

LIGHTNING



Q
Quantum

LIGHTNING

Engineering

LIGHTNING 365/540/730

Program Status

Prepared for Compaq

Program Status

- In Pre-Mass Pro as of 5/20/94
 - 2,500 Units Built
 - » 1,500 365MB Units
 - » 250 540MB Units
 - » 750 730MB Units
- Mass Production Schedule for 6/20/94
- Pre-Mass Pro Yields
 - 94% for AT
 - 82% for SCSI

Major Yield Issues

- Head Non-Linearity for Servo Position
 - Change at $5\% < 15\% / 3$
 - Reduced KLOOP Limits, V_SCALE Limits
- Reduced Length of Seek Used for NULLI and V_SCALE Calibration
- SCSI Interface Firmware Robustness
- Head/Media Selection

Lightning Open Issues

- Low Temperature Issue with One Head Vendor
- Process Tooling Verification (Head De-Gramming)
- Power Matrix Specification
- Analog Scan O/W Specification (Drive Level vs Component Level)
- Seek Timing Failures

Lightning Planned Changes

- Review Low Temperature Issue and Investigate Programmable Channel Changes to Qualify Heads
- Review Seek Timing Failures to investigate Cause - Probably Firmware since SCSI Failures > AT Failures
- Fix Field Identified Firmware Issues

Lightning Specification Review



Quantum

Presented to Compaq 6/9/94

Specification Overview

	<u>Lightning 365</u>	<u>Lightning 540</u>	<u>Lightning 730</u>
Capacity (formatted)	366.8 MB	541.4 MB	733.6 MB
Logical Sector Size	512	512	512
Sectors per Track	64-128	64-128	64-128
Physical Cylinders	3,673	3,673	3,673
Spare sectors per Cylinder	1	1	2
Total sectors	716,470	1,074,705	1,432,940
Number of disks	1	2	2
Number of heads	2	3	4
Form Factor	3.5" x 1.0"	3.5" x 1.0"	3.5" x 1.0"
Seek Time (mSec)	11	11	11
Spindle Speed (RPM)	4,500	4,500	4,500
Disk Rate (MB/Sec)	47.2	47.2	47.3
Interface Rate (MB/Sec)	6	6	6
Cache Size (KB)	96	96	96
Buffer Type	64KB x 16	64KB x 16	64KB x 16
Max Throughput (MB/Sec)	3.3	3.3	3.4
Idle Power	3.2 W	3.5 W	3.7 W

DRIVE SPECIFICATION

1 Model

2 Capacity Available to User (MB)

IDE (MB)

IDE (2 Logical Cylinders Reserved)

SCSI

3 Interface (IDE, SCSI2 Fast, etc)

Interface Part (Mfg & Model)

Will Hot Plugging cause damage?

Will Hot Plugging corrupt bus?

4 Burst I/F Transfer Rate (MB/s)

Transfer Rate @ Head (Mb/s)

Spindle RPM

Avg. Seek Time (typ/max ms)

Seek Time for 1 Cyl (typ/max ms)

Buffer Size (KB)

Buffer Segments

Command Overhead (μ s)

Track Skew (ms)

Cylinder Skew (ms)

Spinup Time (max sec)

5 # Data Cylinders (physical)

Reserved Cylinders

Data Heads (physical)

Sectors/Track or . . .

Table if Zoned Recording

Sector Interleave Factor

Data Bytes/Sector

Defect Mgmt Sectors/Cylinder

Defect Mgmt Cylinders/Drive

Format Efficiency (%)

6 Power Supply Regulation Required

Power Supply Ripple Limit

Peak Amps @ Spinup

Power @ Idle Spin (RMS W)

Power @ Random Rd/Wrt (RMS W)

Power @ Low Power Mode (RMS W)

Power @ Sleep Mode (RMS W)

7 Operating Temperature Range ($^{\circ}$ C)

Air Flow Requirement

Humidity Range (operating)

Incident E-Field Limit

Incident B-Field Limit

Operating Vibration/Shock Limits

NonOp Vibration/Shock Limits

Power Cycle/Start-Stop Limit

Sound Pressure @ Idle Spin (mean/max)

Sound Power @ Idle Spin (mean/max)

Sound Power @ Random Read (mean/max)

Weight

8 Mean Time Between Failure (Hrs)

Lightning 365	Lightning 540	Lightning 730
365.78304	541.384704	731.56608
365.008896	540.352512	730.017792
366.041088	541.499392	732.082176
IDE, SCSI2/3	IDE, SCSI2/3	IDE, SCSI2/3
Qtm KONI	Qtm KONI	Qtm KONI
No	No	No
No	No	No
13-AT,10-SCSI	13-AT,10-SCSI	13-AT,10-SCSI
47.2	47.2	47.2
4,500	4,500	4,500
11.5/14	11.5/14	11.5/14
4/5	4/5	4/5
96	96	96
Variable 1-4	Variable 1-4	Variable 1-4
500	500	500
4	4	4
5	5	5
12	12	12
3,673	3,673	3,673
15	15	15
2	3	4
16 Zones	16 Zones	16 Zones
64 to 128	64 to 128	64 to 128
1:1	1:1	1:1
512	512	512
1	1	2
0	0	0
TBD	TBD	TBD
12V +10%-7%	12V +10%-7%	12V +10%-7%
5V +/-5%	5V +/-5%	5V +/-5%
250mV @ 12V	250mV @ 12V	250mV @ 12V
150mV @ 5V	150mV @ 5V	150mV @ 5V
0.95	0.95	0.95
3.3	3.6	3.6
5.4	7.0	7.0
< 1.0 W	< 1.0 W	< 1.0 W
< 1.0 W	< 1.0 W	< 1.0 W
0 to 55	0 to 55	0 to 55
None	None	None
5% to 85%	5% to 85%	5% to 85%
4 V / Meter	4 V / Meter	4 V / Meter
6 Gauss	6 Gauss	6 Gauss
1.0 / 6.0 G	1.0 / 6.0 G	1.0 / 6.0 G
2.0 / 6.0 G	2.0 / 6.0 G	2.0 / 6.0 G
20,000	20,000	20,000
33/36 dbA @ 1m	33/36 dbA @ 1m	33/36 dbA @ 1m
4.0/4.2 bels	4.0/4.2 bels	4.0/4.2 bels
5.0/5.2 bels	5.0/5.2 bels	5.0/5.2 bels
<1.2 lbs	<1.2 lbs	<1.2 lbs
300,000	300,000	300,000

HARDWARE SPECIFICS

1 Model	Lightning 365	Lightning 540	Lightning 730
2 Areal Density (Mb/Inch^2)	241	241	241
Tracks/Inch	3,794	3,794	3,794
Bits/Inch (max)	63,515	63,515	63,515
Flux Changes/Inch (max)	47,636	47,636	47,636
Servo Type (Dedicated, etc)	Embedded	Embedded	Embedded
Write Threshold (% of Track)	2%	2%	2%
Read Detect Threshold	Adaptive	Adaptive	Adaptive
Read/Write Encoding Method	RLL 1,7	RLL 1,7	RLL 1,7
Encode/Decode Table (separate)			
3 Spin Motor Torque Constant	168 gmf-cm/A	168 gmf-cm/A	168 gmf-cm/A
Spin Motor Type/Configuration	3ø Halless 8 Pole @ 4,500 RPM	3ø Halless 8 Pole @ 4,500 RPM	3ø Halless 8 Pole @ 4,500 RPM
Starting Torque Available ... from Spin Motor (min)	101 gmf-cm	101 gmf-cm	101 gmf-cm
Starting Torque Required by ... Head/Disk Interface (max)	50 gmf-cm	72 gmf-cm	81 gmf-cm
4 Latch Type (Magnetic, Solenoid)	AIRLOCK™	AIRLOCK™	AIRLOCK™
Force Required to ...	Open 2,600 RPM	Open 2,600 RPM	Open 2,600 RPM
Pull Out of Latch (max)	Close 1,700 RPM	Close 1,700 RPM	Close 1,700 RPM
Actuator Type	Rotary Ball Bearing	Rotary Ball Bearing	Rotary Ball Bearing
Actuator Force Constant	850 gmf-cm/A	1060 gmf-cm/A	1060 gmf-cm/A
Actuator Coil Amps (max)	700mA	700 mA	700 mA
Actuator Moment of Inertia	50 gm-cm^2	58 gm-cm^2	58 gm-cm^2
Force Available to ...	N/A	N/A	N/A
Pull Out of Latch (min)			
5 Head Design Type	Thin Film	Thin Film	Thin Film
Nominal Head Fly Height (μl)	2.75	2.75	2.75
Min/Max Head Fly Height (μl)	2.25/3.5	2.25/3.5	2.25/3.5
Head Launch Velocity	120 IPS	120 IPS	120 IPS
Head Gap Width	5.0 +/- 0.6 μm	5.0 +/- 0.6 μm	5.0 +/- 0.6 μm
Magnetic Track Width	7.0μm max @ ID	7.0μm max @ ID	7.0μm max @ ID
Head Gap Length	0.35 +/- 0.03 μm	0.35 +/- 0.03 μm	0.35 +/- 0.03 μm
Head Gram Load	7.0 +/- 0.5 gm	7.0 +/- 0.5 gm	7.0 +/- 0.5 gm
Head Amplitude (min)	225μV	225μV	225μV
Head Resolution (min)	>65%	>65%	>65%
Head Overwrite (min) max	<-25dB	<-25dB	<-25dB
Head Signal/Noise Ratio (min)	>28dB	>28dB	>28dB
6 Media Coercivity	1,600 +/- 50 Oe	1,600 +/- 50 Oe	1,600 +/- 50 Oe
Media Glide Height	2.0μ"	2.0μ"	2.0μ"
Media Roughness	≤0.2μ"	≤0.2μ"	≤0.2μ"
Media Lube Thickness @ ID	0.8μ"	0.8μ"	0.8μ"
Media Lube Thickness @ OD	0.8μ"	0.8μ"	0.8μ"
Media Amplitude (min)	250μV	250μV	250μV
Media Resolution (min)	>65%	>65%	>65%
Media Overwrite (min) max	<-26dB	<-26dB	<-26dB

HARDWARE SPECIFICS

7	Inner Crash Stop Radius	0.8042	0.8043	0.8043
	Inner Data Track Radius	0.7975	0.7975	0.7975
	Inner Data Track Radius	0.831"	0.831"	0.831"
	Inner Crash Stop Radius	0.761	0.761	0.761

8 Agency Certification
 Yes or No (with expected date)

UC	YES	YES	YES
CSA	YES	YES	YES
TUV	YES	YES	YES
FCC	YES	YES	YES

Program Risks

- Thunderbolt Commonality

Technical risk minimized due to commonality with Thunderbolt hardware and firmware

- Higher TPI

3,794 tracks per inch requires higher track following reliability. Evolved from Thunderbolt embedded digital servo technique.

Mechanics must remain stable - TMR

- Head Technology

50% slider is proven technology. Must work closely with vendors and manufacturing to provide consistent process control and yield.

Balance between SNR and Off-track capability must be maintained with higher TPI

- KONI (ASIC)

Cost reduction efforts must be monitored to maintain peak performance levels

Design Risk Considerations

Changes from Thunderbolt 270/540

What

New Heads:

- 5 micron gap
- 50% slider

Slimmer and harder crash stops

Remove damping resistor from flex

Add RC filter in PCBA

Add 2 transistors to servo circuit

Put 2 holes in base casting

Add FPLD to AT-IDE PCBA

Enhanced firmware

Why

To use narrower tracks

To use more disk area

To use more disk area

To reduce noise in channel to achieve error rate

To reduce noise in channel to achieve error rate

To reduce 1/3 stroke seek time

To accommodate push pin servowriter

Enhanced AutoRead in LBA mode

Improve servo code, faster address mode change ID,
minor bug fixes, SCSI Plug and Play

Same as Thunderbolt 270/540

Everything else, including:

Disk

Preamplifier

Read/Write Channel

Servo samples per track (70)

LT 4/94 - 15

KONI Controller Chip

Spindle Motor

Base Casting (except for hole to fit push pin
servowriter)

32 MHz Microprocessor

CONFIDENTIAL


Quantum

ELECTRICAL OVERVIEW

Key Electrical Components

◆ PCB

- » Single sided SMT
- » Integrated power connector

◆ Single 32 MHz processor

- » Buffer control
- » Servo control
- » Vendors: NEC

◆ KONI (ASIC)

- » ENDEC
- » Servo Logic
- » A/D Converter
- » Disk Sequencer (split data field)
- » 20 Mbyte/Sec Buffer Bandwidth
- » DRAM Interface
- » 6MB/Sec AT Interface
- » Vendor: TI

Key Electrical Components, contd.

◆ 128K DRAM

- » 96 KByte Cache
- » 32 KByte Drive Firmware
- » Vendors: NEC, OKI, Hitachi

◆ Hitachi Single Chip Recording Channel

- » 48 MB/Sec
- » Peak Detection
- » Equalizer/Filter
- » Data Separator
- » Write Synthesizer
- » Servo Wedge Detection
- » Vendor: Hitachi

Lightning Critical Component Sourcing

PART	VENDOR	LOCATION OF MANUFACTURE	LEADTIME	MONTHLY CAPACITY FOR LIGHTNING
READ CHANNEL HA153030F	HITACHI	Japan	16 weeks	500,000
PRE-AMP 715N(2)(4) HA16615(1)(2)	VTC HITACHI	Minneapolis Japan	12 weeks 12 weeks	500,000 500,000
VCM DRIVER HA13529FP	HITACHI	Japan	10 weeks	500,000
MOTOR DRIVER HA13481AFP	HITACHI	Japan	10 weeks	500,000
CONTROLLER/IF Konishiki	TI	Miho, Japan KTI, Japan	12 weeks 12 weeks	500,000 500,000
CPU OTP/ROM 78352	NEC	Japan	8 weeks	500,000
D-RAM 64K x 16	TOSHIBA OKI SANYO	Japan Japan Japan	14 weeks 14 weeks 14 weeks	500,000 500,000 500,000
GATE ARRAY	ORBIT	Sunnyvale/S. Korea	6 weeks	500,000
HEADS Thin Film	DEC* TDK* READ-RITE YAMAHA	Mass./PRC/HK Japan Japan/Thailand Japan	10 weeks 10 weeks 10 weeks 10 weeks	600,000 600,000 600,000 200,000
MEDIA	AKCL FUJI* MKC*	Japan Japan Japan	8 weeks 8 weeks 8 weeks	300,000 250,000 300,000
MOTOR	OZU NIDEC	Japan Japan	8 weeks 8 weeks	400,000 200,000

* In qualification

Lightning Firmware Review



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Presented to Compaq 6/10/94

LIGHTNING FIRMWARE DIFFERENCES

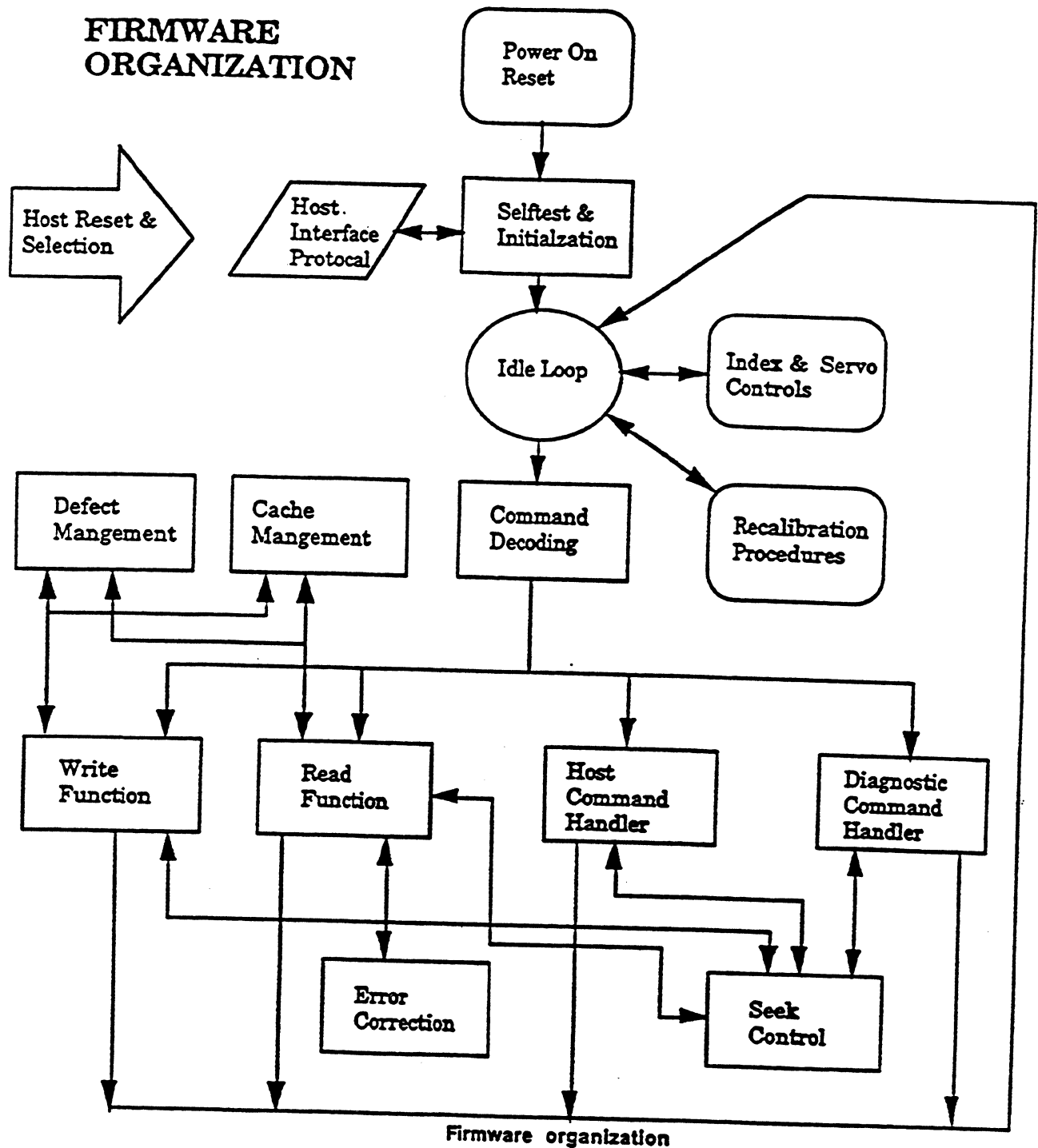
- SCAM SUPPORT FOR SCSI
- LBA MODE CODE CHANGE FOR AT
- POWER MODE
- DRIVE PARAMETER ANALYSIS WILL BE ADDED TO AT FIRMWARE

[illegible]

