 240 ms. Do not adjust R45 at any other track locations!

d. Type '2' to change rack location to TRK00 on HD0. Check to see if the index period is about 280 ms.
e. Type '2' to change track location to TRK90 on HD0. The index period should now be about 193 ms.
f. Type '8' to return to the main menu.

3. A/D CONVERTER OFFSET ADJUSTMENT -- (Control Logic PCB)

a. Disconnect the coax cable from the test drive at J2 on the Analog PCB.
b. From the "MEDIA TESTER UTILITIES", type '2' to select the "1FTAA, 2FTAA, overwrite" mode of the Media Tester Utilities menu. The "CONTINUOUS TESTS" menu should be displayed on the monitor.
c. Type '3' to select the "Write 1f, measure TAA" mode.
d. Adjust pot R9 to 0.01 mV on the monitor display, then back off until display is 0.0 mV.
e. Type '8' to return to the main menu.

4. WRITE CURRENT ADJUSTMENT -- (Control Logic PCB)

a. Attach the write current adapter to HD0 (J3 location).
b. Set the Digital Current meter to the 20 mA range and connect the meter with the positive lead to the head cable end of the write current adapter, and the negative lead to the J3 terminal (PCB side).
c. From the "MEDIA TESTER UTILITIES", Type '1' to select the "Write 1f, 2f, DC erase" mode. The "WRITE CONTINUOUS SIGNALS" menu should be displayed on the monitor.
d. Type '5' to select the DC erase option.
e. With the write current set for 3.5 mA, adjust pot R5 to 3.50 mA (+/-) 0.00 mA.
f. Type '1' to "Change write current". Type '2'<RTN> to select 2.00 mA. Type '5' to DC erase and check current meter to insure that the actual current is 2.00 mA (+/-) 0.10 mA.
g. Type '1' to "Change write current" again. Type '7'<RTN> to select 7.00 mA. Type '5' to DC erase and check current meter to insure that the actual current is 7.00 mA (+/-) 0.35 mA.
h. If the write current values are not within the limits of steps 4.f and 4.g, repeat steps 4.e, 4.f, and 4.g, again.
i. Type '2' to select HD1 (upper surface).
j. Disconnect the head cable from the HD1 jack, J2 on the Twiggy Analog PCB, and connect the write current adapter to the J2 jack.
k. Repeat steps 4.d through 4.g without adjusting pot R5 to insure that the write current for HD1 is also within the specifications.
l. Type '6' to return to the main menu.

5. ANALOG SIGNAL AMPLITUDE -- (Analog and Detection Circuit PCB)

a. Disconnect the write current adapter from the HD1 jack, (J2) on the Twiggy Analog PCB, and connect the Twiggy Attenuator (100:1) to the HD0 jack. Reconnect the twinax cable to J2 of analog PCB.
b. Adjust the input signal at the Synthesizer/Function Generator to the following:
   (1) Frequency = 250 KHz
   (2) Amplitude = 500 mVpp
c. From the "MEDIA TESTER UTILITIES", type '2' to select the "1FTAA, 2FTAA, overwrite" program.
d. Type '4' to select the "write 2f, measure TAA" option.
e. Adjust pot R91 so that the 2FTAA readout on the monitor is 5.00 mV (+/-) 0.01 mV.
f. Increment the amplitude of the input signal from the Synthesizer/Function Generator in 100 mVpp increments and check the linearity of the 2FTAA peak detector for 2% accuracy from 100 mVpp to 1000 mVpp.
g. Return the signal input level of the Synthesizer/Function Generator to 500 mVpp. Type '3' to insure that the 1FTAA also measures the same value as that of 2FTAA.
h. Now change the frequency of the Synthesizer/Function Generator to 125 KHz. Type '3' and '4' alternately to insure that the 1f reading are the same for both 1FTAA and 2FTAA measurements. Should be about 5.05 mVpp on the monitor. If the readings are drastically different, adjust R53 to mid position and repeat step 5.h.
i. Type '7' to pause and connect the Twiggy Attenuator (100:1) to the HD1 jack. Set the frequency of the input signal from the Synthesizer/Function Generator to 250 KHz and the amplitude to 500 mVpp. Type '4' to insure that the 2FTAA reading is also 5.00 mVpp on the monitor as well as the 1FTAA by typing '3'. Repeat steps 5.f through 5.h. Type '2' and reslect HD0 -lower surface.
j. Type '8' to return to the main menu.

