ST412 INTERFACE AND
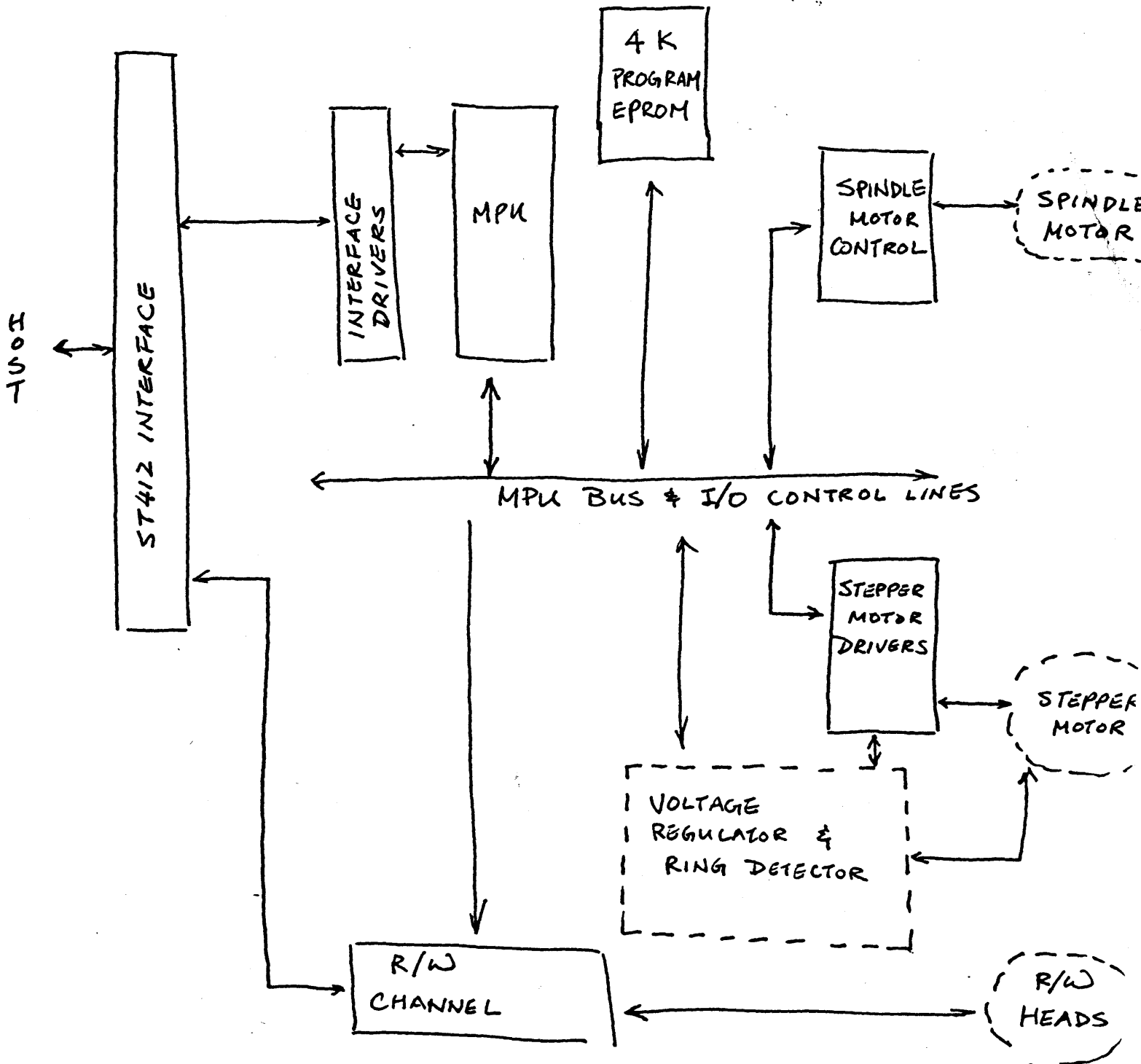
STEPPER MOTOR DRIVE

MICROCODE CLASS

By Litko Chan

12/02/87

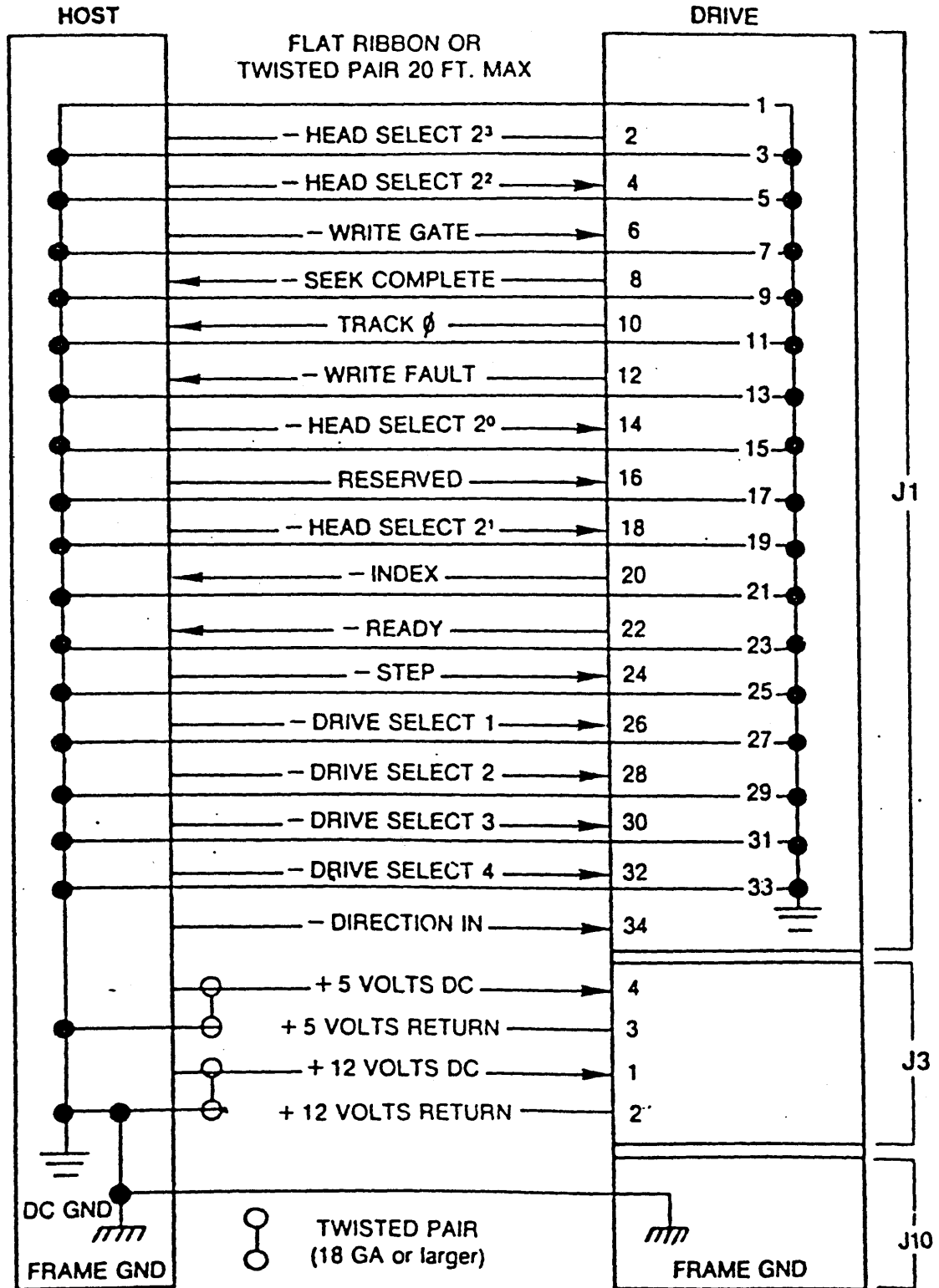# OUTLINE

- Overview.

- ST412 Interface.

- Power-up sequence (ST251).

- Seek modes.

- Drive recalibration (Auto-truncation).

- Recovery Mode.

- Seek settling (Ring Detection).
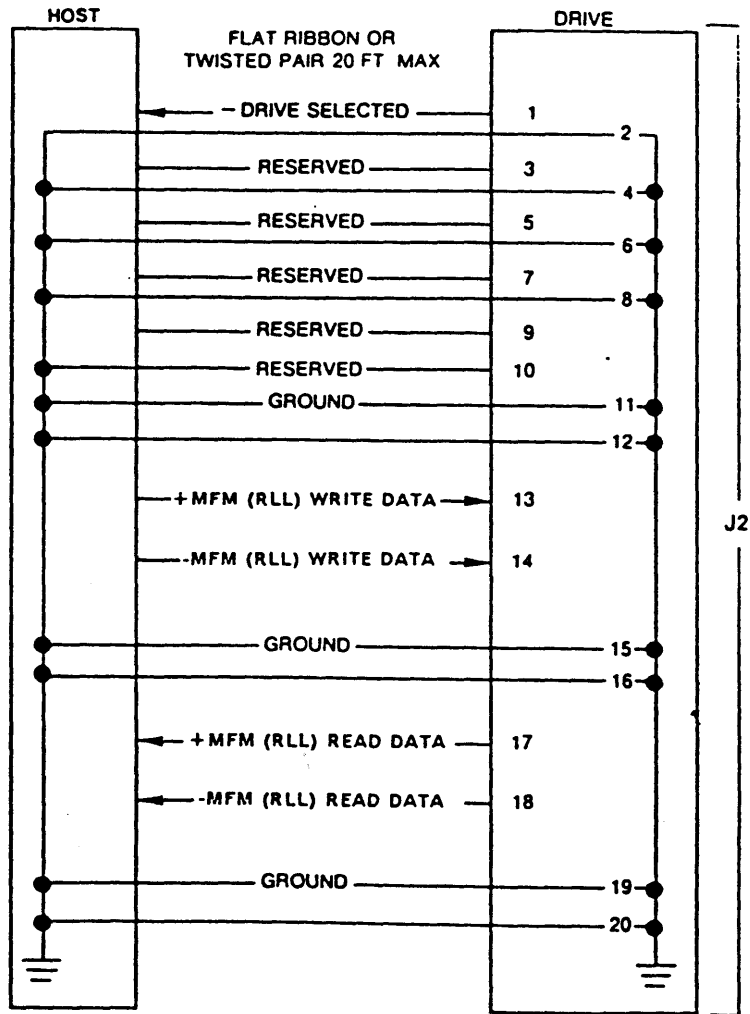
- Auto-tuning.

- Access time.

ST412 STEPPER DRIVE
BLOCK DIAGRAM

```
HOST  <-->  ST412 INTERFACE  <-->  INTERFACE DRIVERS  <-->  MPU

                                   4K PROGRAM EPROM

                                   SPINDLE MOTOR CONTROL  <-->  SPINDLE MOTOR

        MPU BUS & I/O CONTROL LINES

                                   STEPPER MOTOR DRIVERS  <-->  STEPPER MOTOR

                                   VOLTAGE REGULATOR & RING DETECTOR

        R/W CHANNEL  <--  R/W HEADS
```

HOST

ST412 INTERFACE

INTERFACE DRIVERS

MPU

4 K PROGRAM EPROM

SPINDLE MOTOR CONTROL

SPINDLE MOTOR

MPU BUS & I/O CONTROL LINES

STEPPER MOTOR DRIVERS

STEPPER MOTOR

VOLTAGE REGULATOR & RING DETECTOR

R/W CHANNEL

R/W HEADS

Control/Status Signals