—————→ **Code baseline**

→ **Functionality migration**

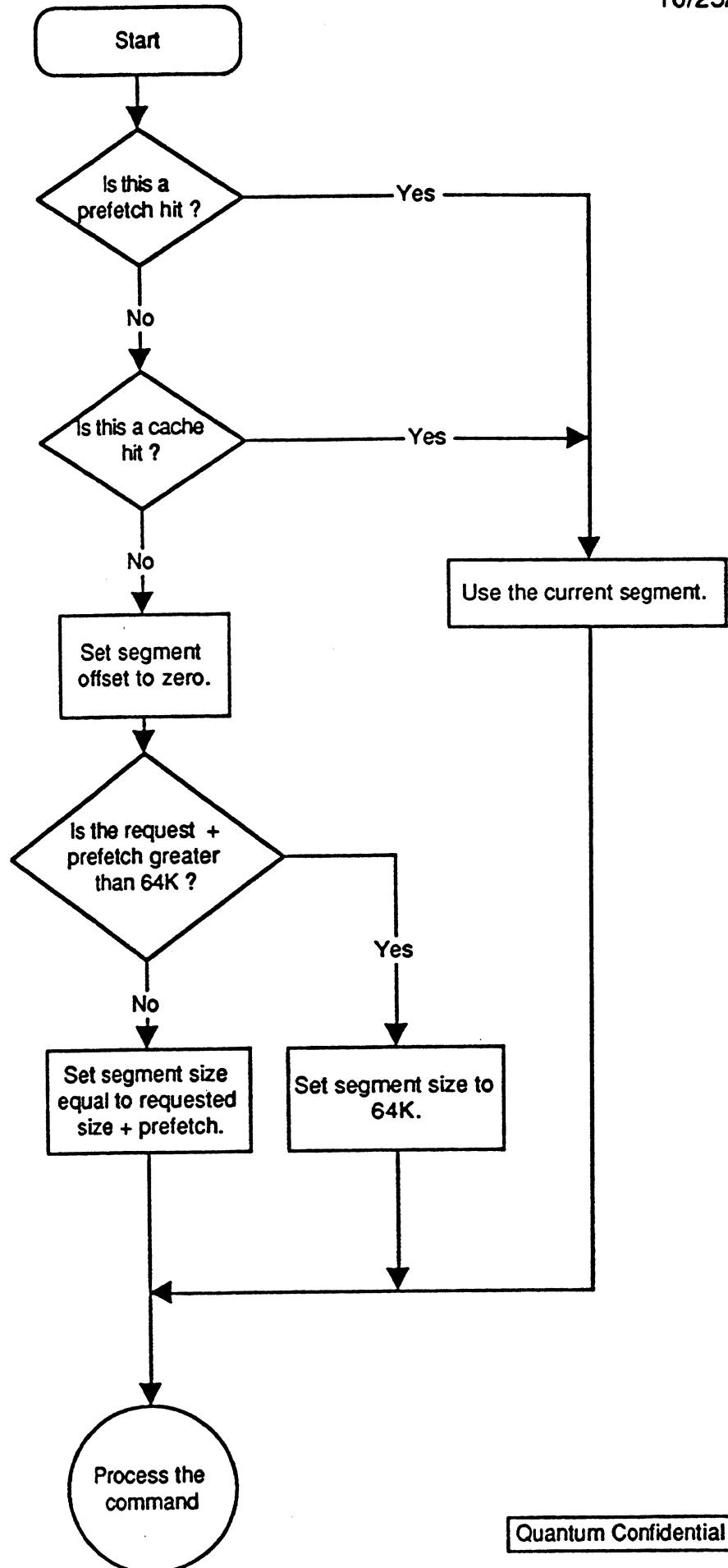
FIRMWARE ORGANIZATION

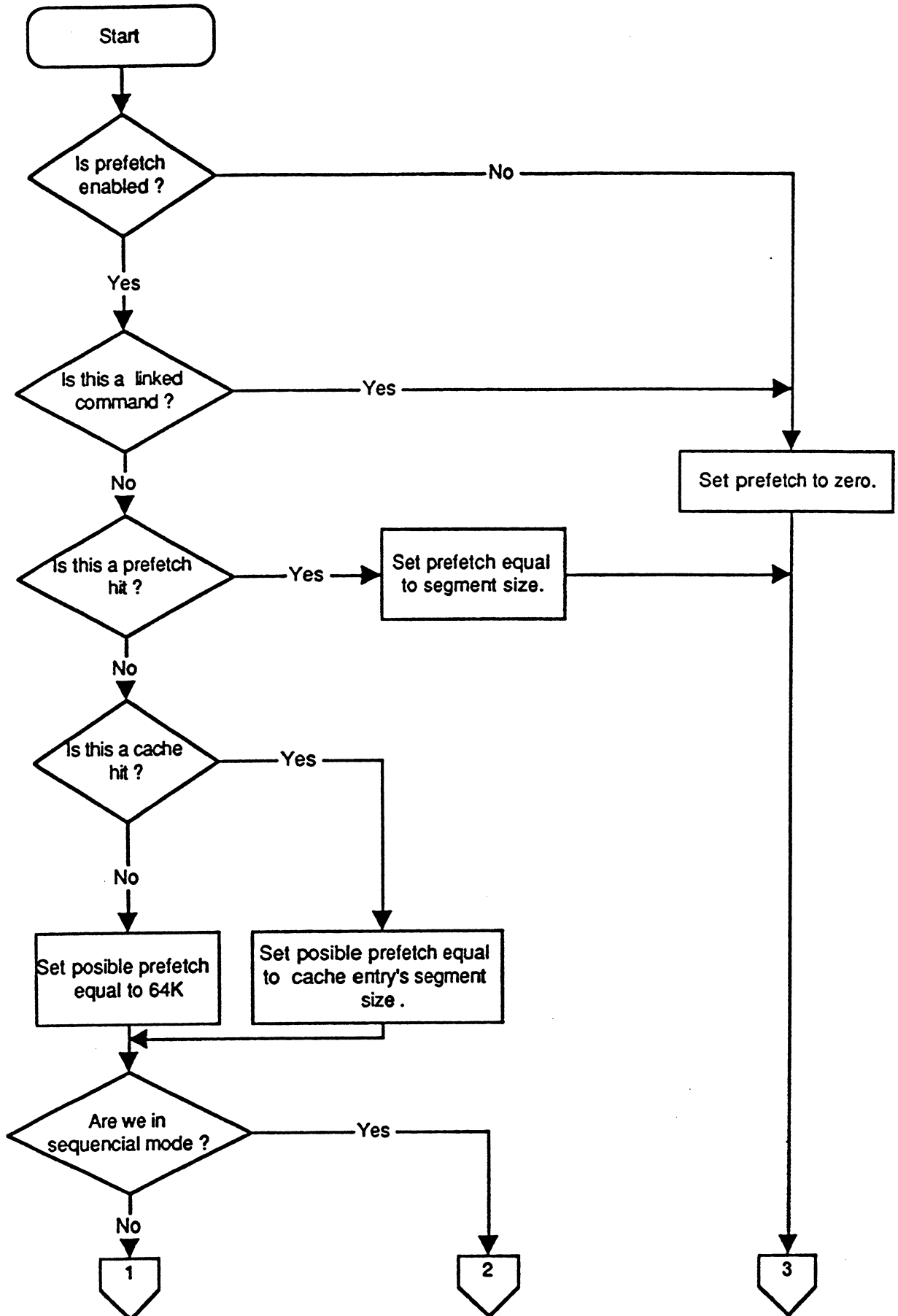


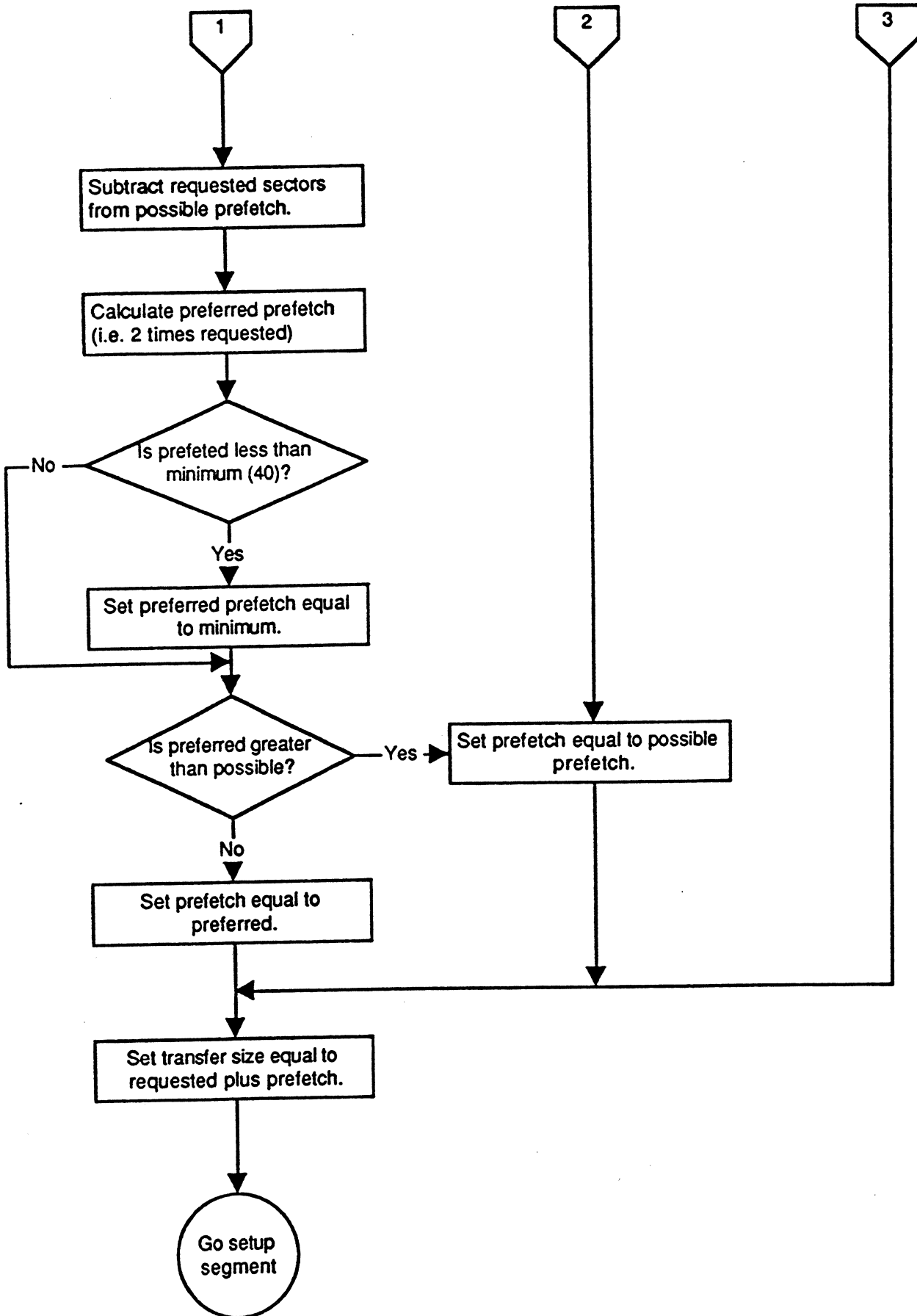
LIGHTNING CACHE ALGORITHM

Cache Setup

10/25/93

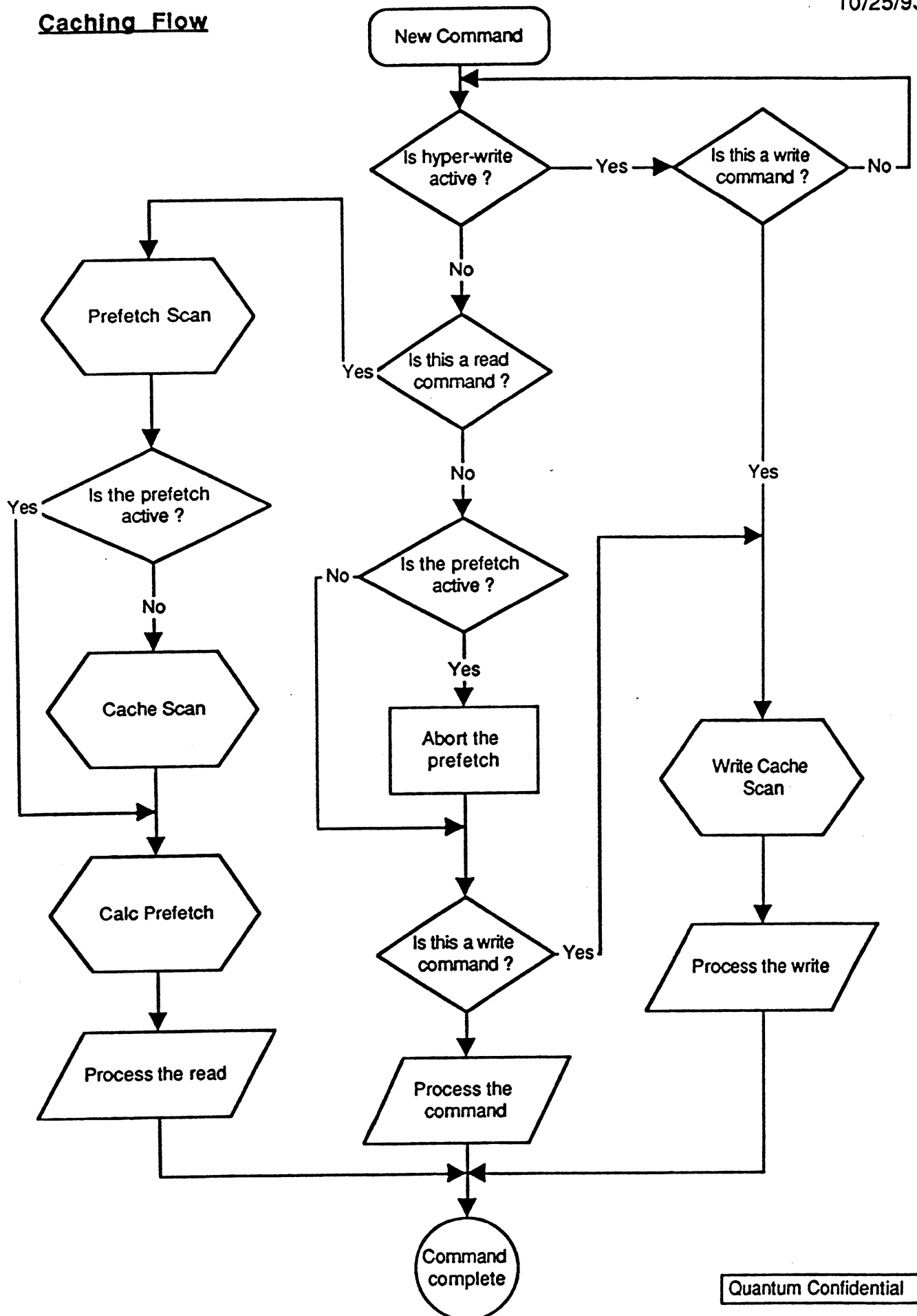


Calculate Prefetch



Caching Flow

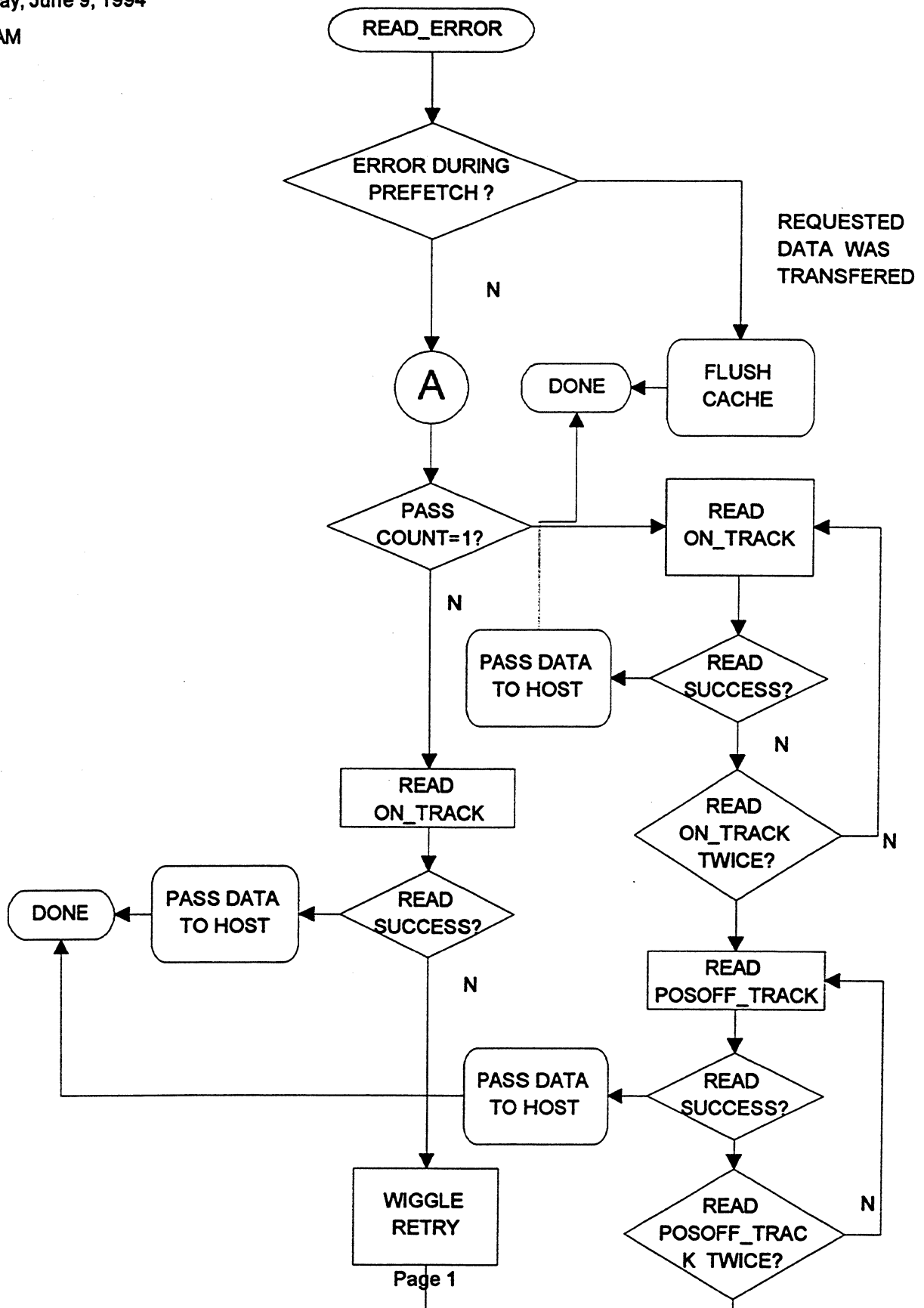
10/25/93

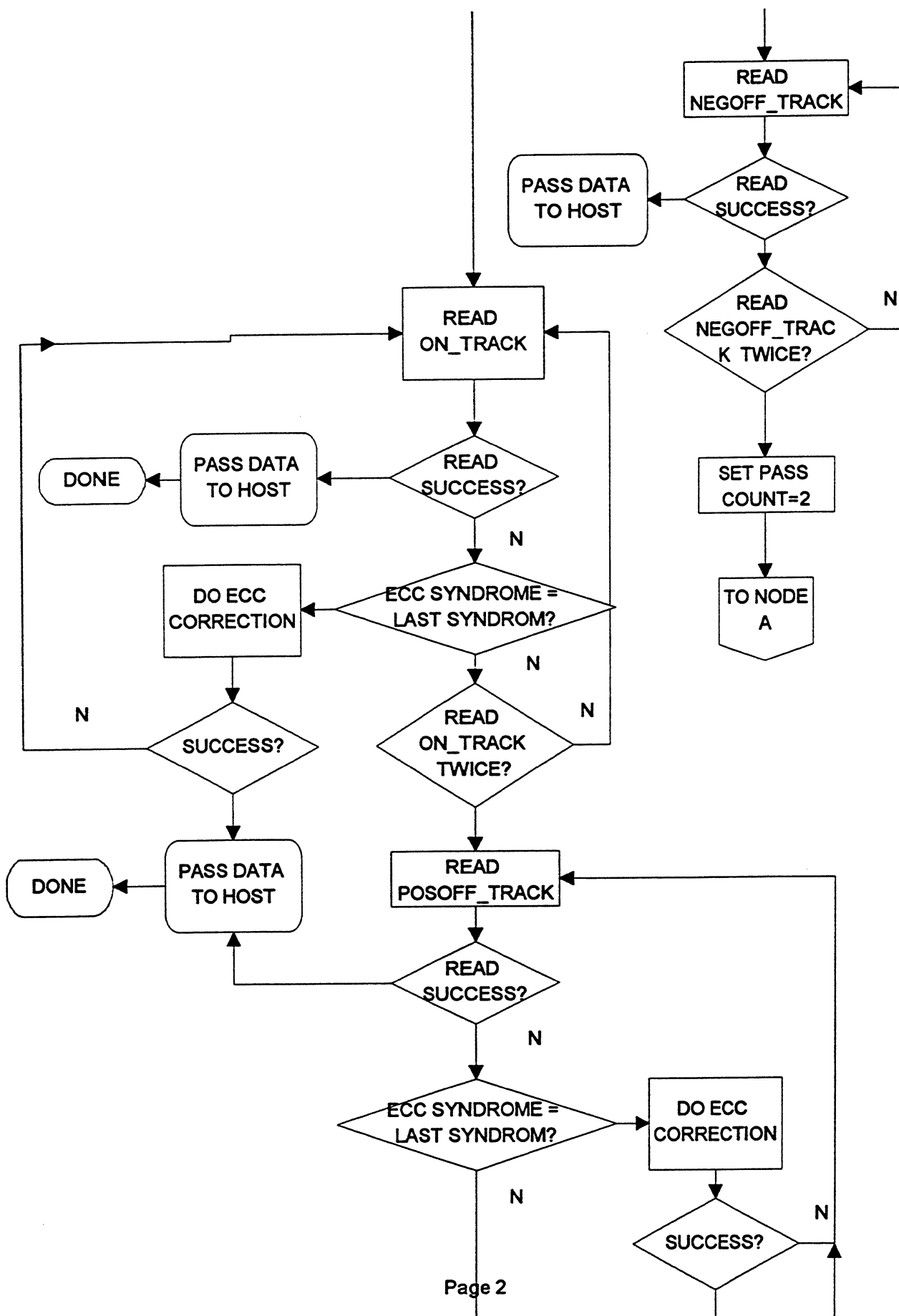


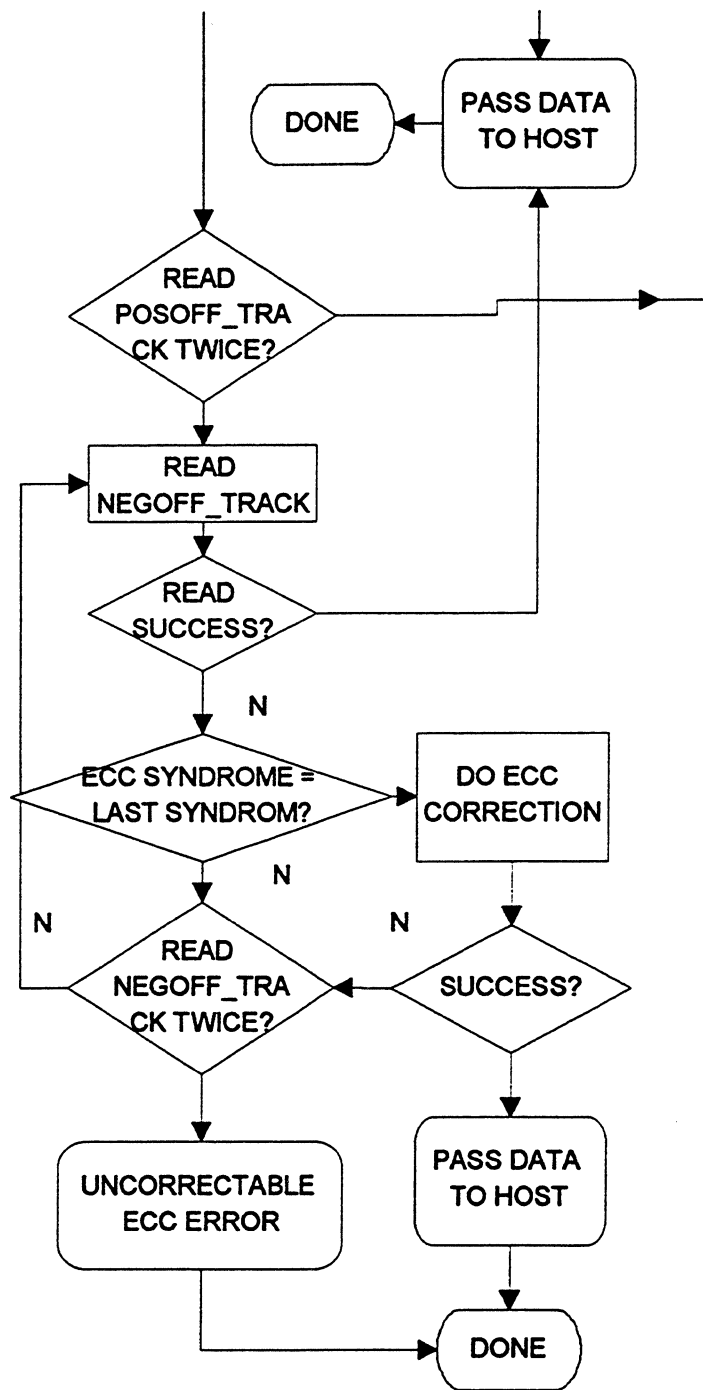