6. WRITEOVER -- (Analog and Detection Circuit PCB)

a. Remove the Twiggy Attenuator (100:1) from the HD1 jack, (J2) of the Twiggy Analog PCB, and connect the Writeover Signal Attenuator to the HD0 jack, (J3). Reconnect HD1 cable to J2.
b. Connect the 125 KHz cable to the Wavetek signal generator and adjust the signal generator frequency to 125 KHz.
c. Connect the 250 KHz cable to the Synthesizer/Function Generator. Set the frequency to 250 KHz and the amplitude to 500 mVpp.
d. Connect a x10 probe from TP3 on the AFT Analog PCB to the 1M input terminal of the Spectrum Analyzer.
e. Type '2' on the AIII to select the "CONTINUOUS TESTS" option. Also, type '6' to select the "Write 1f, 2f; calculate overwrite, pause" mode.
f. Set the Spectrum Analyzer to the following:
   (1) Frequency Span = 500 KHz
   (2) Center Frequency = 250 KHz
   (3) Marker = 250 KHz
   (4) Offset = off
   5)Reference level = 0dbm
   6)Res. BW = 10KHz

   Preset these settings and set the video bandwidth to 300 Hz. Enter the marker offest at 250 KHz and move the marker to -125 KHz. Adjust the Wavetek signal generator frequency so that the peak coincides with the -125 KHz marker exactly.
g. Adjust the amplitude of the 125 KHz signal from the Wafvetek to read -32 dB on the spectrum analyzer.
h. Type <RTN> to exit from the pause mode. Type '5' to select the "Write 1f, 2f; calculate overwrite" mode.
i. Insure that the writeover filter has been trimmed before continuing on to the next step. If the writeover filter has not been trimmed, go to the WRITEOVER FILTER TRIM PROCEDURE immediately.
j. Adjust pot R53 so that the writeover display is exactly -32.0 dB on the monitor.
k. Type '6' to select "Write 1f, 2f; calculate overwrite, pause" mode.
   (1) Readjust the Wavetek 125 KHz signal level as measured on the spectrum analyzer to -38 dB. Type <SPACE BAR> and check to insure that the monitor display is -38.0 dB (+/-) 1 dB.
   (2) Readjust the 125 KHz signal level on the spectrum analyzer to -26 dB. Type <SPACE BAR> and check to insure that the write-over display is -26.0 dB (+/-) 1 dB.
   (3) If not within limits, go back to step 6.j and readjust.
   (4) Now, set the 125 KHz signal level back to -32 dB on the spectrum analyzer. Set the 125 KHz signal level to -52 dB by turning the coarse amplitude adjustment on the Wavetek. Type '6' and check to insure that the writeover display is about -52 dB (+/-) 6 dB.
l. Type <RTN> and type '8' to return to the main menu.

--- END OF CALIBRATION PROCEDURE ---

WRITEOVER FILTER TRIM PROCEDURE:

Turn on power to the AFT.

Boot up the AIII system with the AFT UTILITIES test disk. The "MEDIA TESTER UTILITIES" menu should be displayed on the monitor.

1. ANALOG SIGNAL AMPLITUDE REFERENCE

   a. Adjust the input signal at the Synthesizer/Function Generator to the following settings:
      (1) Frequency = 250 KHz
      (2) Amplitude = 500 vMpp .
   b. Connect the input signal with the Twiggy Attenuator (100:1) to HD0, J3 of the Twiggy Analog PCB.
   c. Type '2' to select the "1FTAA, 2FTAA, overwrite" mode and the monitor should display the "CONTINUOUS TEST" menu.
   d. Type '4' to select the "Write 2F, measure TAA" option.
   e. Adjust pot R91 so that the 2FTAA readout on the monitor is 5.00 mV (+/-) 0.01 mV.
   f. Increment the input signal from the Synthesizer/Function Generator in 100 mVpp increments and insure that the 2FTAA display is within 2% of the input value for the range from 100 mVpp to 1000 mVpp.
   g. Type '7' to select the "Pause while displaying current value" option.
   h. Connect the Twiggy Attenuator (100:1) to the HD1 jack, J2 on the Twiggy Analog PCB and repeat steps 1.c through 1.g. Insure that the 1F/2F readout on the monitor is 5.00 mV.
   i. Type '7' to pause test and reattach the head cables to J2 and J3.