FLAT RIBBON OR
TWISTED PAIR 20 FT. MAX

	1	
— HEAD SELECT 2^3 —	2	
	3	
— HEAD SELECT 2^2 —	4	
	5	
— WRITE GATE —	6	
	7	
— SEEK COMPLETE —	8	
	9	
— TRACK ϕ —	10	
	11	
— WRITE FAULT —	12	
	13	
— HEAD SELECT 2^0 —	14	
	15	
— RESERVED —	16	
	17	
— HEAD SELECT 2^1 —	18	
	19	
— INDEX —	20	
	21	
— READY —	22	
	23	
— STEP —	24	
	25	
— DRIVE SELECT 1 —	26	
	27	
— DRIVE SELECT 2 —	28	
	29	
— DRIVE SELECT 3 —	30	
	31	
— DRIVE SELECT 4 —	32	
	33	
— DIRECTION IN —	34	

J1

— + 5 VOLTS DC —	4
— + 5 VOLTS RETURN —	3
— + 12 VOLTS DC —	1
— + 12 VOLTS RETURN —	2

J3

DC GND

FRAME GND

○
|
○   TWISTED PAIR
(18 GA or larger)

FRAME GND

J10

3

Data Signals

Seagate ST412 Interface Manual

4

ST412 INTERFACE SIGNALS

CONTROL INPUT SIGNALS:

      - DRIVE SELECT LINES

      - HEAD SELECT LINES

      - WRITE GATE

      - STEP

      - DIRECTION IN

      - RECOVERY MODE

CONTROL OUTPUT SIGNALS:

      - DRIVE SELECTED

      - INDEX

      - TRACK O

      - READY

      - SEEK COMPLETE

      - WRITE FAULT

CONTROL INPUT SIGNALS

DRIVE SELECT LINES

The Drive Select line is activated by the controller to select and address the drive.