LIGHTNING ERROR RECOVERY ALGORITHM

Thursday, June 9, 1994

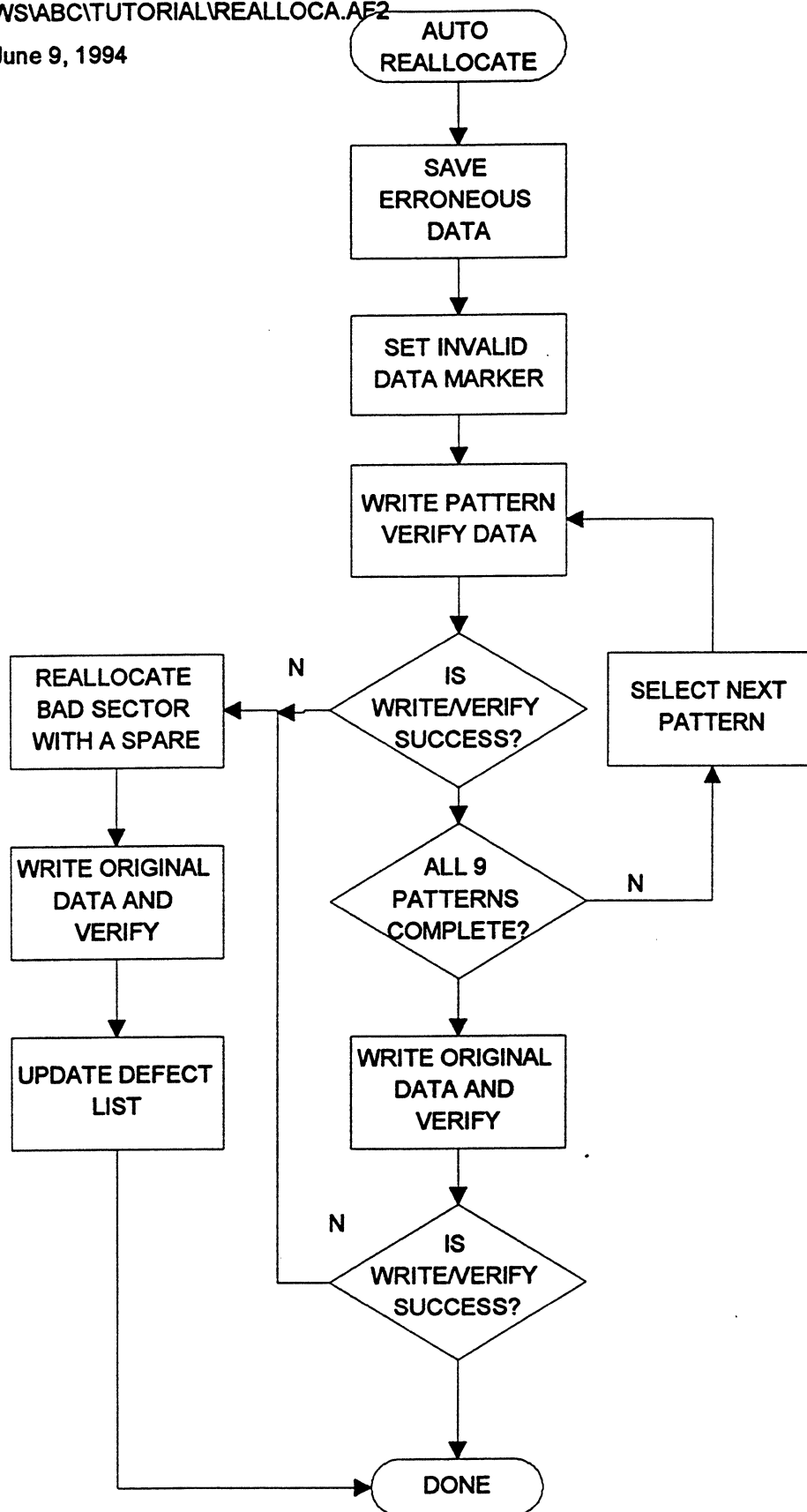
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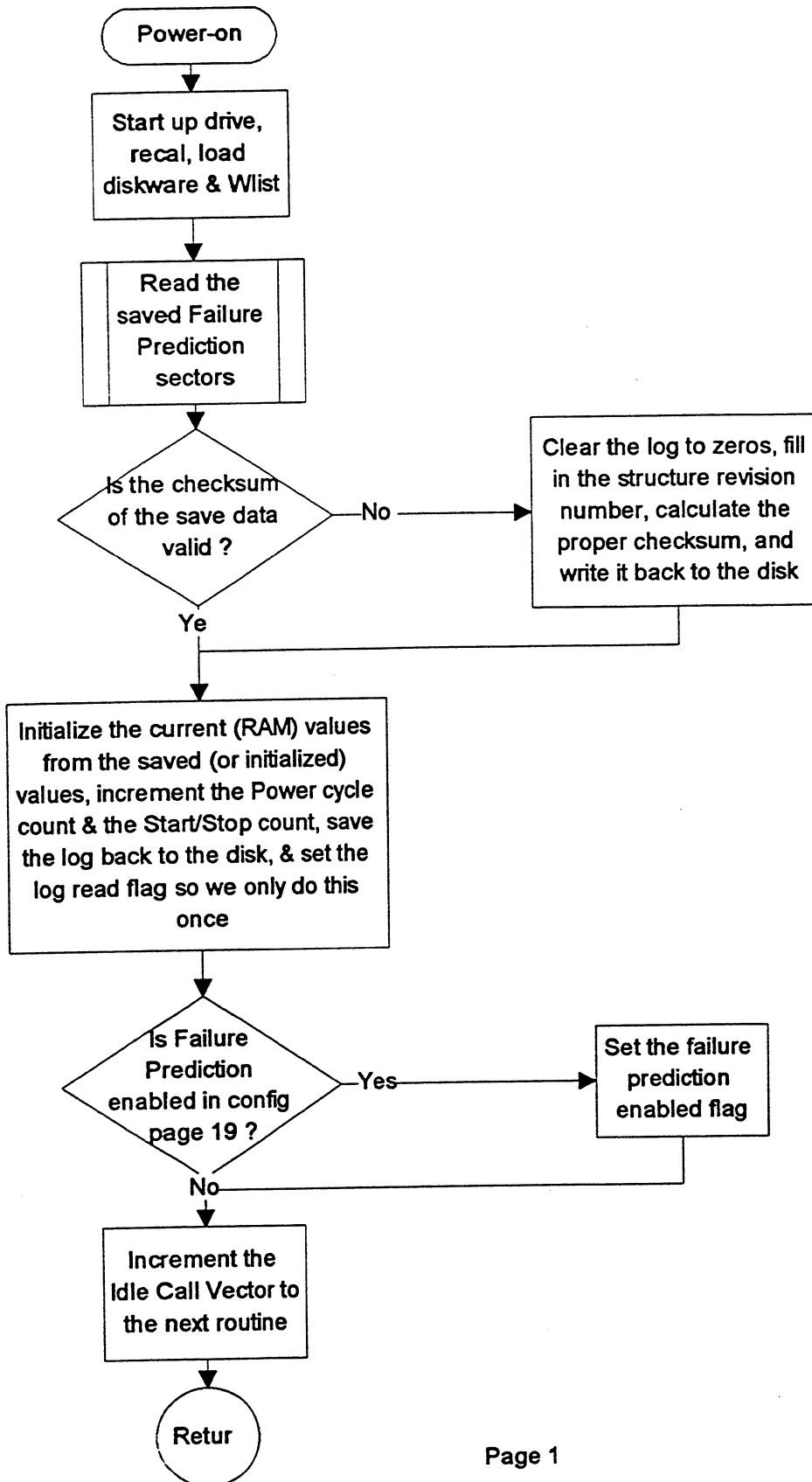


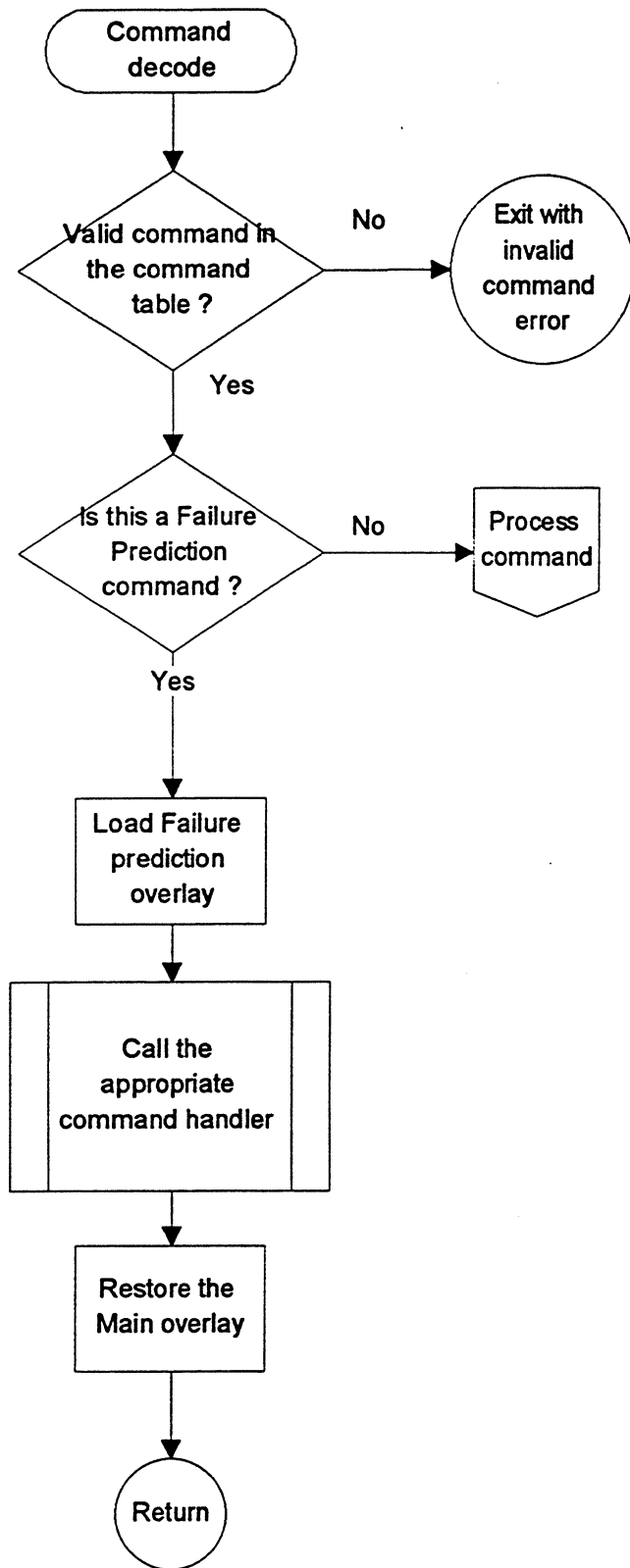
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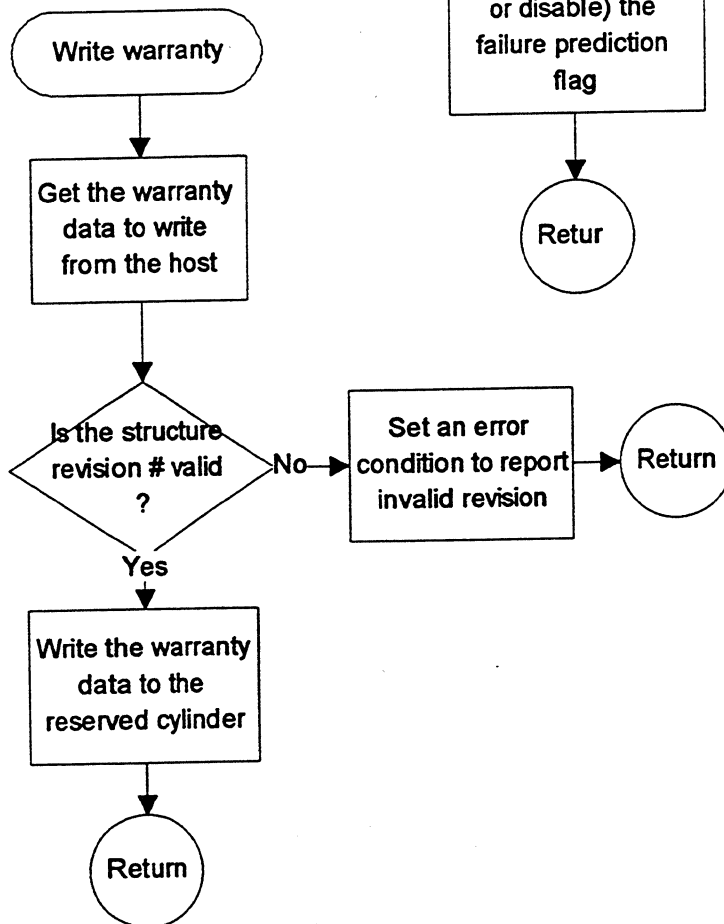
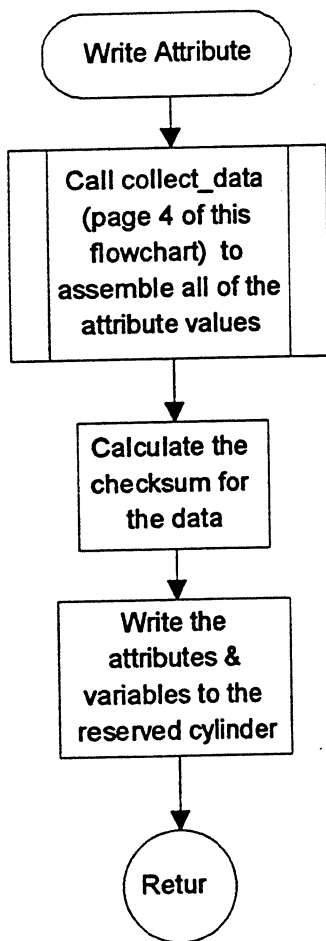
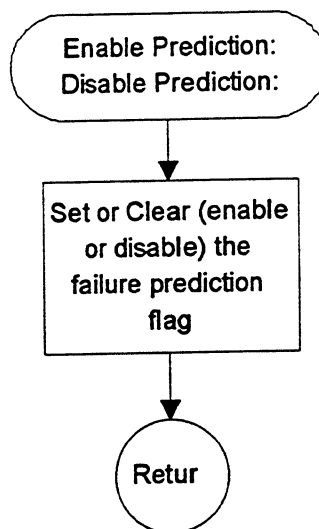
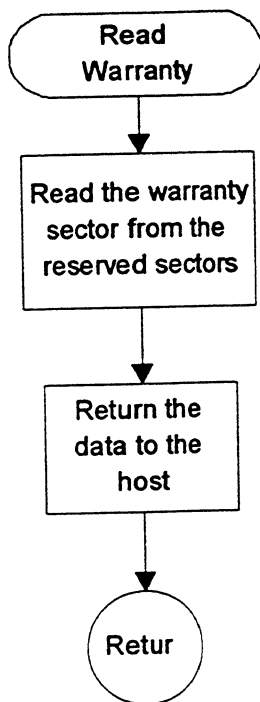
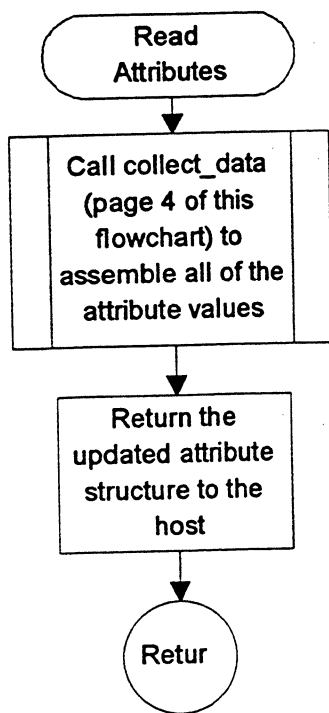