2. WRITEOVER FILTER TRIM

   a. Set the Spectrum Analyzer to the following settings:
      (1) Frequency span = 500 KHz
      (2) Center frequency = 15 250 KHz
      (3) Reference level = 0.0 dBm
      (4) Offset = off.
      Preset these conditions and video bandwidth to 300 Hz.
   b. Connect the Twiggy Attenuator (100:1) plus to the HD0 jack, J3 on the Twiggy Analog PCB> Connect the other end of the BNC to the spectrum analyzer tracking generator output.
   c. Connect a probe from TP4 of the AFT Analog PCB to the 1M ohm input of the spectrum analyzer. You should see an umbrella-shaped waveform on the spectrum analyzer at this point. Simulate this waveform to that drawn on sheet 2/3 of the AFT Analog schematics.

d. Initially, trim C70 for the best peak at 125 KHz. Suggest 30 pf.
e. Adjust R83 for (+/-) 3 dB bandwidth at 125 KHz (+/-) 8 KHz.
f. Trim C76 for best filter slope response. Suggest about 47 pf.
g. Trim C87 for best filter slope response. Suggest about 150 pf.
h. Trim pair C80 and C81 for best notch filter response at 250 KHz. Suggest 51 pf.
i. Trim pair C83 and C86 for best notch filter response at 250 KHz. Suggest 150 pf.
j. If the -80 dB attenuation cannot be achieved with the filter trim, adjust R83 for greater 125 KHz amplification until the -80 dB difference between 125 KHz and 250 KHz can be achieved.
k. This concludes the writeover filter trim procedure, but be sure to recalibrate the test vehicle from the start of this calibration procedure once more with the final tester PCB configuration. Identify the PCB set with the AFT tester number.

ANALOG FLOPPY TESTER (AFT) SELF-CALIBRATION TEST PROCEDURE

OBJECTIVE:

The objective of this procedure is to supplement the AFT calibration procedure to insure correlation between all AFT electronics.

EQUIPMENT NECESSARY:

1. AIII/MIII system
2. Certified Twiggy media
3. AFT UTILITIES rev. Al test disk
4. ANALOG FLOPPY TESTER (AFT)
5. AFT Self Test PCB p/n

TEST PROCEDURE:

1. Remove the cover to the AFT and remove IC U17 on the AFT Analog PCB.
2. Insert the Self Test PCB.
3. Boot up the Appl III with the AFT UTILITIES rev. Al test disk.
4. Apply power to the AFT unit.
5. From the MEDIA TESTER UTILITIES menu, type '3' to select the "Marginalize self-tests" option.
6. From the "SELF TEST MARGINALIZATION" menu, type '3' to select the "Amplitude test" mode. Insert Twiggy media and type <RTN>.
   Type '5'<RTN> for desired signal amplitude.
   Also, type '1'<RTN> for desired percentage of accuracy.
   The signal amplitude should be 5.00 mF (+/-) 1%. Type <RTN> to return to the "SELF TEST MARGINALIZATION" menu.
7. Type '1'<RTN> to select the "Marginalize missing bits and modulation" test mode. Check to insure that the following limits are observed for the AFT units:
   a. MISSING BITS = 40% (+/-) 1% at maximum count of 17.
   b. MODULATION = 110% (+/-) 1% at maximum count of 17.
   Type <RTN> to return to the "SELF TEST MARGINALIZATION" menu.
8. Type '2'<RTN> to select the "Marginalize extra bits" test mode. Check to insure that the following limits are observed for the AFT units:
   a. EXTRA BITS = 35% (+/-) 1% at maximum count of 136.
   b. Also, look for first hit for extra bits at 39% (+/-) 1%.
   Type <RTN> to return to the "SELF TEST MARGINALIZATION" menu.
9. If out of specification, make the necessary corrections to the AFT units off line.
10. Power OFF the AFT unit. Remove the Self Test PCB and install IC U7. Close cover to the AFT unit.

AFT TESTER CONTROL WORD

BIT	FUNCTION
15	Recalibrate
14	Wait for pre-index
13	Delay before reading result (to allow A-to-D to finish conversion)
12	Drive Command
11-9	PIA number (0-4)
8	Port B/Port A
7-0	Output data:
7	Select TAA
6	Select Residual TAA
5	Select Radial Alignment
4	Command Strobe
3-0	Commands: 0 = Write 1 = Erase 2 = Measure TAA 3 = Detect missing bit and modulation errors 4 = Detect extra bits 5 = Measure TAA, detect missing bit and modulation errors

REV.	ZONE	ECO #	REVISION	APPD	DATE

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REFERENCE DISKETTES,

HOW TO GENERATE AND USE IN

TWIGGY HEAD MEDIA EVALUATION

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
NEXT ASSY.	MATERIAL: FINISH:	SIZE A	DRAWING NUMBER SCALE:	SHEET OF

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1.0 Scope

This document details a systematic approach to generating Twiggy Reference Diskettes and is to be used to test and evaluate Twiggy heads and media, so that the head/media manufacturing processes may be properly controlled.