HEAD SELECT LINES

Head Select lines 2^0, 2^1, 2^2 and 2^3 allow the selection of each Read/Write head in a binary code sequence. Head Select line 2^0 is the least significant line. When all Head Select lines are high on the interface, Head 0 is selected.

Note: Depending on the product, one or more Head Select lines may not be required, and therefore terminated. These lines are present on the interface, but the drive will not respond to input signals on any terminated line(s).

WRITE GATE

The active state of this signal, or low level, enables the data to be written to the disc. When inactive, or high, this signal enables data to be transferred from the drive and enables Step pulses to move the heads. Heads may not be moved while Write Gate is active.

STEP

The Step signal is a 2 microsec. minimum width pulse that initiates Read/Write head motion. The Step pulse period determines the access method. The pulse number of pulses determines seek length.

Step pulse periods for specific products may be found in the Product Manuals.

The Direction In line must be stable 100 nsec. before the leading edge of the first pulse and remain stable for a 100 nsec. after the last pulse in a string of Step pulses.

If excessive Step pulses are issued which would cause a seek inward beyond the maximum data cylinder, or outward beyond Track Ø the drive will enter the Auto Truncation mode. Refer to "*2.3.3 Auto-Truncation*".

DIRECTION IN

The Direction line defines the direction the Read/Write heads will move when the Step line is pulsed. With Direction In true, each pulse causes the heads to move one cylinder inward toward the spindle. When Direction In is false, each pulse causes the heads to move one cylinder outward toward Track Ø.

CONTROL OUTPUT SIGNALS

DRIVE SELECTED

Drive Selected is a status signal transmitted over J2, which informs the host system of the selection status of the drive. The signal is driven by a TTL open collector. The signal goes true on the interface only when the drive is configured correctly, and the appropriate Drive Select line is activated by the host system.

INDEX

This signal is provided by the drive once each revolution (16.67 msec. nominal) to indicate the beginning of a track. Normally this signal makes the transition to low to indicate Index. Only the transition from high to low, or the leading edge, is valid.

3.3 TRACK Ø

This signal indicates a low level (true) when the Read/Write heads are positioned at Cylinder Zero.

Track Ø is the only cylinder that provides interface recognition. The drive is designed to recalibrate to Track Ø during power-on and Auto-Truncation operations.

Track Ø may also be accessed via conventional buffered and single-track seek modes. After Track Ø is true, no actions may be taken by the controller until Seek Complete is also true.

READY

This signal, when true together with Seek Complete, indicates that the drive is ready to Read, Write or Step and that all control input signals are valid. When the line is high, all reading, writing, and stepping is inhibited.

During the power-up sequence, Ready remains false until:

1. The recalibration to Track Ø is complete

2. Spindle speed is stable within:

   a. ±0.5% of nominal for the ST4000 series drives

   b. ±0.5% of nominal for the ST251

   c. ±1% of nominal for the ST213, ST225, ST238

3. Drive initialization routines are complete

4. DC voltage are within tolerances

Refer to the Product Manual for maximum power-up time.

SEEK COMPLETE

This signal goes to the low level on the interface when the Read/Write heads have settled on the target track at the end of a seek. Seeking, reading or writing should not be attempted when Seek Complete is false. Seek Complete goes false in the following cases:

1. When a recalibration sequence is initiated (by drive logic) at power-on

2. 100 nsec. typical after the leading edge of a Step pulse

3. If either +5 or +12 Volts are detected as unsafe

4. If the drive attempts a Seek-Retry after settling on a track (Drive-specific feature)

WRITE FAULT

This signal notifies the host system that a condition exists which, if not corrected, may cause an incorrect Write operation.

ST251 POWER UP SEQUENCE

01) Microprocessor gets reset.

02) Initialize all circuitries to default conditions.

03) Stiction jump.

04) Check spindle speed.

05) Loop in step 5 until spindle speed is within +/- .5% of the specified rotational speed (3600 RPM).

06) Recalibrate drive to cylinder 0.

07) Perform two shoe-shine seeks to shretch the band.

08) Perform Auto-tuning to find optimum seeking voltage.

09) Check Life-test Jumper. Jump to step 11 if jumper is open.

10) Perform shoe-shine seeks. Loop if step 10 while the Life-test Jumper remains close.

11) Set TRACK 0, READY, and SEEK COMPLETE.

12) Stay in IDLE loop until a STEP is received.

SEEK MODES

- BUFFERED SEEK:

Buffered seeks are performed when the incoming pulses are
issued by the host a rate of 3 us to 200 us.   The host
must not vary the pulse rate during a single seek command.
In general,   buffered seeks can be separated   into   two
modes:

- NON-OVERLAPPED SEEK MODE (41 US -   200 US)

In non-overlapped seek mode, incoming step pulses are
issued at a fixed rate between 41 to 200 microsecond.
At this rate, initiation of a seek starts shortly
after the LAST pulse is received.

- OVERLAPPED SEEK MODE (3 US -   40 US)

In overlapped seek mode, incoming step pulses are
issued at a fixed rate between 3 to 40 microsecond.
At this rate, the drive is capable of maintaining the
step   count   while   a   seek   is   being   performed.
Therefore, initiation of a seek may be started
shortly after the FIRST pulse is received.   The
advantage of this seek mode is to optimize access
timing.

- SLOW STEP MODE (3 MS OR GREATER)

In Slow-Step, the read/write heads move at the rate
of the incoming step pulses.   The minimum period between
pulses is 3 msec.   SEEK COMPLETE is issued after the drive
received the last pulse and applies sufficient settling
delay after seeking to the final target track. This seek
mode is used typically by some PRE-HISTORIC controllers
for recalibrating the read/write heads back to cylinder 0.