LIGHTNING DRIVE PARAMETERS ANALYSIS

Wednesday, June 8, 1994

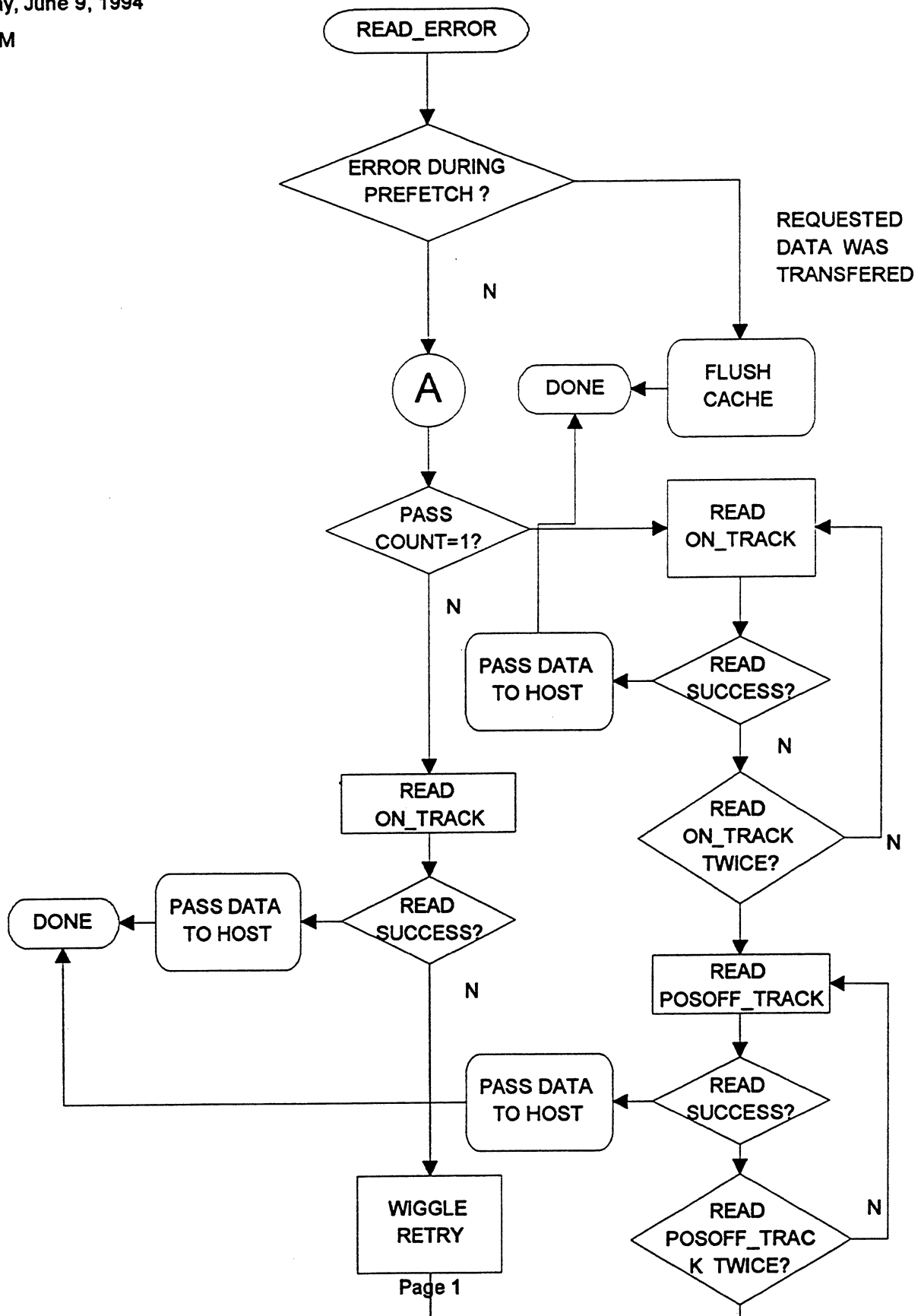


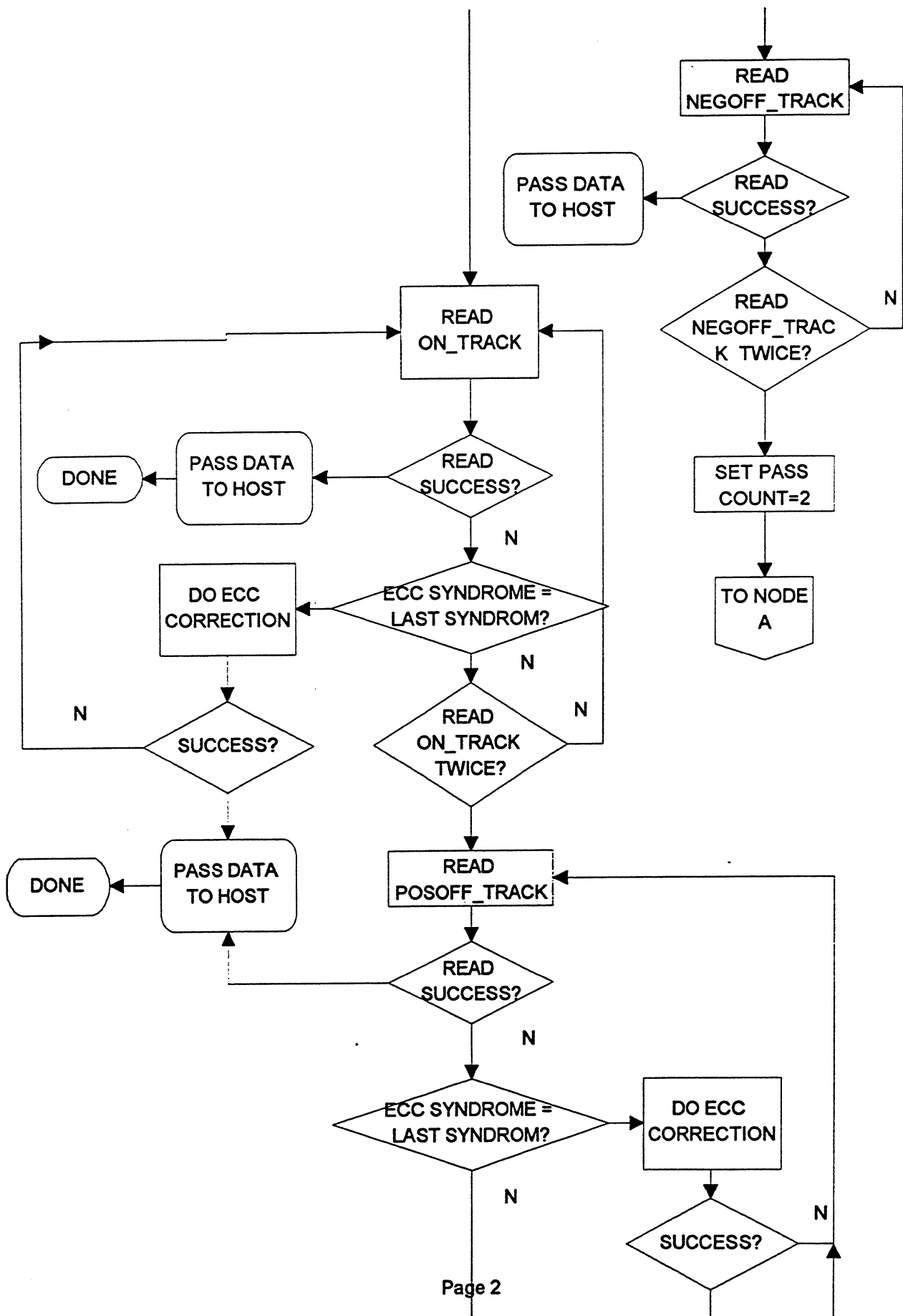


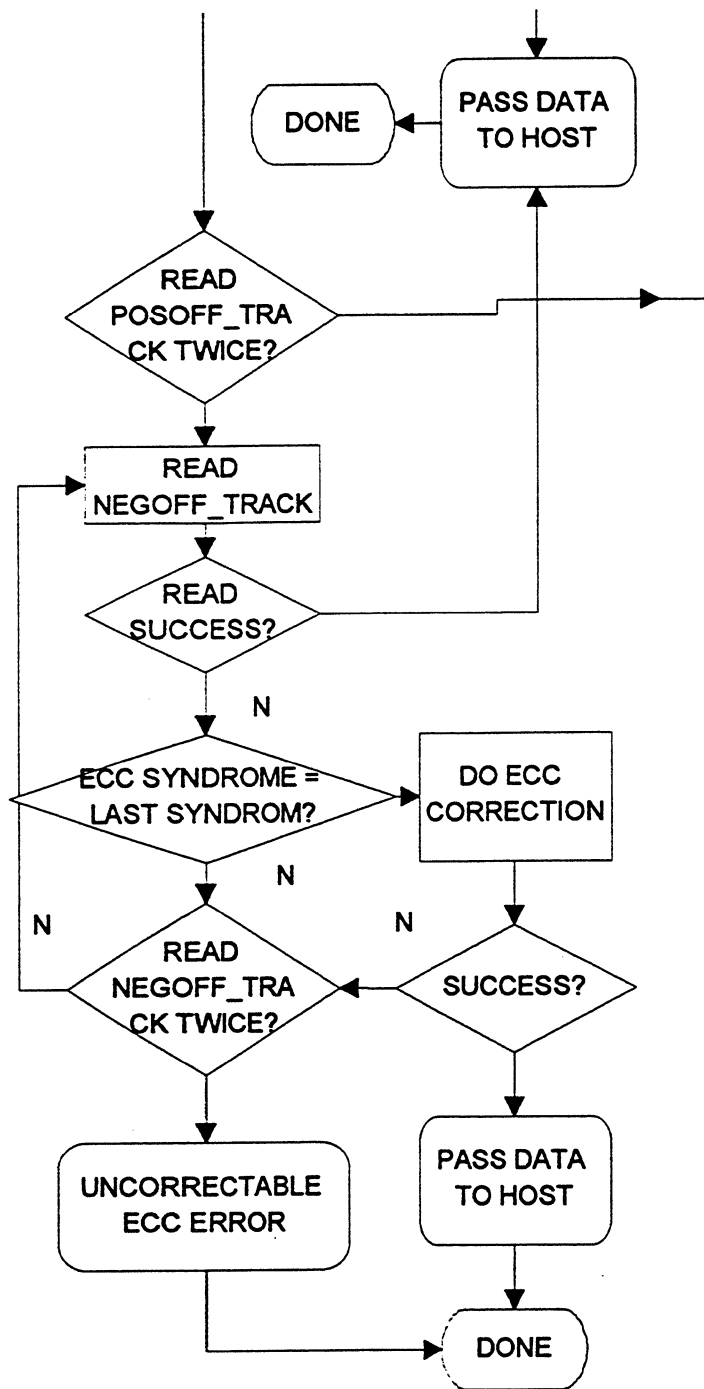


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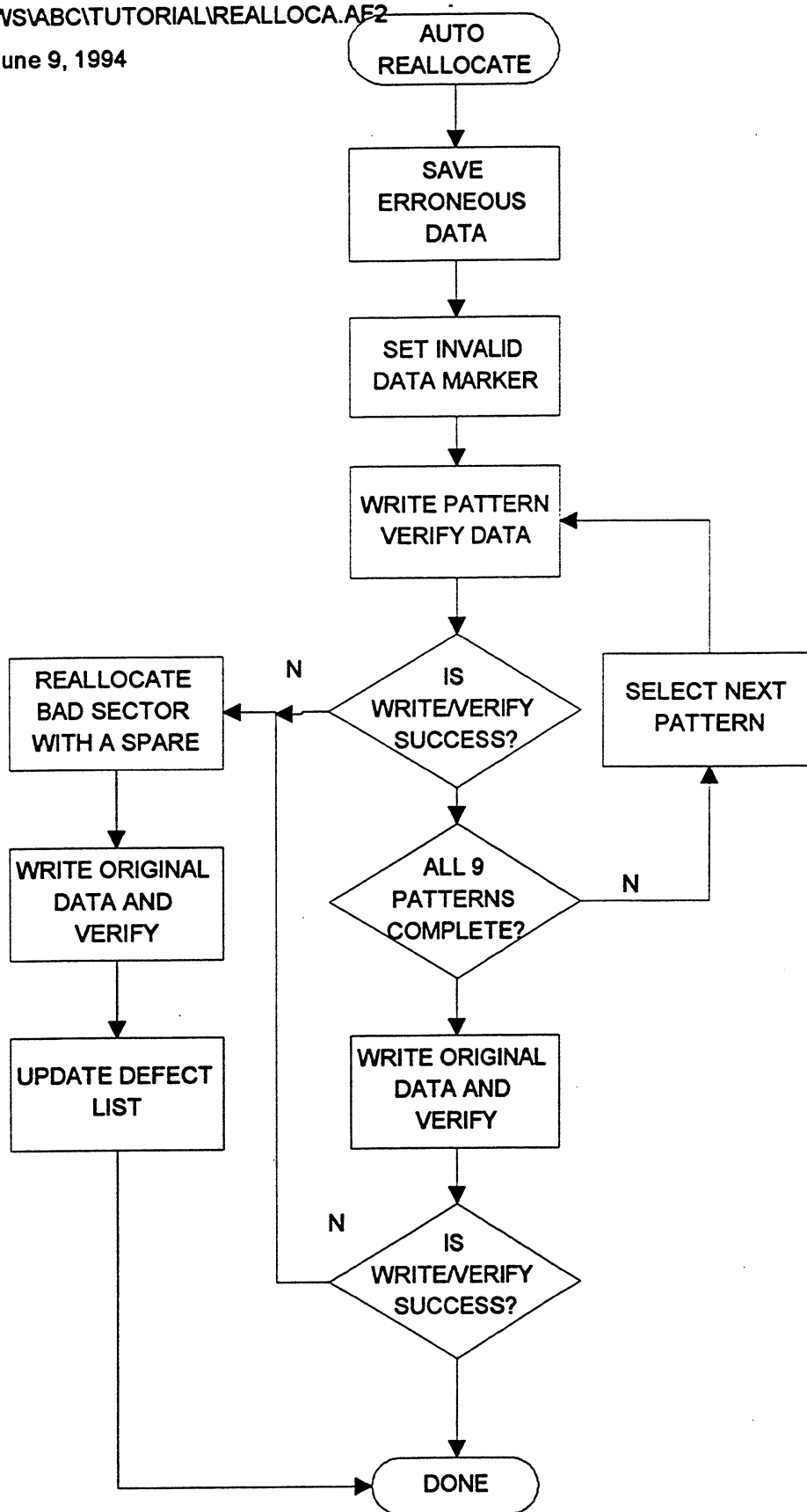
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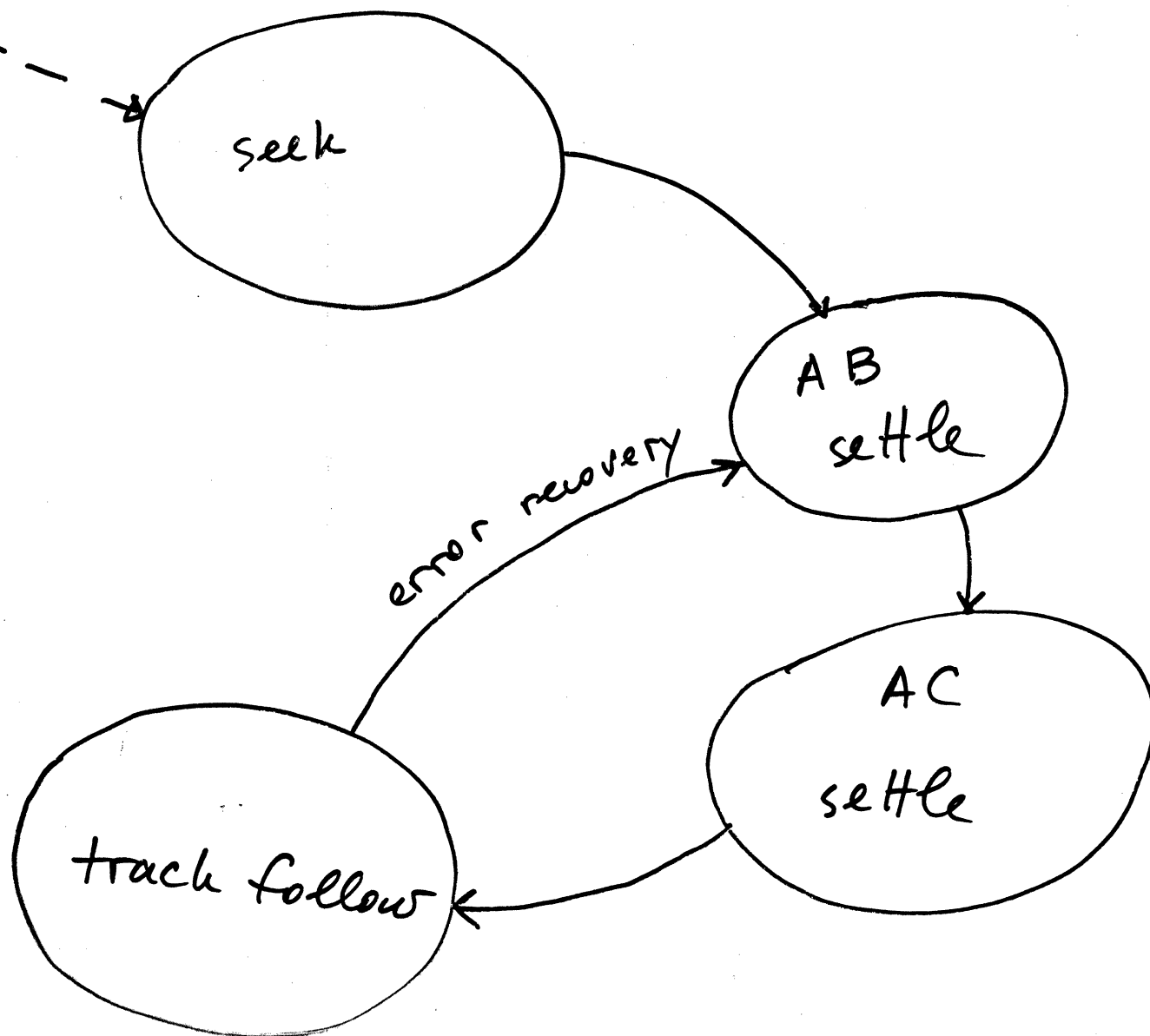
Thursday, June 9, 1994



LIGHTNING POWER UP SEQUENCE

SERVO STATE MACHINE

(seek SETUP)



LIGHTNING POWER UP SEQUENCE

Initialization:

- **Set up vector table at 00h**
- **Initialize SP to top of stack**
- **Set up interrupt priorities**
 - **Spindle Interrupt**
 - **Servo Interrupt**
 - **Timer 0**
 - **Host Reset**
 - **Host Interface**
- **Set up controller ports**

LIGHTNING POWER UP SEQUENCE

Initialization (cont.):

- **Initialize read channel chip power control registers**
- **Initialize idle call vector**
- **Reset sequencer**
- **Initialize sequencer**
- **Initialize cache table**
- **Copy ROM default config pages to RAM**
- **Initialize config parameters**

LIGHTNING POWER UP SEQUENCE

Initialization (cont.):

AT

- **Turn on Command History (if not already disabled)**
- **Initialize all salty parameters**
 - **Wait for POR to deassert**
 - **Read drive select jumper (M/S)**
 - **Set up drive address (Primary/Seconadary)**
 - **Set error register = 1**
 - **Put salty into Auto-Write mode**

LIGHTNING POWER UP SEQUENCE

Spin Up Setup (cont.):

- **Initialize HDA related flags**
- **Clear Up to Speed (not spun up)**
- **Sets Spun Down**
- **Sets Parked**
- **Enable Read-On-Arrival**
- **Enable dithering of VCM on spin up**
- **Set up servo interrupts**

LIGHTNING POWER UP SEQUENCE

Spin Up Setup (cont.):