2.0 Reference Documents

Twiggy Drive Specification #062-0106
Twiggy Diskette Specification #062-0102
Twiggy Read/Write Head Specification #062-0107

3.0 Generation of Reference Diskettes

The main parameters that are being considered are:

i) 1F Track Average Amplitude (1F) in mV,
ii) 2F Track Average Amplitude (2F) in mV,
iii) Resolution (RES) in %, and
iv) Overwrite Ratio (OWR) in dB.

An analysis of Twiggy Read Channel requirements based on the variations in read amplifier gain, head quality, diskette quality, drive's ability to seek and stay ontrack, and read channel's ability to handle missing bit and positively modulated signals, indicates that the "central", "ideal", or "gold" values for these parameters are as follows:

1FGOLD = 5.00 mV
2FGOLD = 3.85 mV
RESGOLD = 77%
OWRGOLD = -38 dB

Since it is practically impossible to have a single "gold" head or a diskette, i.e., a head or diskette exhibiting all of the central properties together, we can only have secondary standards referenced back to the gold values. Although any head or diskette can theoretically be made a secondary standard, it is customary to choose only those heads and diskettes that are within +/-10% of the gold amplitudes, i.e., 1FGOLD and 2FGOLD, as secondary standards or Silver References.

An experiment to accomplish this is as follows:

Start with a large sample of drives and diskettes (i.e., heads and media). Practical considerations usually limit the sample size to 20. Use AFT or an equivalent tester to make every drive see every diskette. Measurements of 1F, 2F, RES, and OWR are made at mid-data zone radius of 1.874" (Track 45 in AFT system) for both top T and bottom B surfaces. For example, we would obtain a matrix for 1F as shown in Fig. 1.

The grand average (average of all entries in the matrix) must be close to a 1FGOLD value of 5.00 mV. Otherwise, the media design and/or head design must be improved. The row averages are equivalent to readings obtainable with a gold head. Similarly, from the respective matrices, row averages are computed for 2F, RES, and OWR. As mentioned earlier, a diskette qualifies as a Silver Reference if its top and bottom surface averages are within +/-10% of the gold values. The corresponding surface averages are called the silver values of that diskette. For such a silver reference diskette the various Diskette Correction Factors are developed as follows:

```
1FDCFT   = 1FGOLD/1FSILT
2FDCFT   = 2FGOLD/2FSILT
RESDCFT  = RESGOLD/RESSILT
OWRDCFT  = OWRGOLD - OWRSILT

1FDCFB   = 1FGOLD/1FSILB
2FDCFB   = 2FGOLD/2FSILB
RESDCFB  = RESGOLD/RESSILB
OWRDCFB  = OWRGOLD-OWRSILB
```

4.0 Use of reference Diskettes

4.1 Head Evaluation

Use AFT or an equivalent head tester to obtain, for a given pair of top and bottom heads, 1F, 2F, RES, and OWR measurements on a Silver Reference diskette at mid-data zone radius to obtain Raw Values. Corrected Values are given by:

```
1FCORT   = 1FRAWT * 1FDCFT
2FCORT   = 2FRAWT * 2FDCFT
RESCORT  = RESRAWT * RESDCFT
OWRCORT  = OWRRAWT + OWRDCFT

1FCORB   = 1FRAWB * 1FDCFB
2FCORB   = 2FRAWB * 2FDCFB
RESCORB  = RESRAWB * RESDCFB
OWRCORB  = OWRRAWB + OWRDCFB
```

Apply the acceptance criteria to these corrected values as per Twiggy Head Specification. Keep histograms for each of these parameters in order to periodically monitor the central or gold value drift, and correct the manufacturing process accordingly.