2.3.3 AUTO-TRUNCATION

The drive will enter the Auto-Truncation mode if the controller issues an excessive number of Step pulses, which would place the Read/Write heads outward beyond Track Ø or inward beyond the maximum data cylinder.

With Auto-Truncation active, the drive will ignore additional pulses, take control of the actuator, and recalibrate the heads to Track Ø.
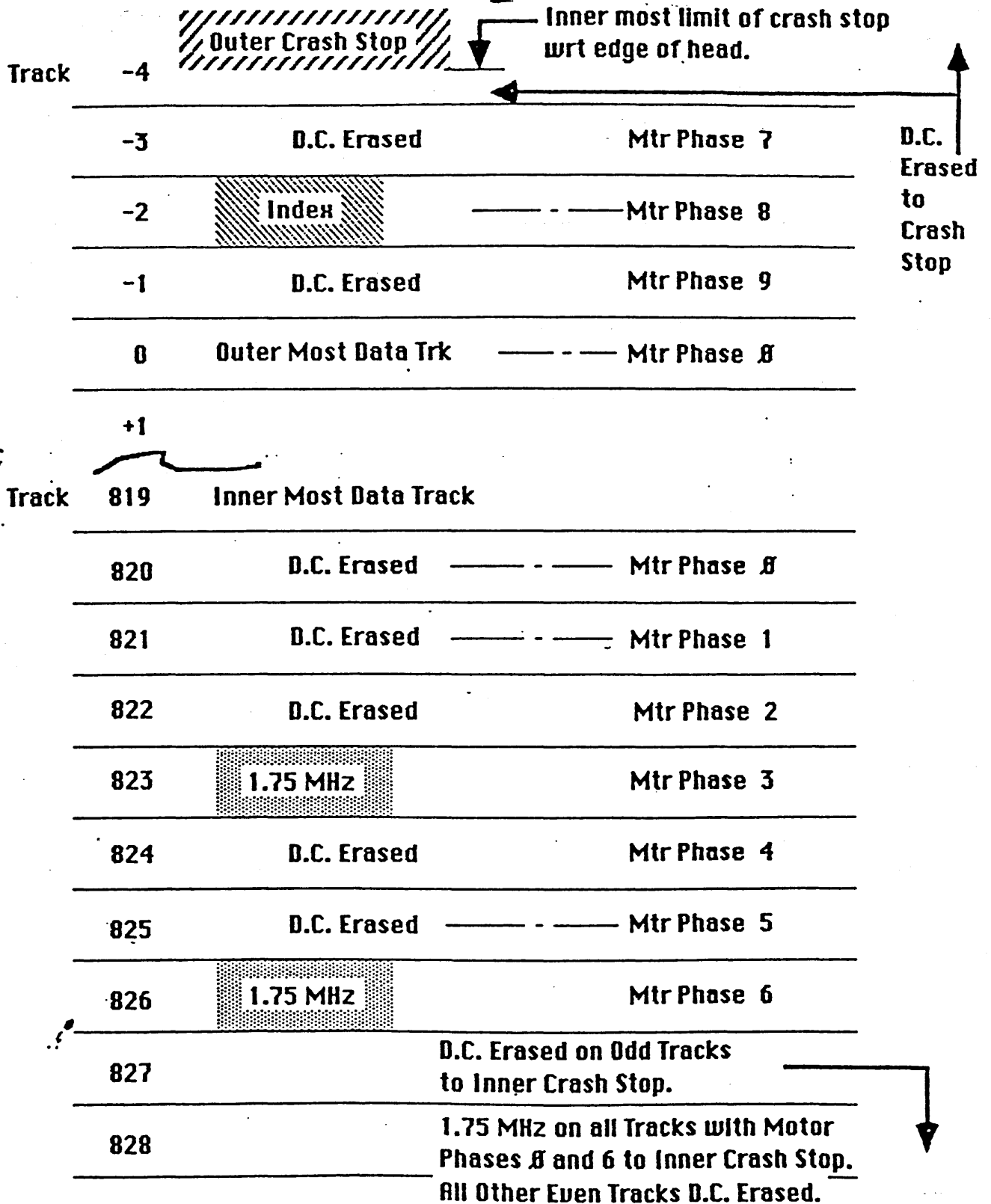
Caution: If the controller is still issuing Slow-Step pulses after the drive issues Seek Complete from Auto-Truncation mode, the drive will either reenter Auto-Truncation mode with Direction In false, or step the remaining cylinders with Direction In true.

ST251

STEP	A	Ā	B	B̄	C	C̄	D	D̄	E	Ē	2φ ON	STEP SIZE	STEP CODE
∅	1	0	0	1	1	0	0	1	1	0		½	AB̄ CD̄E
	0	0	0	1	1	0	0	1	1	0	CD̄	Full	B̄CD̄E
1	0	1	0	1	1	0	0	1	1	0		½	ĀBCD̄E
	0	1	0	0	1	0	0	1	1	0	D̄E	Full	Ā CD̄E
2	0	1	1	0	1	0	0	1	1	0		½	ĀBCD̄E
	0	1	1	0	0	0	0	1	1	0	ĀE	Full	ĀB D̄E
3	0	1	1	0	0	1	0	1	1	0		½	ĀBC̄D̄E
	0	1	1	0	0	1	0	0	1	0	ĀB	Full	ĀBC̄ E
4	0	1	1	0	0	1	1	0	1	0		½	ĀBC̄DE
	0	1	1	0	0	1	1	0	0	0	BC̄	Full	ĀBC̄D
5	0	1	1	0	0	1	1	0	0	1		½	ĀBC̄DĒ
	0	0	1	0	0	1	1	0	0	1	C̄D	Full	BC̄DĒ
6	1	0	1	0	0	1	1	0	0	1		½	ABC̄DĒ
	1	0	0	0	0	1	1	0	0	1	DĒ	Full	A C̄DĒ
7	1	0	0	1	0	1	1	0	0	1		½	AB̄C̄DĒ
	1	0	0	1	0	0	1	0	0	1	AĒ	Full	AB̄ DĒ
8	1	0	0	1	1	0	1	0	0	1		½	AB̄CDĒ
	1	0	0	1	1	0	0	0	0	1	AB̄	Full	AB̄C Ē
9	1	0	0	1	1	0	0	1	0	1		½	AB̄CD̄Ē
	1	0	0	1	1	0	0	1	0	0	B̄C	Full	AB̄CD̄
10 REPEAT	1	0	0	1	1	0	0	1	1	0		½	AB̄CD̄E
	0	0	0	1	1	0	0	1	1	0	CD̄	Full	B̄CD̄E

12

Inner most limit of crash stop wrt edge of head.