- **Initialize variables for cold recal**
- **Disable servo interrupts**
- **Turn actuator off (VCM)**
- **Set up notch filter control registers**

LIGHTNING POWER UP SEQUENCE

Spin Up(cont.):

- **Perform buffer RAM test**
- **Test sequencer**
- **Monitor spindle ready**
- **Unpark Actuator**
 - **Start to move VCM toward ID with open loop current**
 - **Find SAMs (data zone) by sequencing through heads (continuing to move toward ID)**
- **Determine number of good heads**

LIGHTNING POWER UP SEQUENCE

Calibration (cont.):

- **Perform Once Around calibration**
- **Perform Fine PES gain calibration**
- **Perform Nulli calibration**
- **Perform V_SCALE adaption**
- **Perform Servo Loop gain calibration**
- **Check if Rezero required**

Lightning Electrical Review



Quantum

Presented to Compaq 6/9/94

LIGHTNING DRIVE

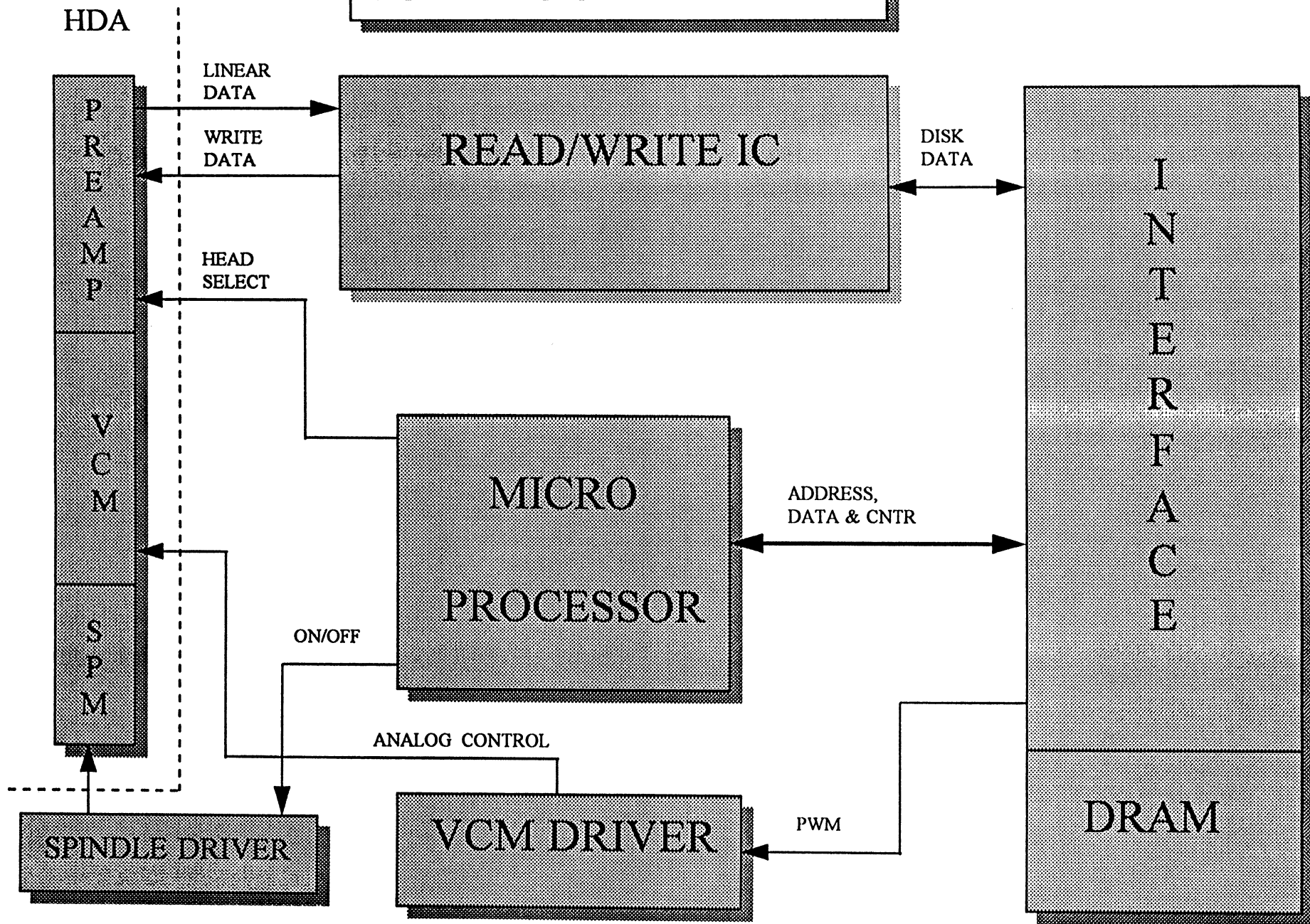
HDA:

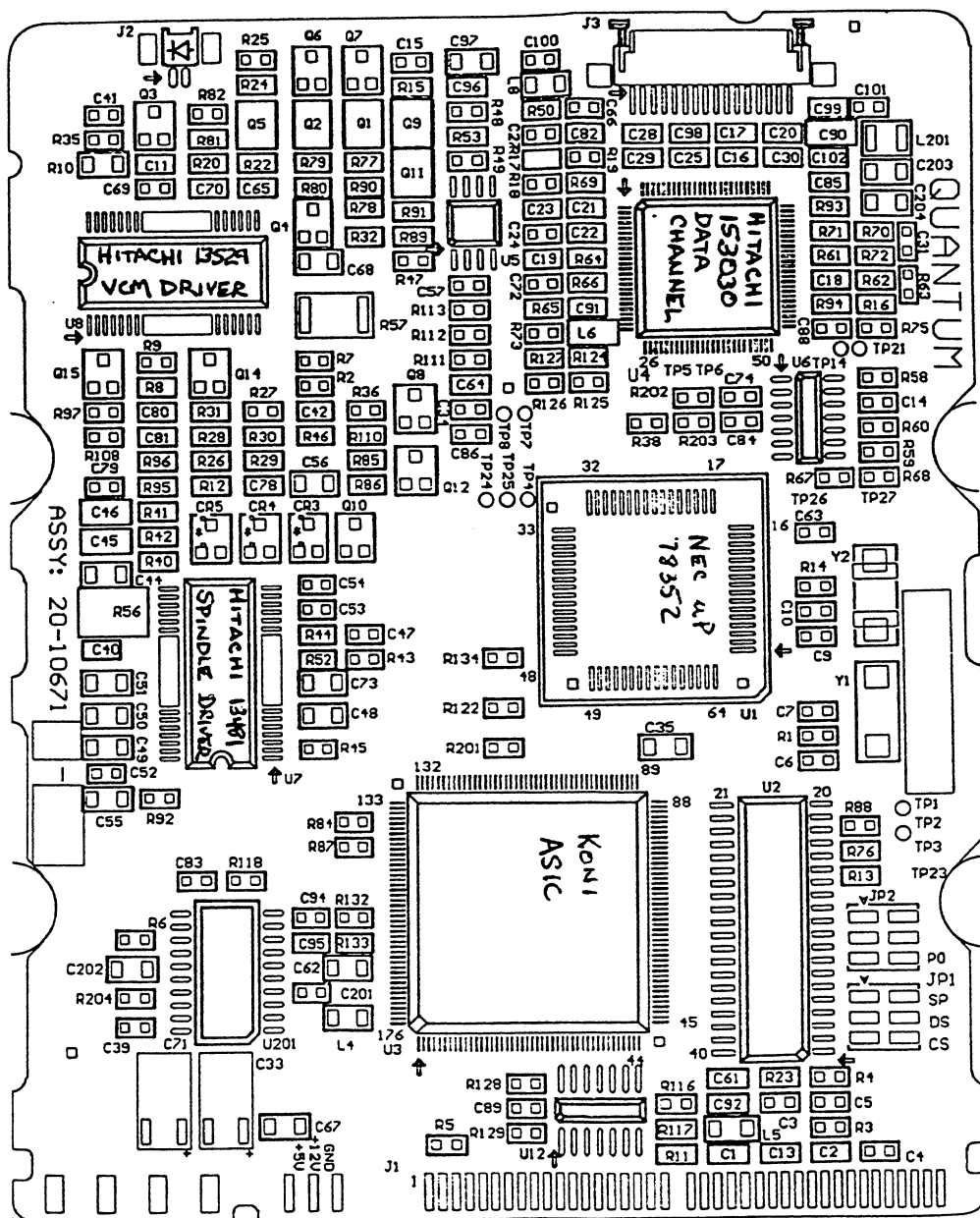
- HEADS
- DISK(S)
- PRE-AMP
- SPINDLE MOTOR
- VOICE COIL MOTOR

PCB:

- MICROPROCESSOR
- INTERFACE IC
- SPINDLE MOTOR DRIVER
- VOICE COIL MOTOR DRIVER
- READ/WRITE CHANNEL IC

PCB BLOCK DIAGRAM





KEY ELECTRICAL COMPONENTS

- MICRO PROCESSOR
- INTERFACE ASIC
- 128K DRAM
- SINGLE CHIP READ/WRITE CHANNEL
- VOICE COIL MOTOR DRIVER
- SPINDLE MOTOR DRIVER
- HEAD PRE-AMP
- LBA MODE ASSIST IC

MICROPROCESSOR

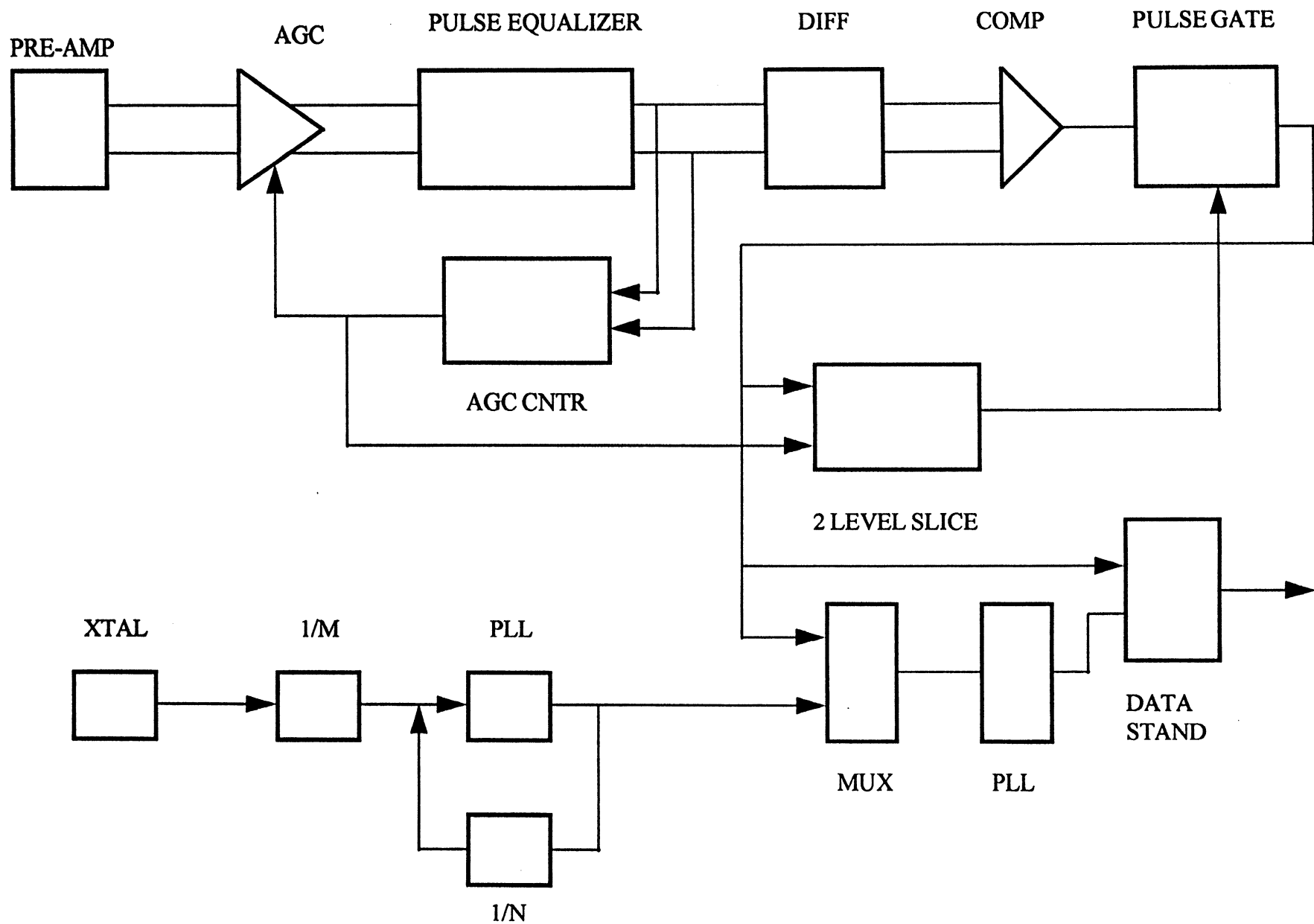
- 16 BIT, 32 MHz NEC 78352
- 32K BYTES MASK ROM
- 32 K BYTES FROM BUFFER

KONI INTERFACE ASIC

- SERVO LOGIC & ADC
- READ/WRITE SUPPORT
- 20 MB/S, 16 BIT DRAM CONTROLLER
- 13 MB/S ATA OR 10 MB/S SCSI INTERFACE

READ CHANNEL

- HITACHI HD 153030RF - 50 Mb/S
- AGC
- FILTER
- PLL & READ PULSE GENERATOR
- WRITE CLOCK GENERATOR
- WRITE PRE-COMP
- SERVO BURST SAMPLE AND HOLD



READ CHANNEL IC

3.2 Track Format

Wedge (70 per Revolution)

Wedge (70- x's per rev)

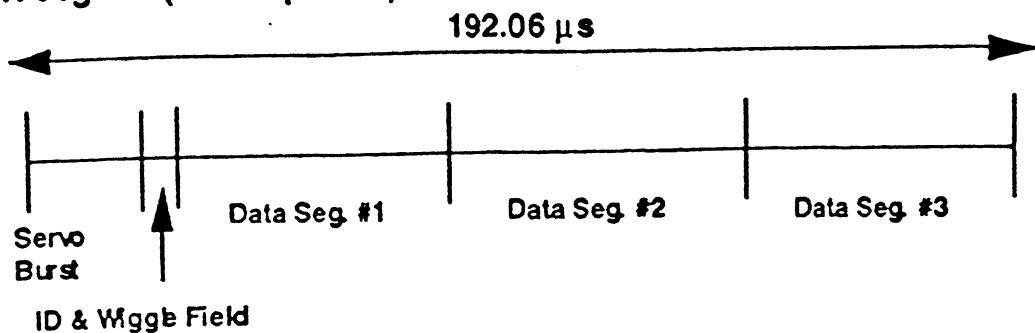


Figure 3-1. Track Wedge Format.

Servo Burst (12.40 μ s)

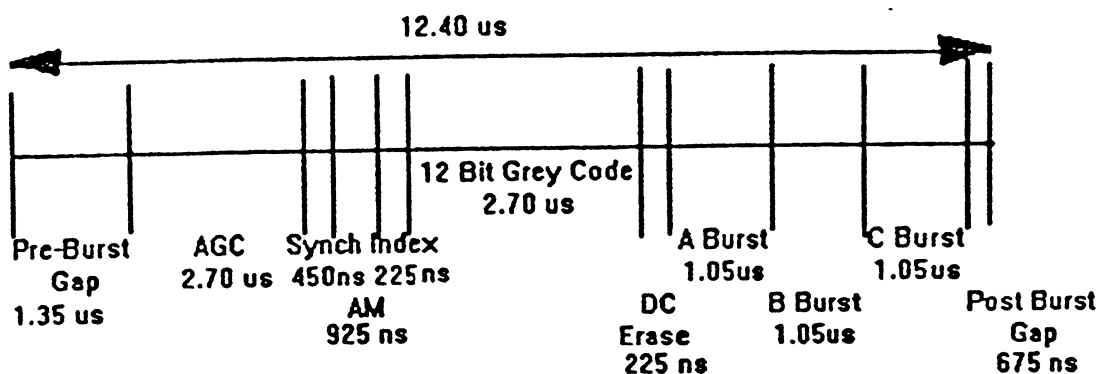


Figure 3-2. Servo Burst Format.

ID Field (26 Bytes)

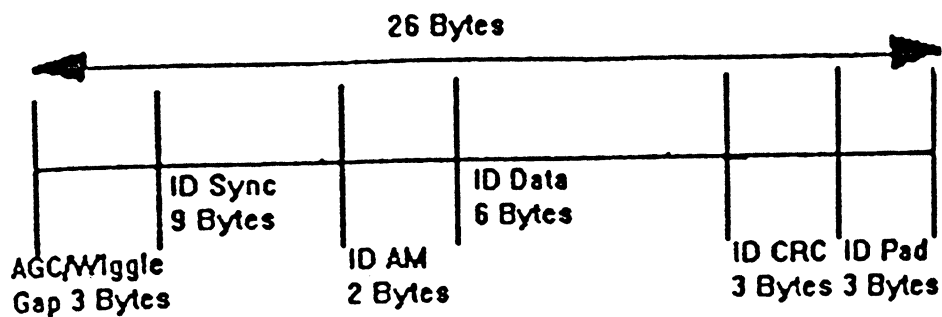


Figure 3-3. ID & Wiggle Field Format.

Data Segment (546 Bytes)

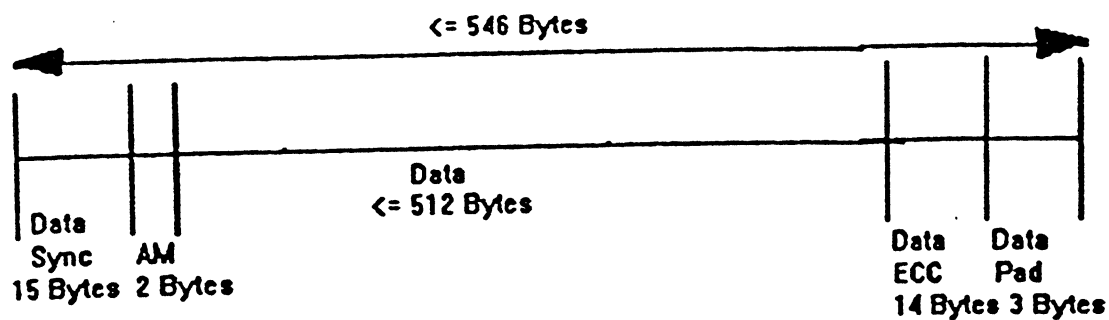


Figure 3-4. Data Segment Format.

Zone Bit Recording

- Number of zones: 16

- RLL 1,7 code

- Recording frequency:	Thunderbolt	Lightning
-------------------------------	--------------------	------------------

Highest Data Rate:	46.20 Mb/S	47.2 Mb/S
---------------------------	-------------------	------------------

Lowest Data Rate:	23.33 Mb/S	24.73 Mb/S
--------------------------	-------------------	-------------------

- Track Per Inch (TPI):	2875	3794
--------------------------------	-------------	-------------

LPS-732 Track Layout --- 2 disk Lightning

16 zones - ID after Wedge

Last Rev: 2/15/93

Req Cap	732.0003 Mil Bytes
Spare	2 per cyl
Surfaces	4
Rod	1.7992 "
Rid	0.8310 "
Stroke	0.9682 "
RPM	4501.80 rpm
Trot	13328.000 uSec
Frot	75.0300 Hz
TPI	3794
Tot. tracks	3673
Trks/zone	
max. FCI	47636
% of req.	100.36%
Total Cap	734.6278 Mil bytes
User sector	1434820

	Bytes	uSec
ID Sync	9	
ID AM	2	
ID Data	6	
ID CRC	3	
ID Pad	3	
Total	23	
Data bytes	512	
Data Sync	15	
Data AM	2	
Data ECC	14	
Data Pad	3	
Tot. bytes	546	
Split ovhd	20	
AGC/Wlg	3	0.97
		max.