4.2 Media Evaluation

If AFT or equivalent media tester is used, first characterize both the top and bottom test heads using a Silver Reference diskette as follows: Take 1F, 2F, RES, and OWR measurements at mid-data zone radius on the silver reference diskette. These are raw values seen by the test heads. The Head Correction Factors are given by:

```
1FHCFT   = 1FGOLD/(1FRAWT * 1FDCFT)
2FHCFT   = 2FGOLD/(2FRAWT * 2FDCFT)
RESHCFT  = RESGOLD/(RESRAWT * RESDCFT)
OWRHCFT  = OWRGOLD - (OWRRAWT + OWRDCFT)

1FHCFB   = 1FGOLD/(1FRAWB * 1FDCFB)
2FHCFB   = 2FGOLD/(2FRAWB * 2FDCFB)
RESHCFB  = RESGOLD/(RESRAWB * RESDCFB)
OWRHCFB  = OWRGOLD - (OWRRAWB + OWRDCFB)
```

Save and use these head correction factors until the heads need to be calibrated again. The frequency of head calibration depends on the rate of head wear and can be determined experimentally.

Now for any given diskette, obtain raw 1F, 2F, RES, and OWR values at mid-data zone radius. The corrected values are given by:

```
1FCORT  = 1FRAWT * 1FHCFT
2FCORT  = 2FRAWT * 2FHCFT
RESCORT = RESRAWT * RESHCFT
OWRCORT = OWRRAWT + OWRHCFT

1FCORB  = 1FRAWB * 1FHCFB
2FCORB  = 2FRAWB * 2FHCFB
RESCORB = RESRAWB * RESHCFB
OWRCORB = OWRRAWB + OWRHCFB
```

Apply the acceptance criteria to these corrected values as per Twiggy Media Specification. As indicated in the head evaluation case, keep histograms for each of these parameters in order to periodically monitor the central or gold value drift, and correct the manufacturing process accordingly.

4.3 Generation of Additional Reference Diskettes:

Evaluate a set of diskettes as per 4.2 and obtain the corrected values for 1F, 2F, RES, and OWR. Then compute the DCF's for each diskette as follows:

1FDCFT = 1FGOLD/1FCORT
2FDCFT = 2FGOLD/2FCORT
RESDCFT = RESGOLD/RESCORT
OWRDCFT = OWRGOLD - OWRCORT

1FDCFB = 1FGOLD/1FCORB
2FDCFB = 2FGOLD/2FCORB
RESDCFB = RESGOLD/RESCORB
OWRDCFB = OWRGOLD - OWRCORB

A diskette qualifies as a silver reference if its DCF's are within 0.9 and 1.1.