Track   -4   ///// Outer Crash Stop /////

-3   D.C. Erased   Mtr Phase 7   D.C. Erased to Crash Stop

-2   Index   — — - —Mtr Phase 8

-1   D.C. Erased   Mtr Phase 9

0   Outer Most Data Trk   — — - — Mtr Phase 0

+1

Track   819   Inner Most Data Track

820   D.C. Erased   — — - — — Mtr Phase 0

821   D.C. Erased   — — - — — Mtr Phase 1

822   D.C. Erased   Mtr Phase 2

823   1.75 MHz   Mtr Phase 3

824   D.C. Erased   Mtr Phase 4

825   D.C. Erased   — — - — — Mtr Phase 5

826   1.75 MHz   Mtr Phase 6

827   D.C. Erased on Odd Tracks to Inner Crash Stop.

828   1.75 MHz on all Tracks with Motor Phases 0 and 6 to Inner Crash Stop. All Other Even Tracks D.C. Erased.

NOTE: All area outside of tracks 0 to 819 must be D.C. Erased on 1/2 track increments before Index and 1.75 MHz are written.

13

Index Track Data Pattern

2-11-86
K. Johnson

14
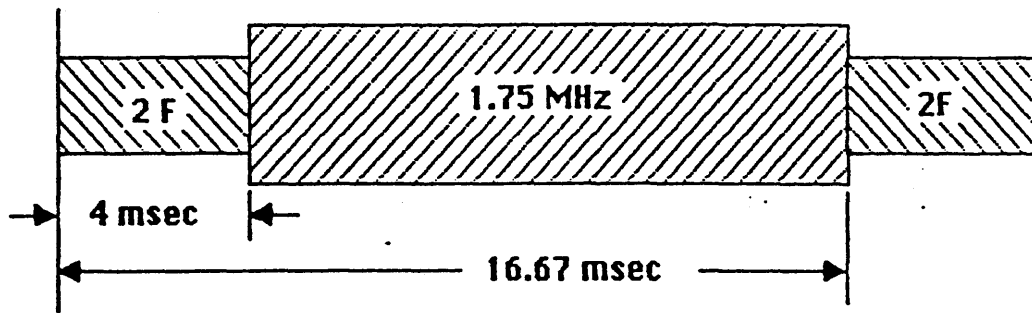
ST251 RECAL SEQUENCE   12/4/85

1. RESET SEQUENCER TO PHASE 0.

2. SWITCH TO PHASE 8 (SAME PHASE AS -2).

3. VERIFY INDEX PATTERN.

4. GO TO STEP 14 IF INDEX PATTERN FOUND.

5. VERIFY GUARD BAND. (PHASE 0 AND PHASE 6)

6. GO TO STEP 16 IF GUARD BAND DETECTED.

7. SEEK 10 TRACK OUT.

8. VERIFY INDEX PATTERN.

9. GO TO STEP 14 IF INDEX PATTERN FOUND.

10. VERIGY GUARD BAND.

11. GO TO STEP 16 IF GUARD BAND DETECTED.

12. APPLY "DATA RECAL SEQUENCE".

13. GO TO STEP 17.

14. APPLY "INDEX RECAL SEQUENCE".

15. GO TO STEP 17.

16. APPLY "GUARD BAND RECAL SEQUENCE".

17. ~~LOCK INDEX.~~

18. SET TRACK 0.

19. SET SEEK COMPLETE.

L.RC

15

1

ST 251 RECAL SEQUENCE

POWER ON SEQUENCE

RECAL

RESET
SEQUENCE
TO PHASE Ø

SWITCH TO
PHASE 8

INDEX
FOUND
?
— yes
— NO

GUARD
BAND
FOUND
?
— YES
— NO

SEEK
1Ø TRACKS
"OUT"

INDEX
FOUND
— YES
— NO

GUARD
BAND
FOUND
?
— YES
— NO

CALL:
"INDEX RECAL
SEQUENCE"

CALL
"DATA RECAL
SEQUENCE"

CALL
"GUARD BAND
RECAL
SEQUENCE"

SET
TRACK Ø,
SEEK COMPL.
ETC.