Srv Fq	40 MHz	
Srv Clk	25 nSec	
Srv T	2.025 uSec	(Pre & Post gaps)
Srv N	415 Clocks	(Total of fields other than gaps)
Nservos	70 samples	
Tservo	12.4 uSec	(includes pre & post gaps)
Tdata	178.000 uSec	
Servo sample freq =	5252.1 Hz	Srv OH 6.51%
Wedge-to-Wedge time =	190.400 μs	Fmt OH 10.02%

Pre & Po	AGC	Servo		Gray cod	DC	Bursts
Gaps	Time	Sync	SAM	Index	Erase	(each)
μs	2.025	2.7	0.45	0.925	0.225	1.05
Clks	81	108	18	37	9	42
Total Sevo Burst length = 12.400 μs = 496 T						

Zone	Zone Rod	Zone Rid	Cyls	Max. FC/in.	Data Rat [Mb/s]	Fclk [MHz]	Fmax [MHz]	Twindo [nS]	ID time [μs]	Sect. time [μs]	Sect/burs w/o split	Time left [μs]	Preamble & AM [μs]	plit Sec	Total Sect (incl. spares)	Zone Cap per surface
OD		1.7992														
System	1.7992	1.7952	15	32915	37.14	55.7	13.9	8.97	4.95	117.60	1	54.800	4.31	30	100	764160
1	1.7952	1.6687	480	45035	47.24	70.9	17.7	7.06	3.90	92.47	1	81.129	3.39	58	128	31334400
2	1.6687	1.5986	266	45601	45.82	68.7	17.2	7.27	4.02	95.33	1	78.134	3.49	54	124	16819712
3	1.5986	1.5306	258	45931	44.19	66.3	16.6	7.54	4.16	98.84	1	74.448	3.62	50	120	15785472
4	1.5306	1.4708	227	45501	42.07	63.1	15.8	7.92	4.37	103.84	1	69.218	3.80	44	114	13191424
5	1.4708	1.4065	244	45676	40.38	60.6	15.1	8.25	4.56	108.17	1	64.679	3.96	39	109	13554688
6	1.4065	1.3543	198	45646	38.86	58.3	14.6	8.58	4.74	112.41	1	60.235	4.12	34	104	10492416
7	1.3543	1.2918	237	45329	36.81	55.2	13.8	9.06	5.00	118.67	1	53.678	4.35	29	99	11952384
8	1.2918	1.2259	250	45138	34.78	52.2	13.0	9.58	5.29	125.58	1	46.440	4.60	23	93	11840000
9	1.2259	1.1690	216	45623	33.52	50.3	12.6	9.94	5.49	130.30	1	41.500	4.77	19	89	9787392
10	1.1690	1.1071	235	45986	32.00	48.0	12.0	10.42	5.75	136.50	1	35.000	5.00	15	85	10167040
11	1.1071	1.0356	271	46817	30.48	45.7	11.4	10.94	6.04	143.33	1	27.850	5.25	11	81	11169536
12	1.0356	0.9726	239	46690	28.54	42.8	10.7	11.68	6.45	153.02	1	17.689	5.61	5	75	9116416
13	0.9726	0.9189	204	46821	27.04	40.6	10.1	12.33	6.80	161.53	1	8.783	5.92	1	71	7363584
14	0.9189	0.8530	250	47636	25.54	38.3	9.6	13.05	7.20	171.03	0	169.856	6.26	66	66	8384000
15	0.8530	0.8311	83	47347	24.73	37.1	9.3	13.48	7.44	176.60	0	169.591	6.47	64	64	2698496
ID	0.8310															

[LPS730.XLW]LPS-732 Track Layout

6/3/94

Total cap = 734.628
% of goal 100.36%

Bytes/surface = 183656960
Bytes/disk = 367313920

R.K. Scott

Zone Boundaries

Zone Track Numbers		
Zone	Start	End
System	-15	-1
1	0	479
2	480	745
3	746	1003
4	1004	1230
5	1231	1474
6	1475	1672
7	1673	1909
8	1910	2159
9	2160	2375
10	2376	2610
11	2611	2881
12	2882	3120
13	3121	3324
14	3325	3574
15	3575	3657

Actual Sectors/Track

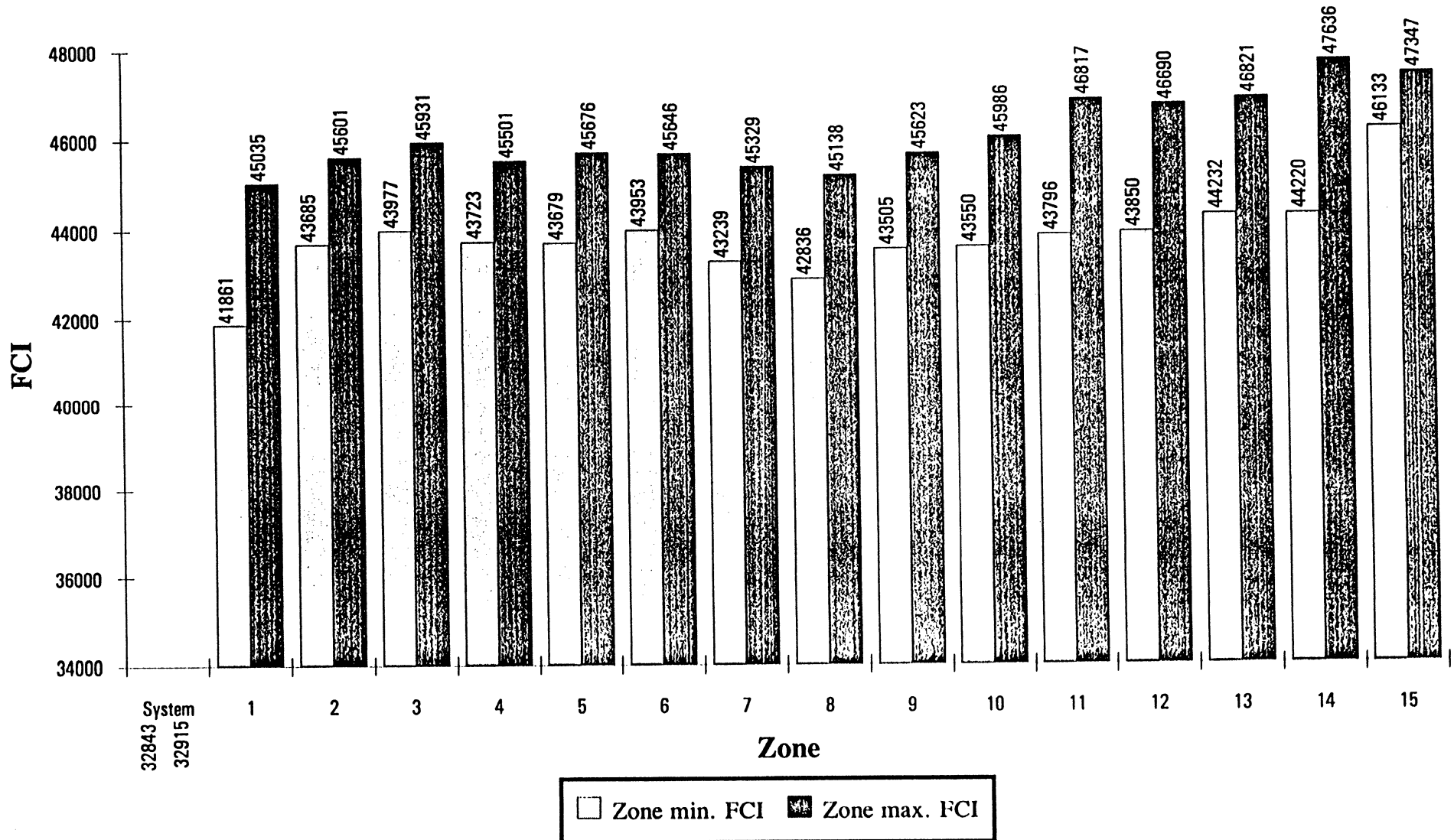
Total Sect (incl. spares)	Zone Cap per surface
100	764160
128	31334400
124	16819712
119	15653376
113	13075200
108	13429760
105	10593792
98	11831040
93	11840000
89	9787392
85	10167040
80	11030784
75	9116416
70	7259136
66	8384000
64	2698496

Total cap = 732.082
% of goal 100.01%

Bytes/surface = 183020544
Bytes/disk = 366041088

LIGHTNING 732

FCI vs. Zone

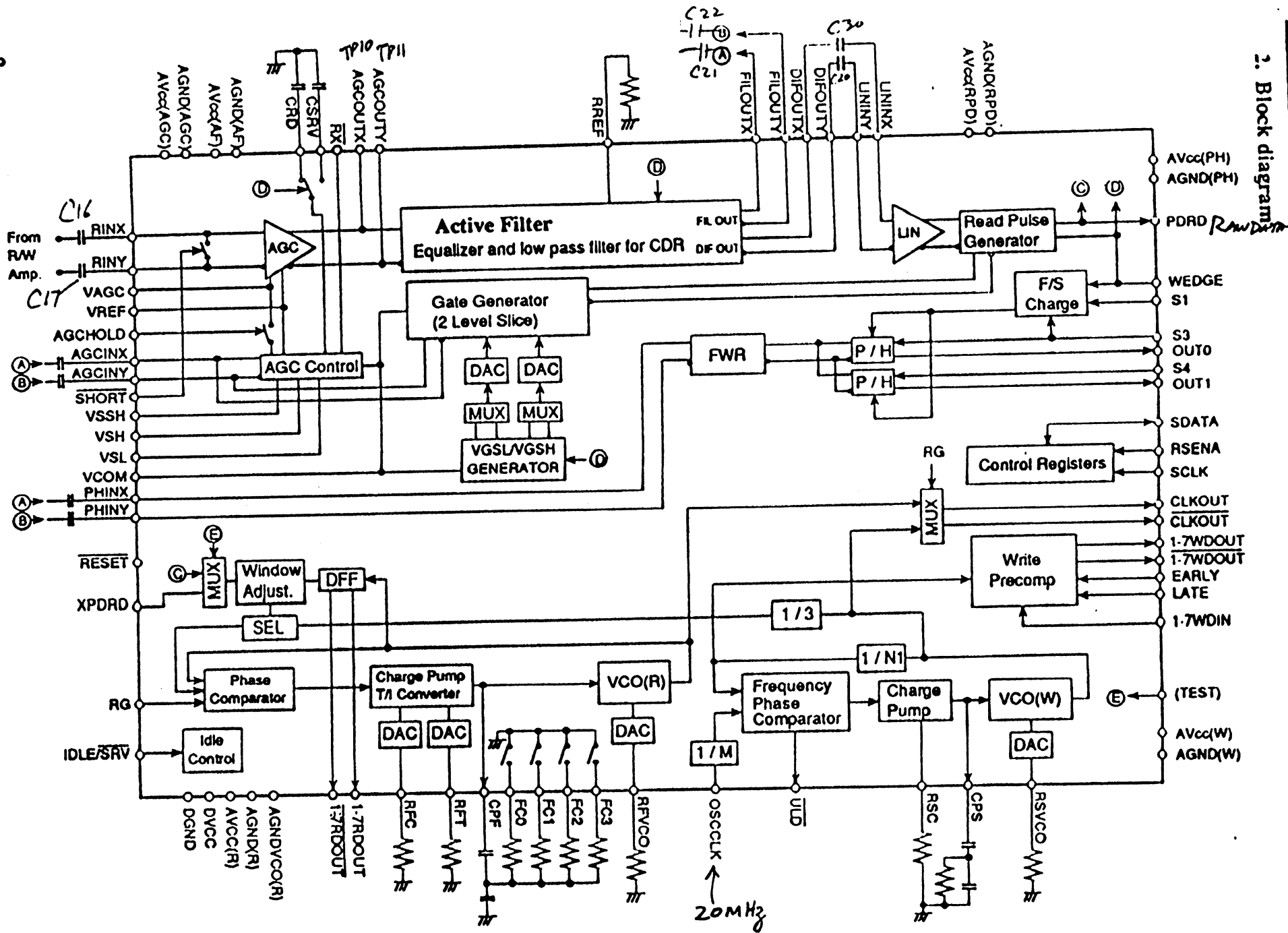


Head /media

- * Thin film head.
- * 42 turns min.
- * PW50 < 60nS.
- * Coercivity 1600+/-50 Oe.
- * Flying Height 3.0uIN

	Thunderbolt	Lightning
* Primary Pole width:	6.5um	5.0um
* Max FCI:	45906	47347

2. Block diagram



HITACHI R/W CHANNEL CHIP

VOICE COIL DRIVER

- HITACHI HA13529F
- 1.2A OUTPUTS
- INTEGRATED OP AMPS

SPINDLE MOTOR DRIVER

- BACK EMF POSITION SENSING
- AUTO COMMUTATION
- SELF STARTING
- 2 AMP OUTPUT

READ/WRITE PRE-AMP

- VTC VM7100C
- 2 OR 4 CHANNEL PARTS
- 3 mW SLEEP MODE
- WRITE CURRENT DISABLE

LBA MODE ASSIST

- DETECTS COMMAND MODE CHANGES

READ/WRITE CHANNEL

- HEADS & MEDIA
- FORMAT
- ELECTRONICS
- ADAPTIVE

HEADS & MEDIA

- AREAL DENSITY INCREASED WITH
 1. 2 % INCREASE IN FCI
 2. 32 % INCREASE IN TPI
- MEDIA UNCHANGED AT 1600 Oe
- HEADS:
 1. CHANGED TO 50 % SLIDER
 2. 42 TURNS
 3. 3 uIN FLYING HEIGHT
 4. 60 PW50

TRACK FORMAT

- ID AFTER EACH OF 70 SERVO WEDGES PER TRACK
- 16 ZONES - 1.9:1 DATA RATE RATIO

Lightning Servo Topics

- **Lightning / Thunderbolt Comparison**
 - Commonalities
 - Differences
- **Servo - Mechanical System**
- **PCB**
- **Servo Burst Format**
- **Loop Diagrams**
- **TMR**
- **Seek Performance**

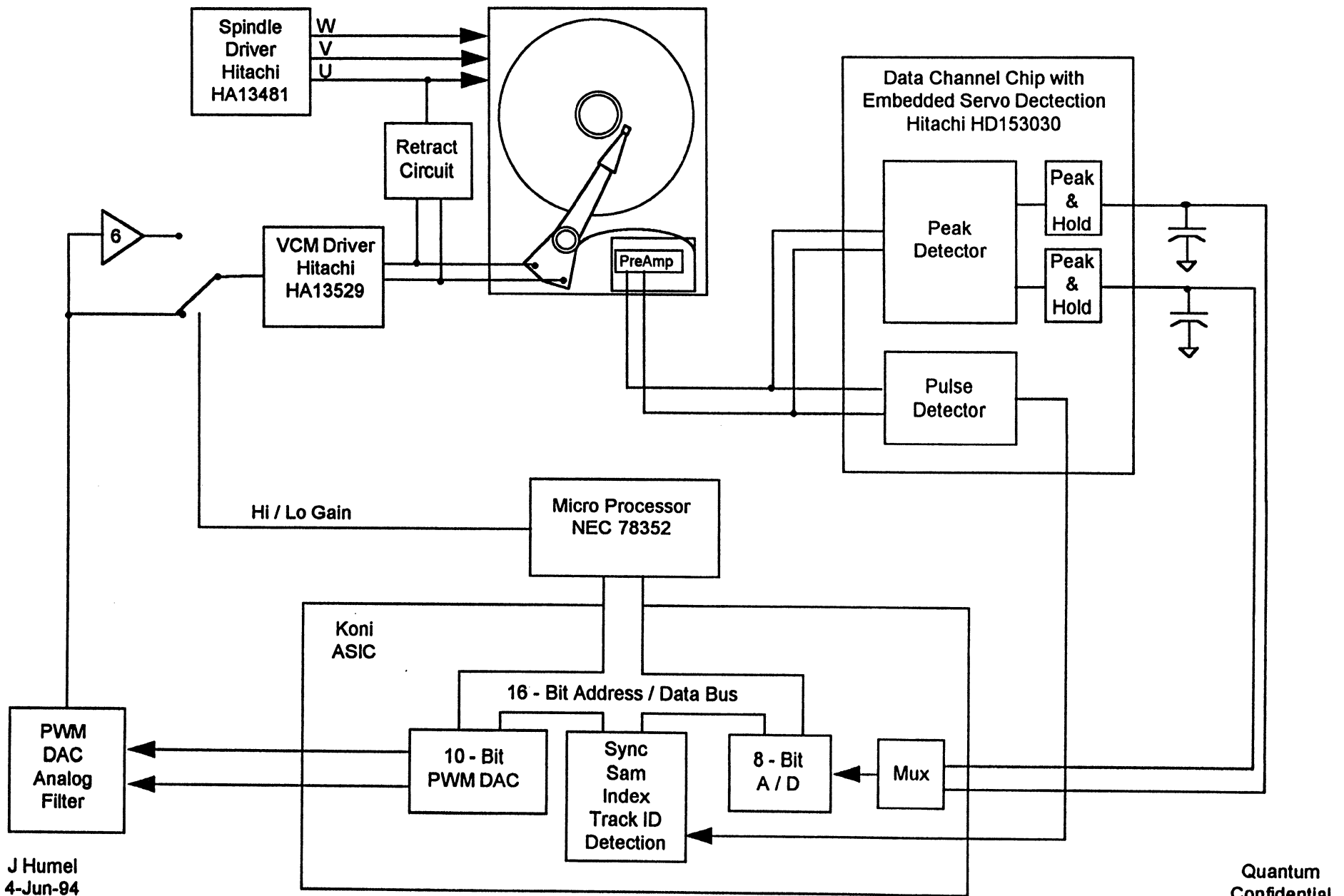
Lightning/Thunderbolt Commonalities

- **Embedded Sektored Digital Servo**
- **70 Servo Sectors (Wedges)**
- **4500 RPM**
- **5.25 KHz Sample Rate**
- **8 Bit A/D**
- **10 Bit PWM D/A**
- **Digital Notch Filter at 2 x 5.25 KHz**

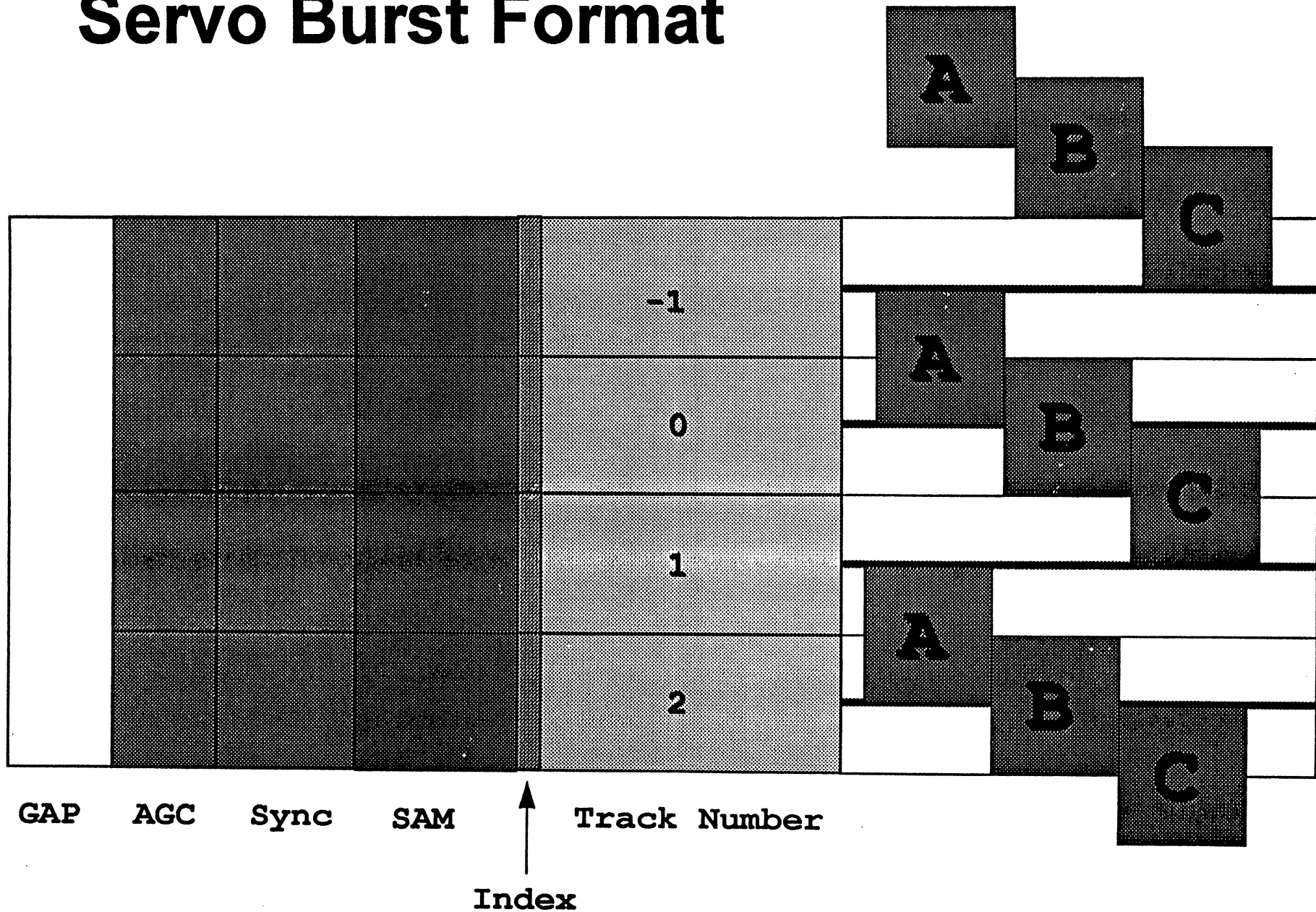
Lightning / (Thunderbolt) Differences

- **3794 / (2875) Tracks per Inch**
- **3658 / (2740) User Data Cylinders**
- **365 / (270) MB per 1 Disk**
- **730 / (540) MB per 2 Disks**
- **6x / (4x) VCM Gain Switch**
- **Gain changes per 3794 TPI**