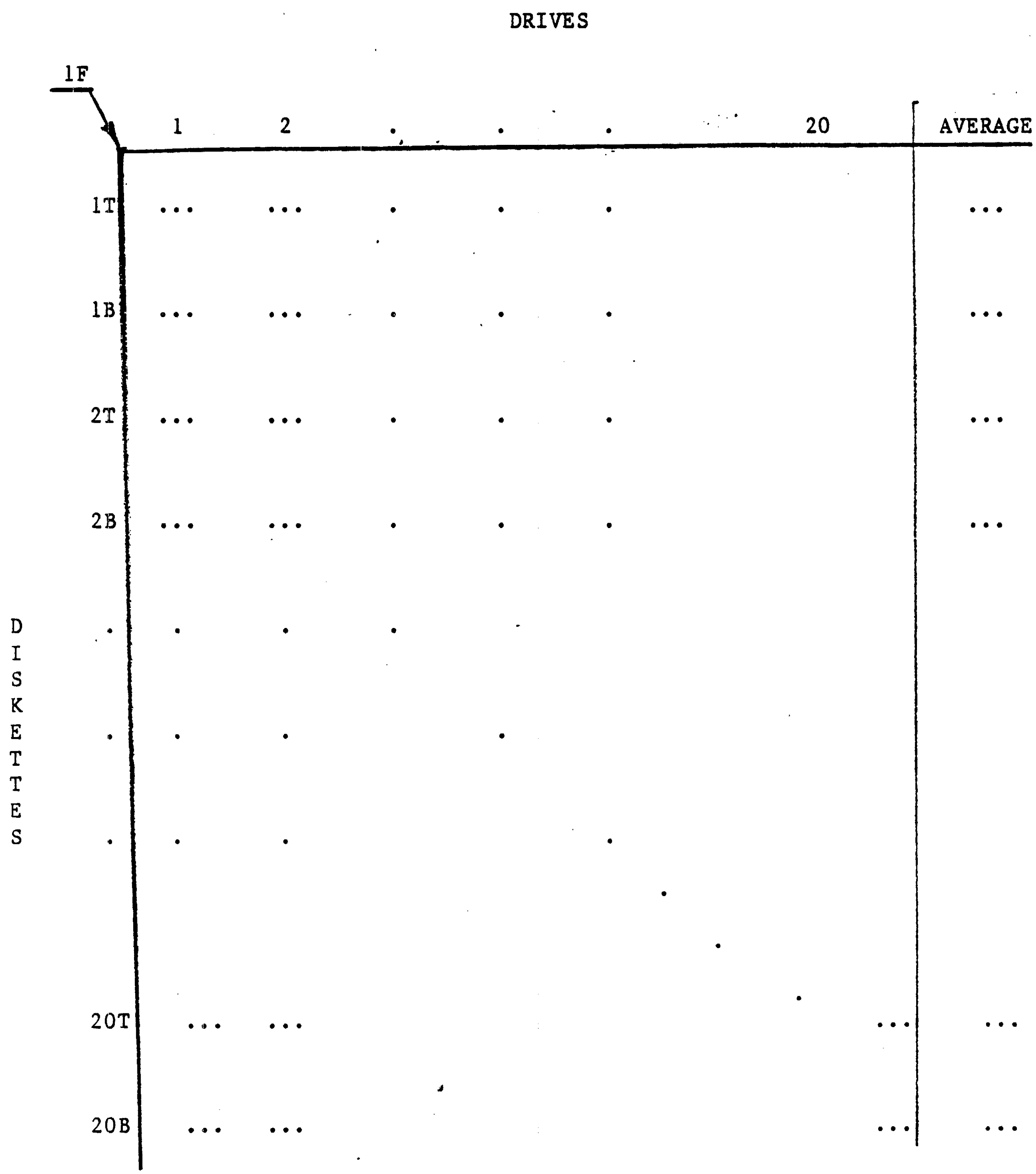

FIG.1 MATRIX OF 1F VALUES

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SIZE A

DRAWING NUMBER

SCALE:

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TWIGGY HIGH-DENSITY R/W
HEAD SPECIFICATION

TOLERANCES		
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES.		
DECIMALS	.X ±	
	.XX ±	
	.XXX ±	
ANGLES	XX.X ±	
FRACTIONS	±	
DIMENSIONS IN PARENTHESIS ARE IN MILLIMETERS.		

DRAWN BY [illegible]	DATE [illegible]
CHECKED BY	DATE
APPROVED BY	DATE
RELEASED BY	DATE

apple computer inc.

TITLE [illegible]

SIZE	DRAWING NUMBER
A	062-[illegible]

MATERIAL:

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1. SCOPE

1.1 This document specifies the general, physical and magnetic requirements of a flexible drive read/write head with single read/write gap and separate straddle erase, as required to be compatible with a 62.5 TPI, 10,000 FCPI, mass storage system. It is intended to be specifically used with digital recording, and APPLE reproducing equipment, employing an access mechanism capable of positioning to data tracks.

2. REFERENCE DOCUMENTS

2.1 Twiggy Reference Diskette Procedure #080-0018.

2.2 Twiggy Drive Specification #062-0106

2.3 AFT Specification #062-0115

2.4 Media Specification #062-0102

3. GENERAL REQUIREMENTS

3.1 Materials

The core material is hot pressed manganese-zinc ferrite. The component parts are glass bonded and supported by a plastic superstructure as described in APPLE Drawing #815-5005.

3.1.1 Ferrite: Hot Pressed Manganese Zinc (MnZn).

Permeability (Uo):	4000 minimum @ 0.1 MHz 2300 minimum @ 1.0 MHz 1150 minimum @ 3.0 MHz
Saturation Flux Density (Bs):	4000 Gauss @ 10 Oe
Coercive Force (Hc):	0.15 Oe
Curie Temperature (Tc):	140°C minimum
Density:	4.65 grams/cc
Hardness:	700 Vickers
Thermal Coefficient of Expansion:	11.0 x 10^-6 in/in/degree C
Resistivity:	20 ohm/cm minimum

3.1.2 Calcium Titinate

Grain Size:	5 microns
Porosity:	0.5% maximum
Density:	4.4 grams/cc
Hardness:	700 Vickers minimum
Thermal Coefficient of Expansion: (25 to 300 C)	11.0 x 10^-6 in/in/degree C