DONE

16
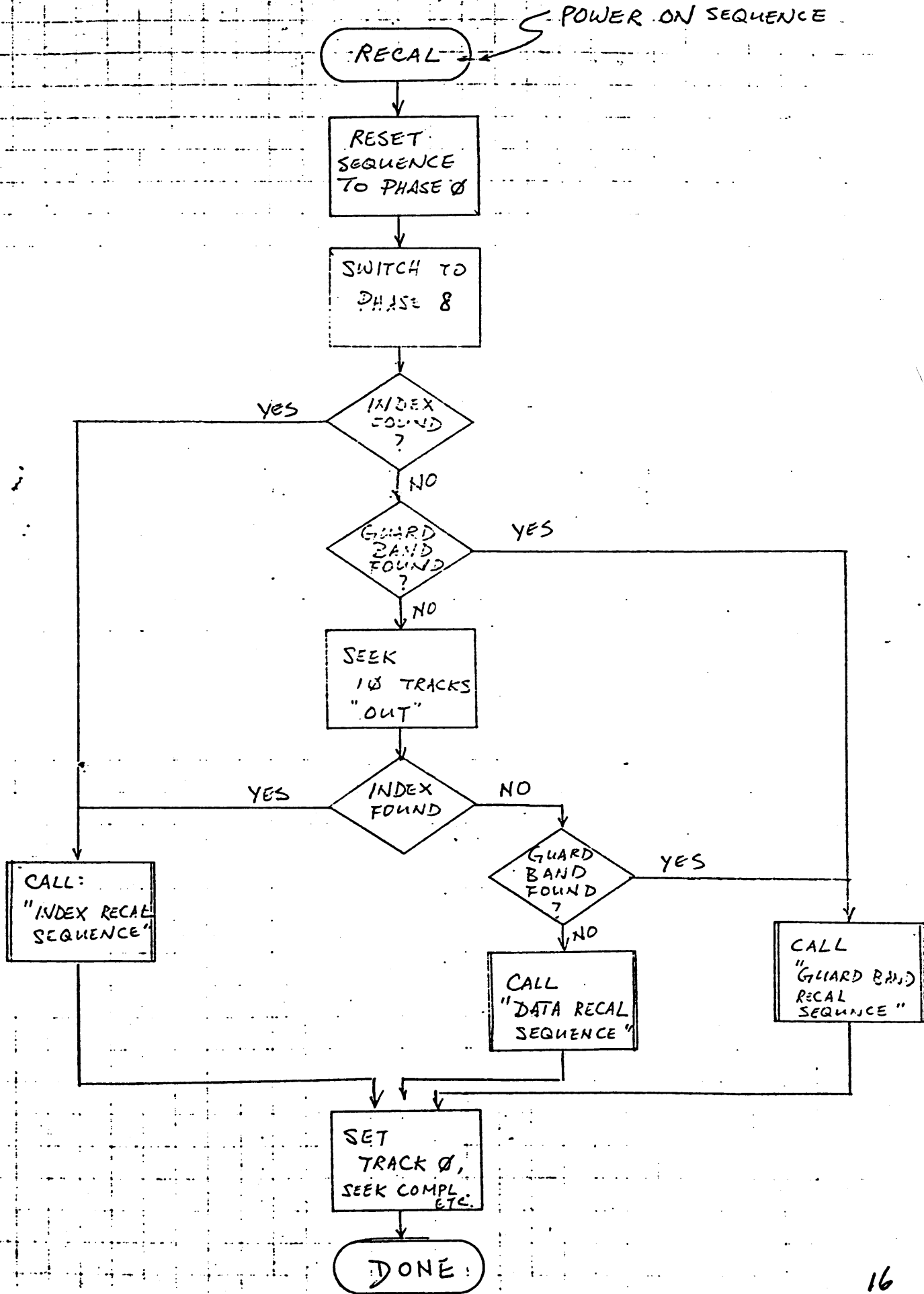
GUARD BAND RECAL SEQUENCE   12/4/85

1. BUFFER SEEK 800 TRACKS OUT.

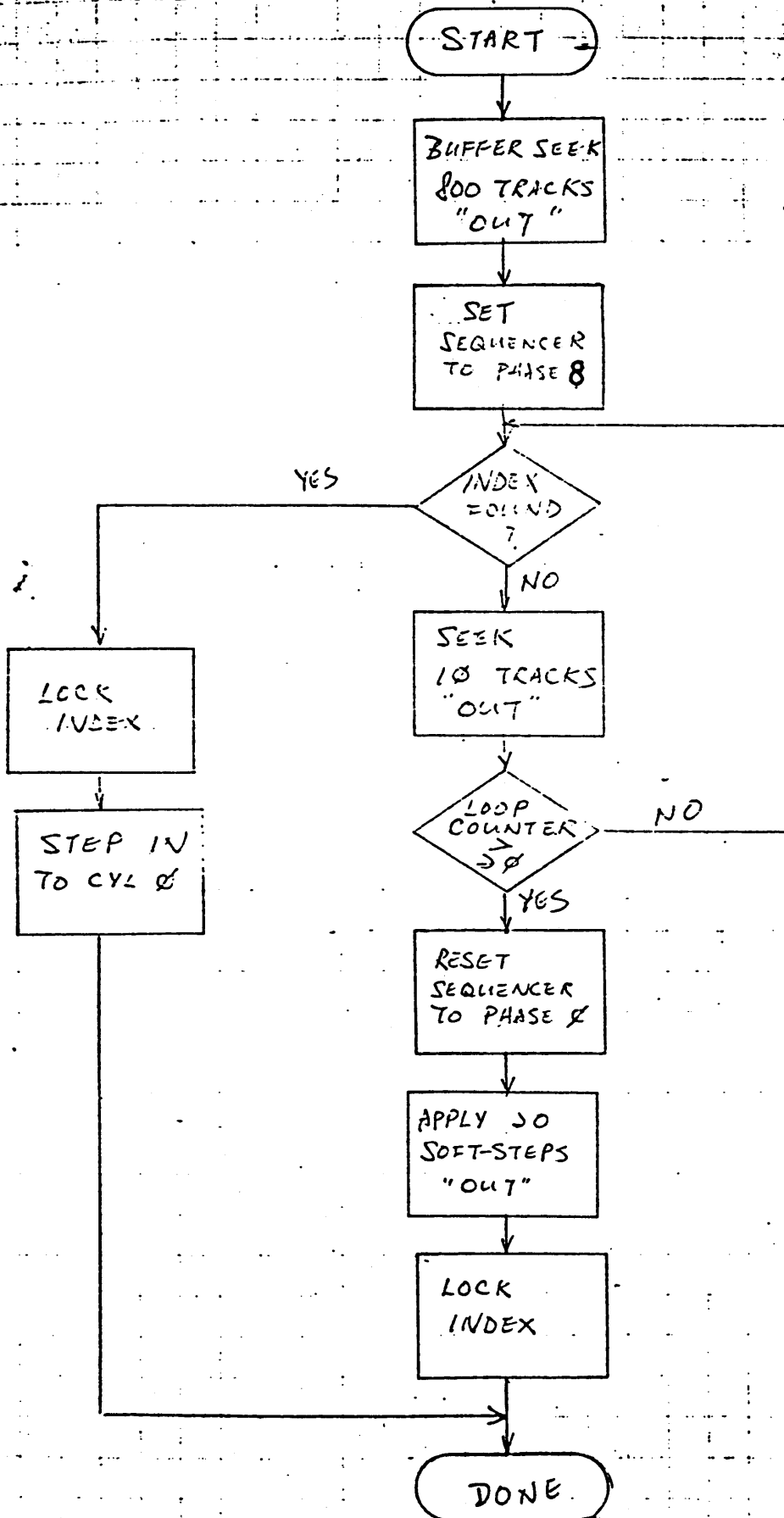2. SET SEQUENCER TO PHASE 8.