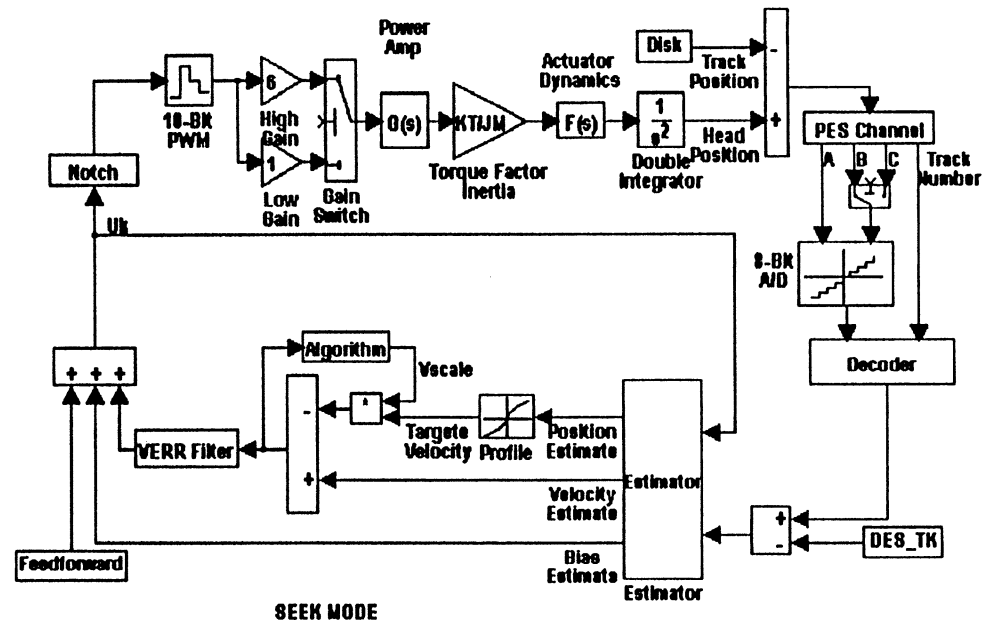
Servo - Mechanical System



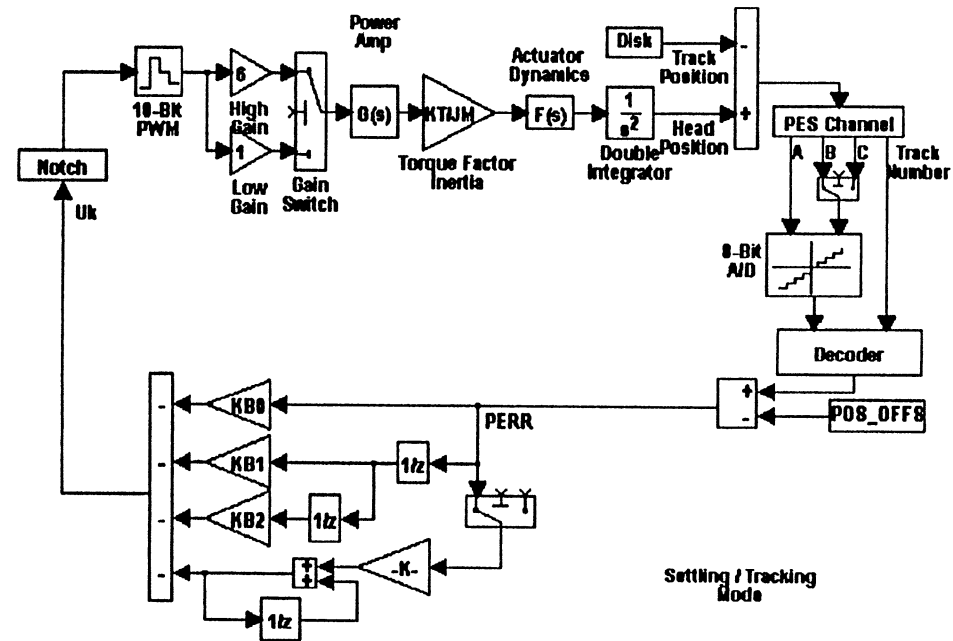
Servo Burst Format

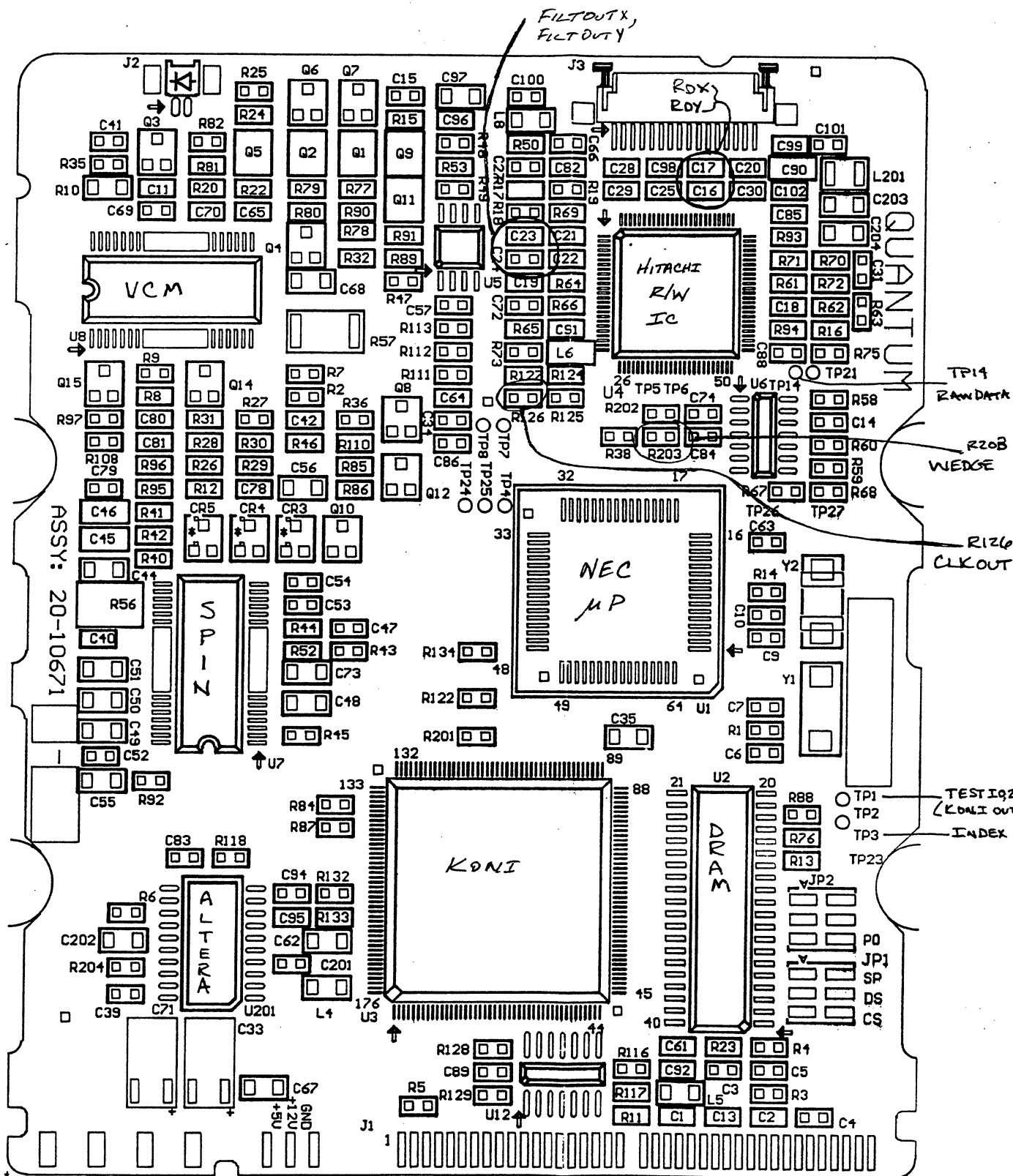


Lightning Seek Diagram

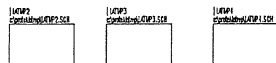


Lightning Tracking Diagram





LIGHTNING 366/732 AT

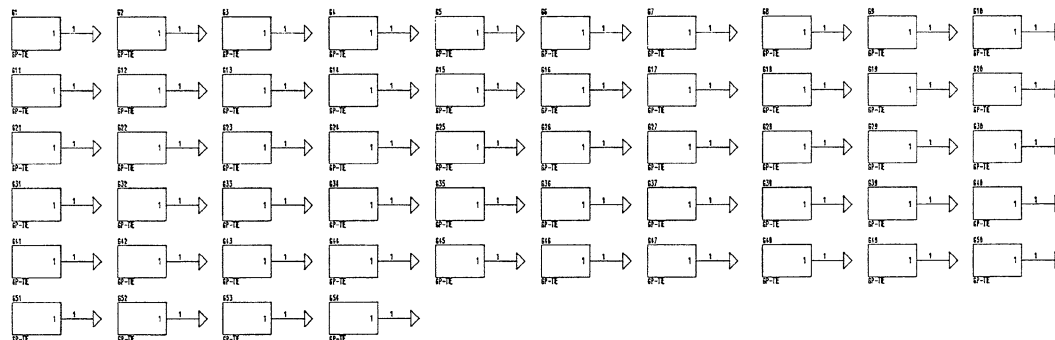
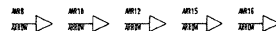
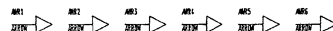
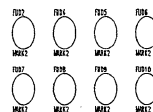