	Size	Max. Perm.
Void Dist. per 0.2 inch x 0.2 specimen:	>0.003"	0
	0.002"-0.0029"	2
	0.001"-0.0019"	4
	0.0003"-0.0009"	6

3.1.3 Glass: High Temperature

Softening Point:	=> 700°C
Annealing Point:	525°C
Thermal Coefficient of Expansion: (0° to 300°C)	11.0 x 10^-6 in/in/degree C

3.1.4 Glass: Low Temperature

Softening Point:	=> 370°C
Working Temperature:	500°C
Thermal Coefficient of Expansion:	11.0 x 10^-6 in/in/degree C

3.2 Environment

3.2.1 Temperature/Humidity

The head shall withstand operating temperatures between 50°F and 140°F (10°C to 60°C), storage temperatures of -49°F to 160°F (-45°C to 71°C), and relative humidity in the range of 8% to 80% (storage and operating). No moisture shall be in or on the head.

4. PHYSICAL REQUIREMENTS

4.1 Dimensions

Read/write gap width:	0.0095 +/- 0.0003 inches (0.241 +/- 0.076 mm)
Read/write gap length:	45 +/- 10 microinches (1.1 +/- 0.1 um)
Read/write gap depth:	0.0015 +/- 0.0005 inches (0.038 +/- 0.013mm)
Erase gap:	0.001 + 0.0005, - 0.0 inches (0.025 +/- 0.013mm)
Erase gap width:	0.0055 inches maximum (0.13 mm)
Erase gap depth:	0.0045 +/- 0.0005 inches (0.115 +/- 5 mm)
Crown face contour:	2.0 +/- 0.2 inches radius (51 +/- 5mm)

4.1.1 The head ceramic/ferrite assembly shall comply with the dimensions given in APPLE Drawing #SK2054.

4.2 Quality

4.2.1 Surface Finish

The crowned ceramic/ferrite face shall be 3 microinches (0.076 microns) AA or better. Scratches shall be less than 0.0001 inches (0.0025 mm), with a maximum of three (3) scratches per head.

4.2.2 Read/Write Gap Zone

Read/write gap chips shall be limited to 0.0005 inches (0.0127 mm) maximum length. The sum of the lengths of all gap chips will be 0.0009 inches (0.0229 mm) maximum (ETW 0.0081 inchs (0.206 mm) minimum) with 0.0003 inches (0.076 mm) maximum gap edge chip. No more than two (2) discontinuities per gap will be permitted.

4.2.3 Erase Gap Zone

The core face areas within +/- 0.008 inches (+/- 0.203 mm) of the read/write gap in the direction of media rotation and 0.013 inches (0.330 mm) wide centered on the read/write core shall have edge chips of 0.0003 inches (0.076 mm) maximum into the gap and 0.002 inches (0.051 mm) long on read/write and erase cores. No more than two (2) discontinuities per gap will be permitted.

4.3 Design Life

The useful life of the read/write head shall be 16,000 hours minimum in contact with APPLE disk, moving at 50 IPS, with a nominal pressure pad force of 23 grams on the front head, and 20 grams on the rear head.

4.4 Cleaning

The head construction shall allow periodic cleaning with methl-alcohol or freon based solvent (without acetone or methylene chloride) without harm.

5. ELECTRICAL REQUIREMENTS

All electrical parameters shall be measured in the ambient conditions of 73° +/- 5°F (23° +/- 3° C). The parameters will be measured at the head terminals with no cable connected.

5.1 Inductance

Read/write Coil (center tap open):	2.50 mH +/- 0.5 mH at 1 KHz
Read/write Coil, per leg:	600 uH +/- 120 uH at 1 KHz
Read/write Coil Balance (leg 1/leg 2):	0.85 to 1.17
Erase Coil:	600 uH +/- 120 uH

5.2 Resistance

Read/write Coil (per leg):	20 ohms maximum
Erase Coil:	15 ohms maximum

5.3 Resonance Frequency at Connector

The resonance frequency (measured at read/write terminals with center tap open) shall be greater than 800 KHz.

5.4 Insulation Resistance

The resistance between the coils and cores shall be greater than 50 mega-ohms at 100 VDC.

5.5 Grounding

The back bar of the read/write core shall be electrically connected to the read/write coil center tap.

6. RECORDING PERFORMANCE TEST CONDITIONS

6.1 Environment

Unless otherwise stated, measurements shall be carried out in ambient conditions of 73° +/- 5°F (23° +/- 3°C) and 40% to 60% relative humidity after 24 hours of acclimatization (head, media and test fixtures).