3. VERIFY INDEX PATTERN.

4. GO TO STEP 12 IF INDEX PATTERN DETECTED.

5. SEEK 10 TRACKS OUT.

6. REPEAT STEP 3 - STEP 5 UP TO 13 TIMES.

7. RESET SEQUENCER TO PHASE 0

8. APPLY 20 SOFT-STEPS TOWARD THE O.D.

9. LOCK INDEX.

10. GO TO STEP 13.

11. LOCK INDEX.

12. STEP "IN" TO CYLINDER 0.

13. DONE.

LRC

17

2

GUARD BAND RECAL SEQUENCE

```
                    ( START )
                        |
                        v
              +--------------------+
              |   BUFFER SEEK      |
              |   800 TRACKS       |
              |     "OUT"          |
              +--------------------+
                        |
                        v
              +--------------------+
              |      SET           |
              |  SEQUENCER         |
              |  TO PHASE 8        |
              +--------------------+
                        |
                        v
                      / INDEX \
              YES    /  FOUND  \
         +---------<     ?      >
         |          \         /
         |           \       /
         |               | NO
         |               v
         |     +--------------------+
         |     |    SEEK            |
         |     |   10 TRACKS        |
         |     |     "OUT"          |
         |     +--------------------+
         |               |
         v               v
  +-------------+      / LOOP  \
  |   LOCK      |     / COUNTER \   NO
  |   INDEX     |    <    >      >------+
  +-------------+     \   >0    /       |
         |             \      /         |
         v               | YES          |
  +-------------+        v              |
  |  STEP IN    |  +--------------------+
  |  TO CYL 0   |  |    RESET           |
  +-------------+  |  SEQUENCER         |
         |         |  TO PHASE 0        |
         |         +--------------------+
         |               |
         |               v
         |         +--------------------+
         |         |  APPLY 10          |
         |         |  SOFT-STEPS        |
         |         |    "OUT"           |
         |         +--------------------+
         |               |
         |               v
         |         +--------------------+
         |         |   LOCK             |
         |         |   INDEX            |
         |         +--------------------+
         |               |
         +---------------+
                         |
                         v
                     ( DONE )
```
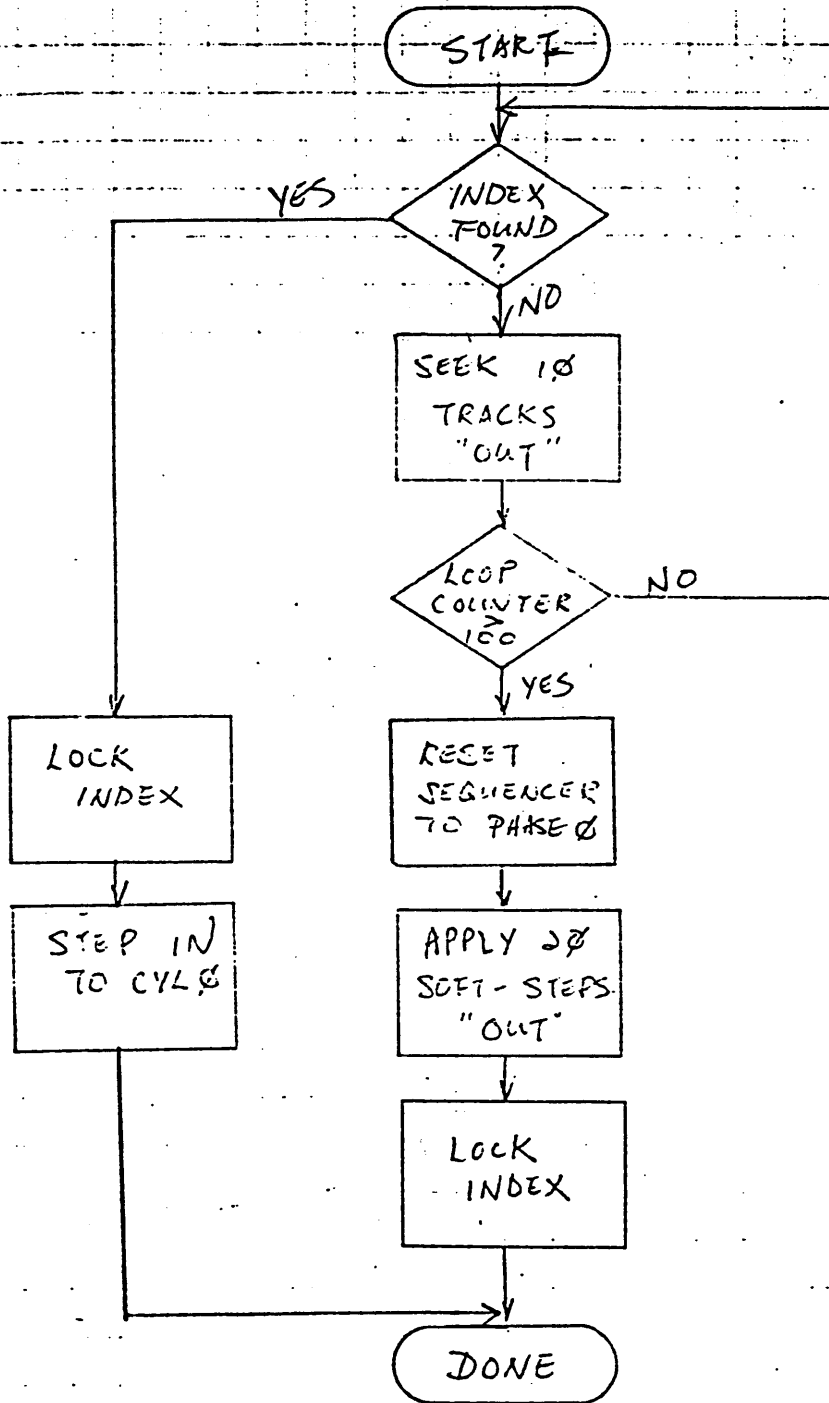
18