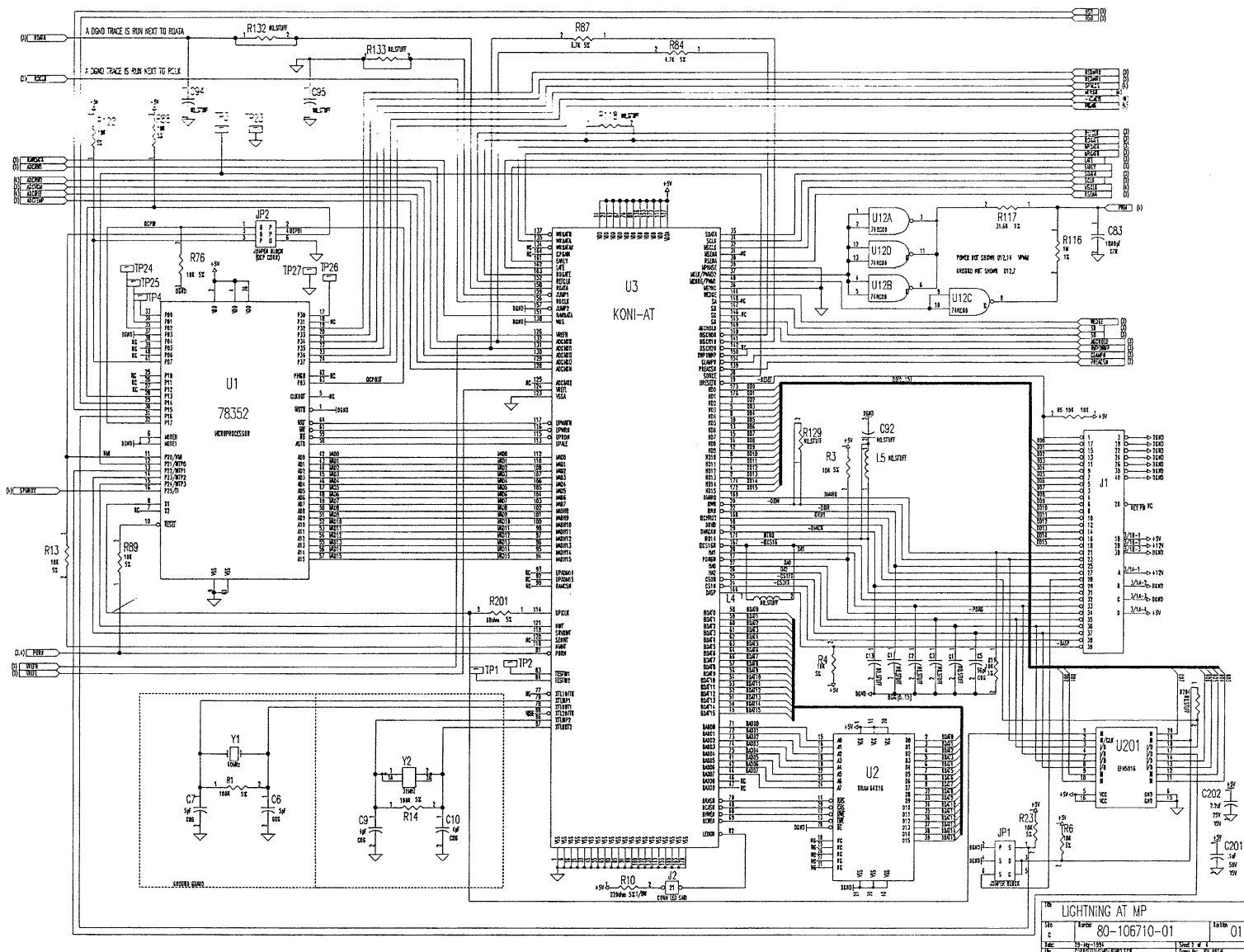
1. LUMP2
2. LUMP3
3. LUMP4

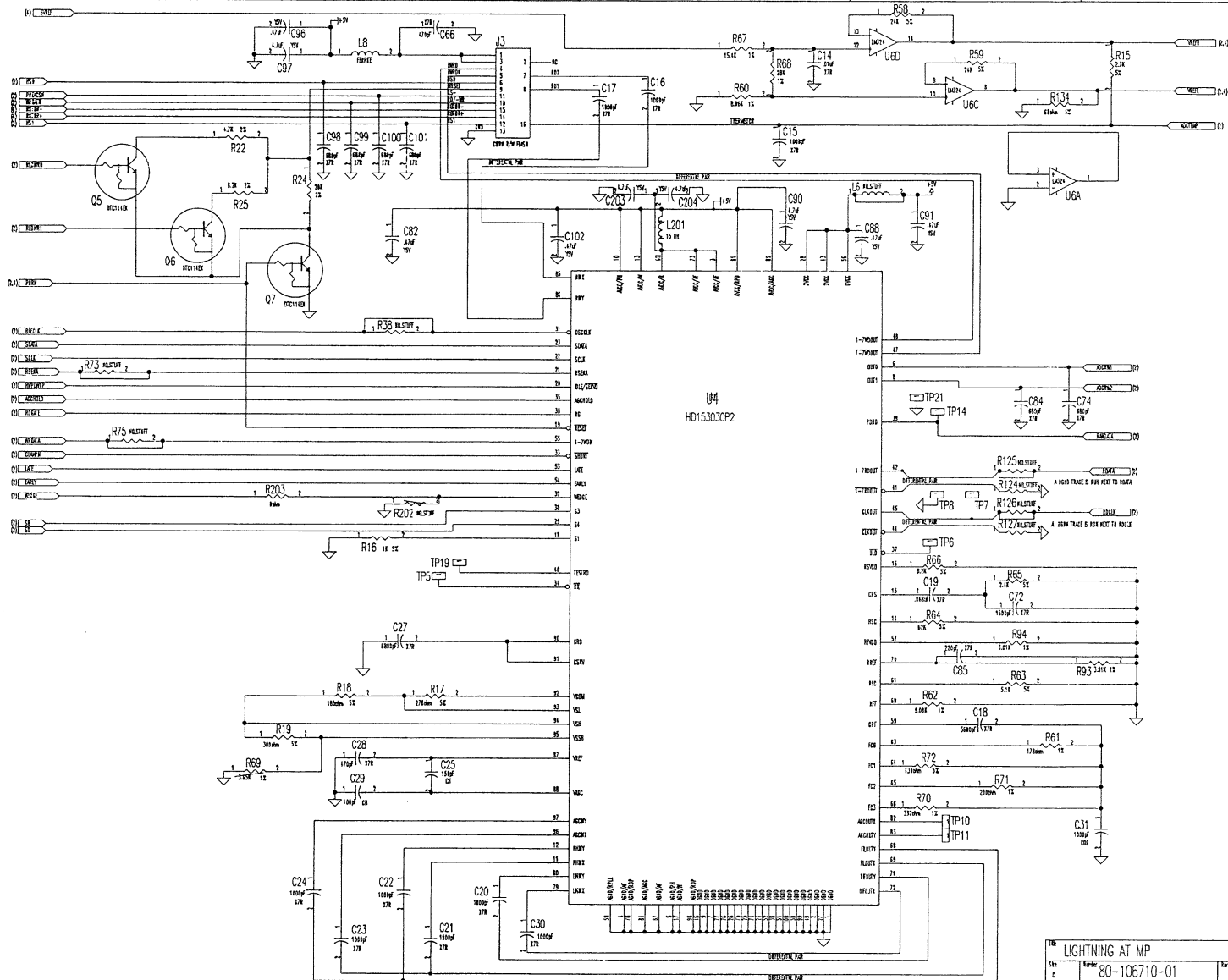
1. LUMP2
2. LUMP3
3. LUMP4

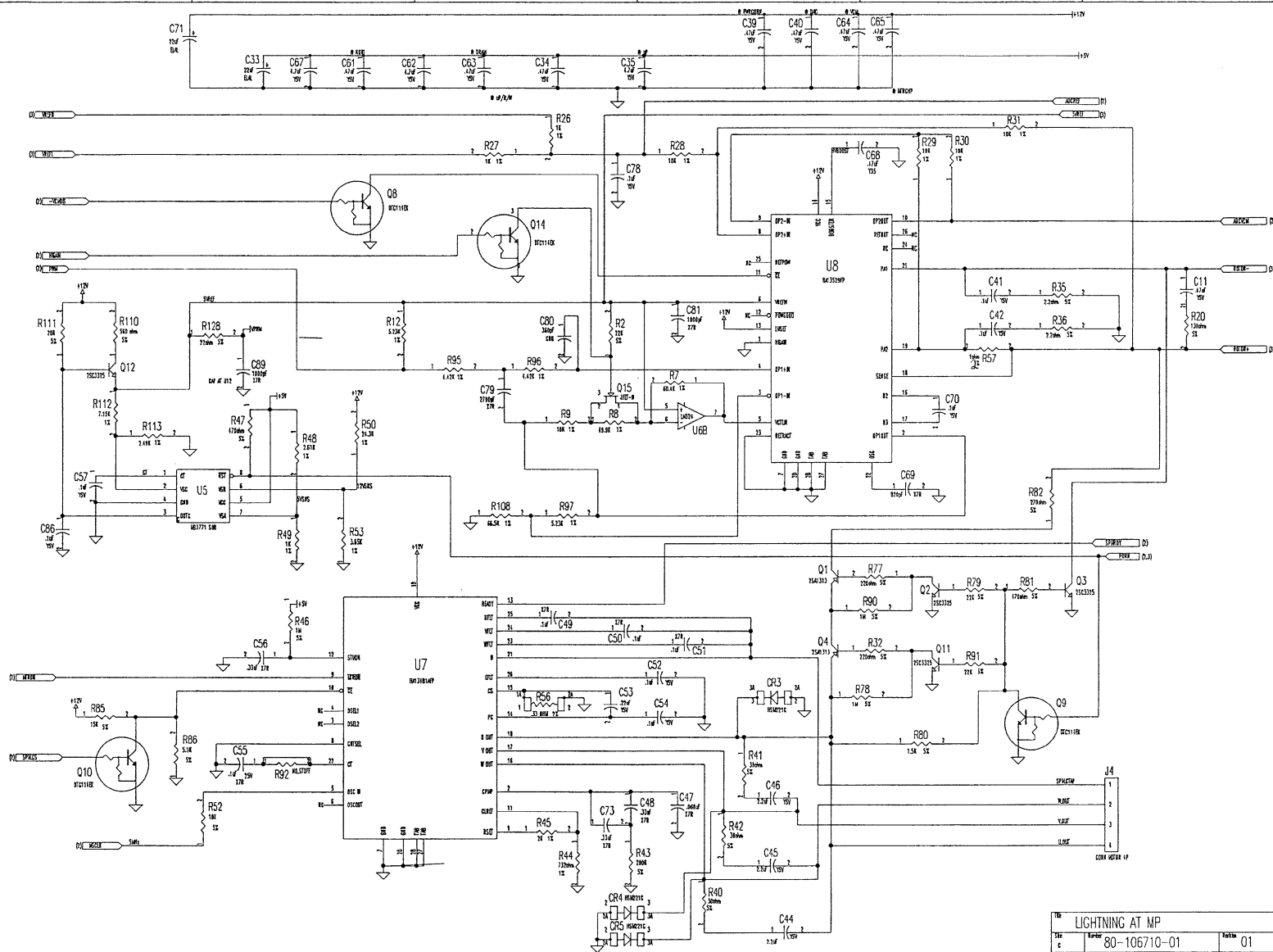
1. LUMP2
2. LUMP3
3. LUMP4

PRELIMINARY









Lightning Mechanical Review



Quantum

Presented to Compaq 6/9/94

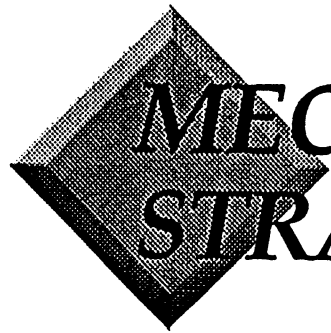


MECHANICAL DESIGN OVERVIEW

- ❖ **Design Strategy**
- ❖ **Changes from Thunderbolt**
- ❖ **Design Maturity**

LIGHTNING MECHANICAL REVIEW FOR COMPAQ

**6/9/94
D. Basehore**



MECHANICAL DESIGN STRATEGY

❖ Evolution not Revolution

- Minimum Changes for Minimizing Risk**
 - ◆ Evolve from a proven platform**
 - ◆ Change only those items needed for higher TPI and Improved Manufacturability**
- Assuring Quick Time to Market**
 - ◆ Substantial MKE Robots/Tooling in Place**
 - ◆ Beat the competition to market**

LIGHTNING MECHANICAL REVIEW FOR COMPAQ

**6/9/94
D. Basehore**



MECHANICAL DESIGN STRATEGY

❖ Work Closely with Mfg Partner MKE

- Maximize Yields

- ◆ Rotor Test Fixture in Place**
- ◆ Assures Quality of Rotor Molding/ Coil Winding**
- ◆ Enables Mechanical Resonance Control**

- Minimize Cost

- ◆ Spindle Bearing Seals Modified**
- ◆ Spindle Motor Hub and Stator Processing Changed**
- ◆ Cover Plating Process Modified**
- ◆ Push Rod Servowriter on Three Shifts**
- ◆ One Piece VCM Magnets**

LIGHTNING MECHANICAL REVIEW FOR COMPAQ

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KEY MECHANICAL SPECIFICATIONS

<u>PARAMETER</u>	<u>THUNDERBOLT</u>	<u>LIGHTNING</u>
Access Time (ms)	12.0	11.0 ****
RPM	4500	4500
Vibration:		
Non Operating	2.0 G P-P (5-500 Hz.)	2.0 G P-P (5-500 Hz.)
Operating	1.0 G P-P (5-300 Hz.) .5 G P-P (300-500 Hz.)	1.0 G P-P (5-300 Hz.) .5 G P-P (300-500 Hz.)
Shock:		
Non Operating	60 G, 11 ms	70 G, 11 ms ****
Operating	6.0 G, 11 ms (no soft err) 10 G, 11 ms (no hard err) 18 G, 3 ms (no hard err)	6.0 G, 11 ms (no soft err) 10 G, 11 ms (no harderr) 18 G, 3 ms (no hard err)

LIGHTNING MECHANICAL REVIEW FOR COMPAQ

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KEY MECHANICAL SPECIFICATIONS

ACOUSTICS

THUNDERBOLT

LIGHTNING

Sound Pressure:

(Distance = 1 Meter)

Idle (Avg./Max.)

33 dBA / 36 dBA

33 dBA / 36 dBA

Seeking (Avg./Max.)

— —

40 dBA / 45 dBA

Sound Power:

Idle (Avg./Max.)

40 dBA / 42 dBA

40 dBA / 42 dBA

Seeking (Avg./Max.)

— —

48 dBA / 50 dBA

Note : On Lightning the Max. Condition is Defined as the Mean + 3 Sigma

LIGHTNING MECHANICAL REVIEW FOR COMPAQ

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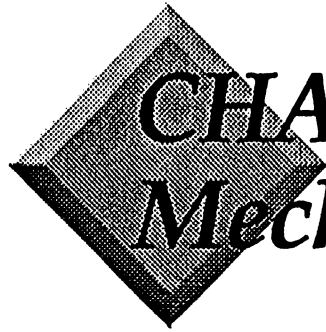
CHANGES FROM THUNDERBOLT

Mechanical Parts

PART	CHANGE	MOTIVATION
❖ Thin Film Heads	50% vs 70% Slider	Disk Space
❖ Push Rod Seal	Push Rod Servowriter	Mfg Process
❖ Clock Head Seal	Push Rod Servowriter	Mfg Process
❖ R/W Flex Cable	Lower Noise Layout	R/W Channel Design
❖ UL Label	Unique Designation	Product Identification

LIGHTNING MECHANICAL REVIEW FOR COMPAQ

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CHANGES FROM THUNDERBOLT

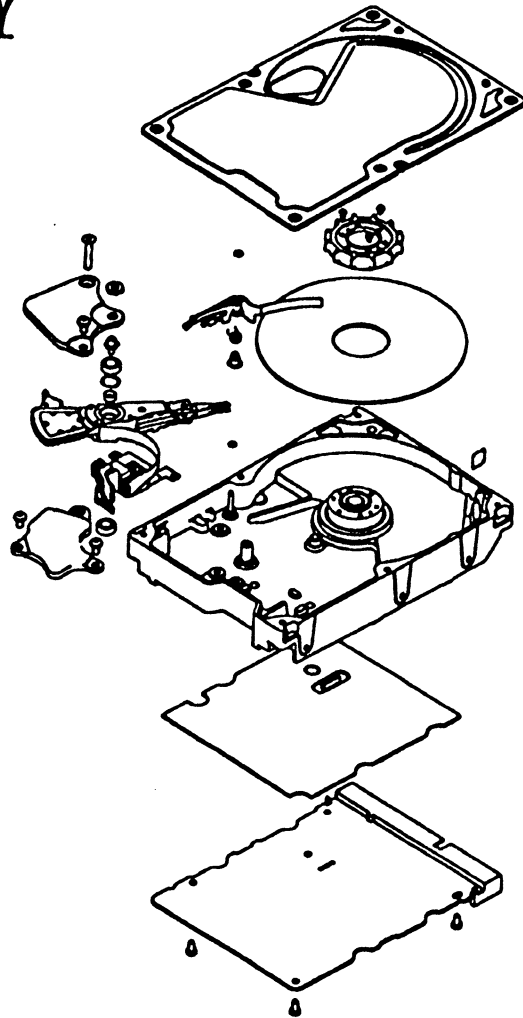
Mechanical Parts

PART	CHANGE	MOTIVATION
❖ Base Casting	Push Rod Servowriter	Mfg Process
❖ Rotor Machining	Push Rod Servowriter	Mfg Process
❖ VCM Magnet	Two Piece to One	Cost Reduction
❖ Cover Gasket	EPDM vs Poron	Cost Reduction
❖ OD Crash Stop	Harder & Smaller	Disk Space

LIGHTNING MECHANICAL REVIEW FOR COMPAQ

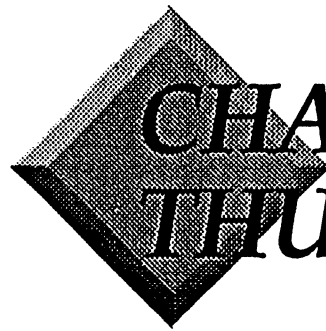
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MECHANICAL DESIGN ASSEMBLY



LIGHTNING MECHANICAL REVIEW FOR COMPAQ

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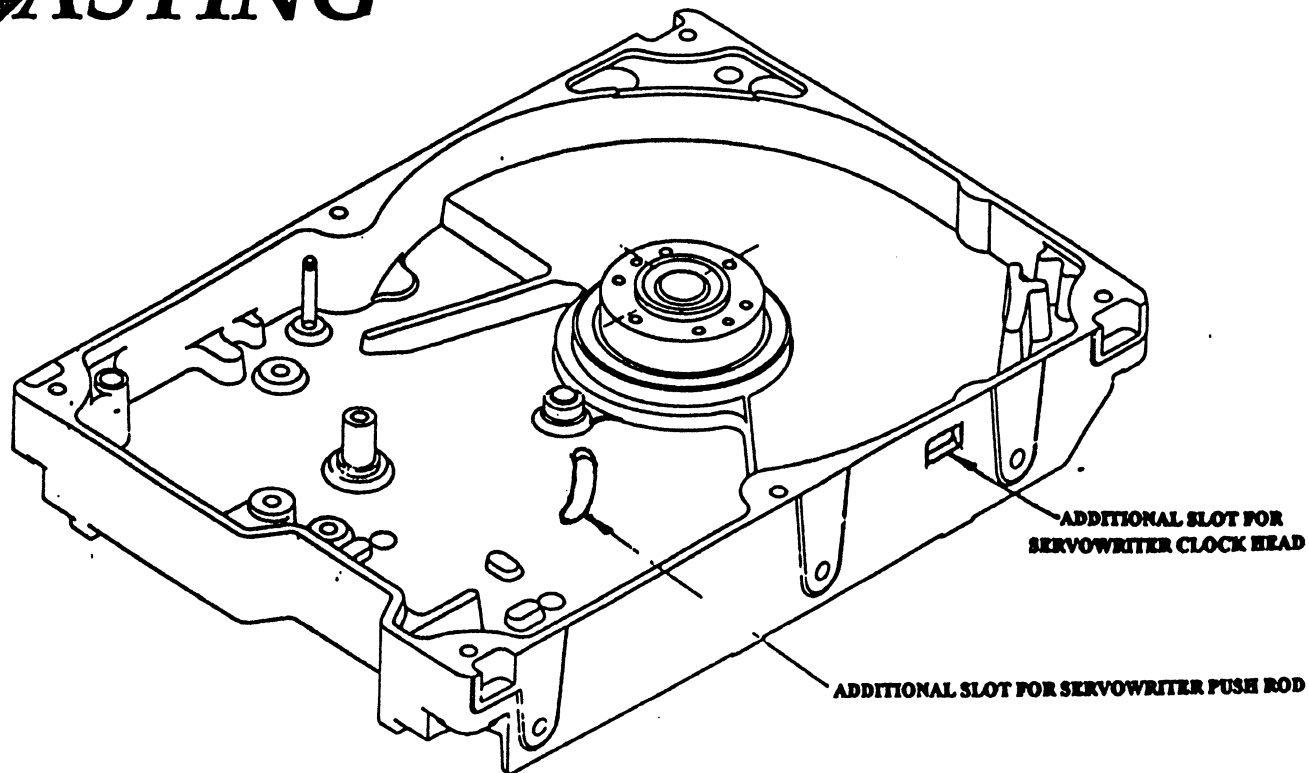
CHANGES FROM THUNDERBOLT --- MFG

- ❖ **Base Casting Modified with Slots for Push Rod Servowriter**
- ❖ **Rotor Machining Modified for Push Rod Servowriter**
- ❖ **HDA is Servowritten with Cover On**
- ❖ **Seals are Applied in Mfg to Cover Slots**
- ❖ **Enables Automated Servowrite Process with no Operator Dependency**

LIGHTNING MECHANICAL REVIEW FOR COMPAQ

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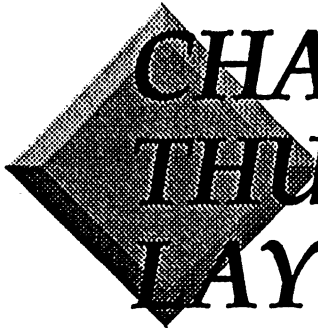
CHANGES FROM THUNDERBOLT --- BASE CASTING



BASE MODIFICATIONS FOR PUSH ROD SERVOWRITER

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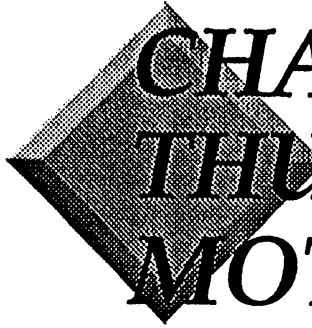


CHANGES FROM THUNDERBOLT --- TRACK LAYOUT

- ❖ **Track Density Change from 2875tpi to 3794tpi**
- ❖ **OD Crash Stop Smaller for Increased Outer Diameter of Data Zone**
 - Lightning Outer Radius is 1.804
 - Thunderbolt Outer Radius is 1.786
- ❖ **OD Crash Stop Material is Harder for Reduced Dynamic Compression**
 - Lightning - .036 in Compression
 - Thunderbolt - .055 in. Compression

LIGHTNING MECHANICAL REVIEW FOR COMPAQ

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CHANGES FROM THUNDERBOLT --- SPINDLE MOTOR

- ❖ **Spindle NRRO Reduced from 12.0 to 6.0
Microinches Max - Improved Bearing Quality**
- ❖ **Manufacturing Cost Reductions Implemented
with no Performance Degradation**
 - ◆ **Spindle Bearing Seals Changed to Shields on One Side
of Bearing**
 - ◆ **Spindle Motor Hub Processing Changed to Forging vs
Machining**
 - ◆ **Motor Stator Coating Changed to Plastic to Enable
Automated Soldering Operations**

LIGHTNING MECHANICAL REVIEW FOR COMPAQ

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CHANGES FROM THUNDERBOLT --- HEAD STACK

❖ Heads

- 50% Sliders on Modified Type 8 Suspensions - Thunderbolt Uses 70% Sliders**
- Lower Gram Load - 7 Grams vs. 9.5 Grams on Thunderbolt**
- Track Width is 5 microns nominal vs. 6.5 microns on Thunderbolt for Accommodation of Higher TPI**
- Nominal Flying Height is Same at 3.0 Microinches**

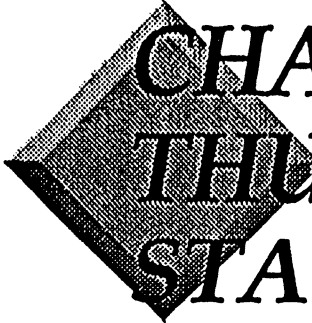
❖ 540 MB Head Stack Can Be:

- Built with three heads from the onset**
- Built with four heads and then reclassified into any three good heads that meet the test criteria**

❖ Rotor Machining Modified for Push Rod Servowriter

LIGHTNING MECHANICAL REVIEW FOR COMPAQ

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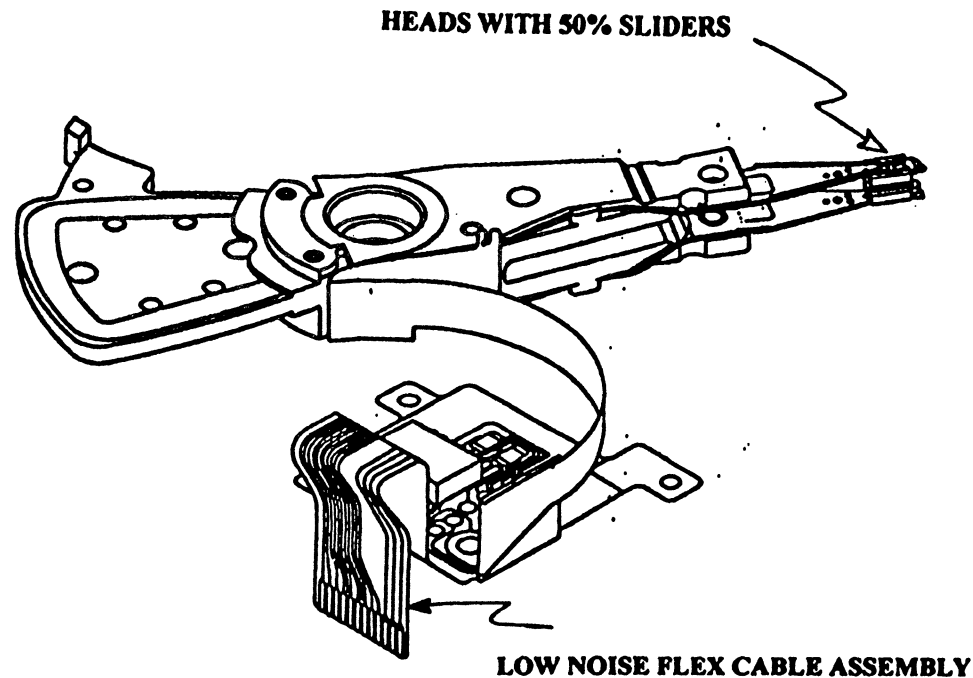
CHANGES FROM THUNDERBOLT --- HEAD STACK

- ❖ **Read/Write Flex Assembly Modified to Lower
Read Channel Noise and Improve Window
Margins**
 - **Same Mechanical Outline**
 - **Minimum Noise Trace Layout**
 - **Damping Resistor Removed**

LIGHTNING MECHANICAL REVIEW FOR COMPAQ

**6/9/94
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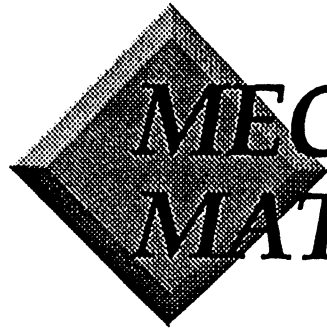
CHANGES FROM THUNDERBOLT --- HEAD STACK



MODIFICATIONS TO THE ACTUATOR ASSEMBLY

LIGHTNING MECHANICAL REVIEW FOR COMPAQ

6/9/94
D. Basehore



MECHANICAL DESIGN MATURITY

- ❖ **No Major Design Issues to be Resolved**
- ❖ **DVT / FMT Testing is Proceeding with No Mechanical Related Issues Noted**
- ❖ **TMR Analysis Has Shown Good Design Margins at New Track Density**

LIGHTNING MECHANICAL REVIEW FOR COMPAQ

**6/9/94
D. Baschore**