6.2 Test Track Locations

The nominal radius of the centerline of all tracks shall be calculated by using the following formula:

RN = X - N/62.5 inches (RN = (X) - N/62.5 x 25.4 mm)

where:
- RN = nominal radius
- N = the track number
- X = 2.25 inches
- (X) = 57.15 mm

The centerline of the recorded tracks in the testing environment (6.1) shall be within +/- 0.001 inch (+/- 0.025 mm).

6.3 Media Velocity

The media velocity for all tests, on any track, shall be 50 IPS +/- 1 IPS.

6.4 Reference Media

For detailed specification of reference media see APPLE Twiggy Reference Diskette Procedure, #080-0018.

6.4.1 Source

APPLE COMPUTER will provide reference test diskettes for the purpose of correlation of recording performance test data.

6.4.2 Reference Media Physical Properties

Substrate Material:	Bi-axially oriented polyethylene terepthalate.
Substrate Thickness:	0.003 +/- 0.00035 inches (0.0762 +/- 0.0089 mm)
Thermal Coefficient of Expansion:	6.0 to 13.9 x 10^-6 in/in/deg.F (1.1 to 2.5 x 10^-5 mm/mm/deg.C)
Hygroscopic Coefficient of Exp.:	15.0 x 10^-6 in/in/% RH maximum (15.0 x 10^-6 mm/mm/% RH)

6.4.3 Reference Media Magnetic Properties

Coercivity:	600 Oe nominal
Coating Thickness:	50 microinches (1.27 um) nom.
Coating Resistivity:	Less than 5 x 10^9 ohms per sq.

6.4.4 Jacket Dimensions

(See APPLE Drawing No. 062-0102)

6.5 Test Drive Alignment

The test drive fixture shall be such that the following conditions will exist when recording performance measurements are made.

Penetration:

Tangency:	Media to button tangency point will be within 0.008 inches (0.023 mm) of the center of the read/write gap
Head Load Force:	Front Head 23 grams +/- 2 grams Rear Head 20 grams +/- 2 grams
Head Load Pad Area:	0.028 sq. in. (1.80 sq. mm)

6.6 Test Recording Currents

The following recording currents shall be used for making recording performance measurements.

Write Current:	7.0 mA peak to peak +/- 0.1 mA
Risetime (10% to 90%)	800 nS maximum
Overshoot:	5% maximum
Erase Current:	50 mA DC +/- 0.5 mA

6.7 Test Amplifier

The amplifier used for recording performance measurements shall have an input impedance of 10K ohms shunted by 10 pF (maximum) and be fully differential.

7. RECORDING PERFORMANCE REQUIREMENTS

See the Application Section of APPLE Twiggy Reference Media Specification (#080-0018) for details.

7.1 Output

The read output amplitude shall be greater than 3.0 mV peak to peak TAA at 10,000 FCI (2F) and less than 6.0 mV peak to peak TAA at 5,000 FCI (1F).

7.2 Resolution

The resolution (RES) at a given track of a disk is defined as the ratio of the 2F track average amplitude to the 1F track average amplitude, i.e.,

$$RES = 2FTAA/1FTAA$$

The resolution at any track of the diskette shall be greater than or equal to 0.7.

7.3 Overwrite Ratio

The overwrite ratio (OWR) of a disk at a given track is defined as the ratio of the residual 1F track average amplitude after the track has been overwritten at 2F frequency without an intervening DC erase to the 1F track average amplitude before overwritng. If R1FTAA denotes the residual 1F track average amplitude, then the overwrite ratio is expressed as:

$$OWR = 20 \log (R1FTAA/1FTAA) \text{ dB}$$

The overwrite ratio for any track of the diskette shall be less than or equal to -35 dB.

7.4 Asymmetry

Measuring a 1F output wave form, the period from positive peak to negative and the period from negative peak to positive peak shall not have a difference of more than 150 nS.

Asymmetry = Longer period - Shorter period

7.5 Erase Efficiency

$$20 \log \frac{\text{Eout after off track erase}}{\text{1FTAA}} \leq -26\text{dB, at 0.004" off track.}$$

7.6 Self Erase

The output signal level shall be decreased by no more than 5% from its initial value after ten (10) sweeps across the recorded track by the non-energized head.

7.7 Output Reduction Due to Erase

The output signal level, of a track written without erase, shall not be decreased by more than 5% when that track is written with erase.