1. VERIFY INDEX PATTERN.

2. GO TO STEP 9 IF INDEX PATTERN DETECTED.

3. SEEK 10 TRACKS OUT.

4. REPEAT STEP 1 - STEP 3 UP TO 93 TIMES.

5. RESET SEQUENCER TO PHASE 0.

6. APPLY 20 SOFT-STEPS TOWARD THE O.D.

7. LOCK INDEX.

8. GO TO STEP 11.

9. STEP "IN" TO CYLINDER 0.
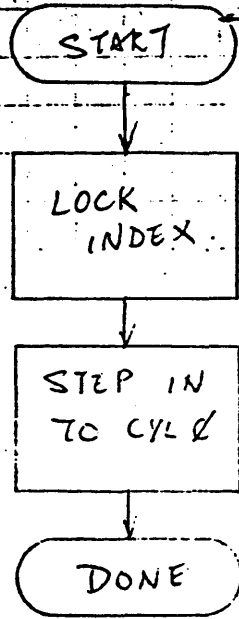
10. LOCK INDEX.

11. DONE.

LRC

19

DATA RECAL SEQUENCE

```
                        ( START )
                            |
                            |
          YES               v
    <--------------   < INDEX
    |                   FOUND ? >
    |                        |
    |                        | NO
    |                        v
    |                 +-------------+
    |                 |  SEEK 10    |
    |                 |  TRACKS     |
    |                 |  "OUT"      |
    |                 +-------------+
    |                        |
    |                        v
    |                 < LOOP          >   NO
    |                 < COUNTER       > ------->
    |                 <   >           |
    |                 <   100         |
    |                        |
    |                        | YES
    |                        v
    v                 +-------------+
+---------+           |  RESET      |
| LOCK    |           |  SEQUENCER  |
| INDEX   |           |  TO PHASE Ø |
+---------+           +-------------+
    |                        |
    v                        v
+---------+           +-------------+
| STEP IN |           |  APPLY 20   |
| TO CYL Ø|           |  SOFT-STEPS |
+---------+           |  "OUT"      |
    |                 +-------------+
    |                        |
    |                        v
    |                 +-------------+
    |                 |  LOCK       |
    |                 |  INDEX      |
    |                 +-------------+
    |                        |
    +----------------------->v
                        ( DONE )
```

INDEX RECAL SEQUENCE   12/4/85

1. STEP "IN" TO CYLINDER 0.

2. LOCK INDEX.

3. DONE.

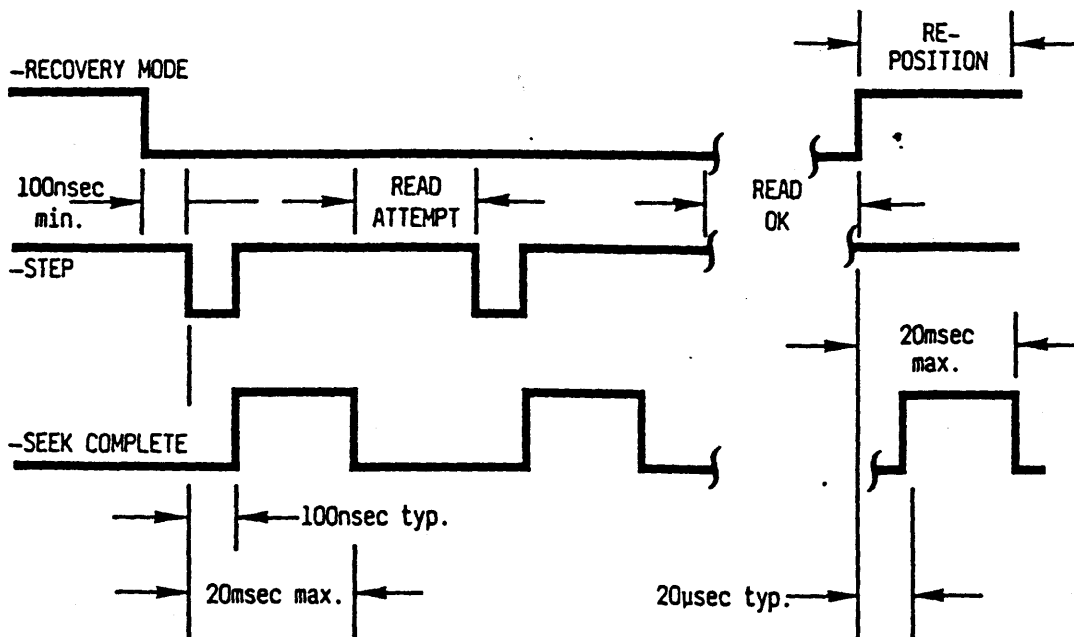# INDEX RECAL SEQUENCE

```
          ( START )
              │
              ▼
        ┌───────────┐
        │   LOCK    │
        │   INDEX   │
        └───────────┘
              │
              ▼
        ┌───────────┐
        │  STEP IN  │
        │  TO CYL ∅ │
        └───────────┘
              │
              ▼
          ( DONE )
```

22

RECOVERY MODE

RECOVERY MODE provides a read/write head micro-positioning option. It may be used after the controller has completed its retry options on a read error.

RECOVERY MODE is initiated by the controller asserting the RECOVERY MODE line low (true) at the interface. This changes the STEP line to a micro-step function after 100nsec. A step at this time will cause SEEK COMPLETE to go false 100nsec after the drive receives the step pulse. The drive then micro-steps off track using the optimum algorithm, allowing 20msec for the heads to settle, and then takes the SEEK COMPLETE line true. The controller may then attempt to read data. Refer to Figure 17 below. If data is not read correctly, the controller may issue an additional step pulse. Up to eight separate micro-step algorithms may be accessed before the sequence is repeated.

When data is read correctly, the controller exits RECOVERY MODE by taking the RECOVERY MODE line false on the interface. The drive then returns the heads to the nominal position by taking SEEK COMPLETE false, waiting 20msec for the heads to settle and reasserting SEEK COMPLETE.
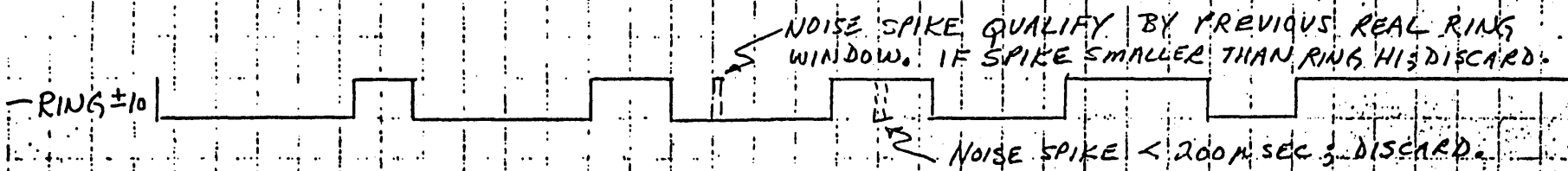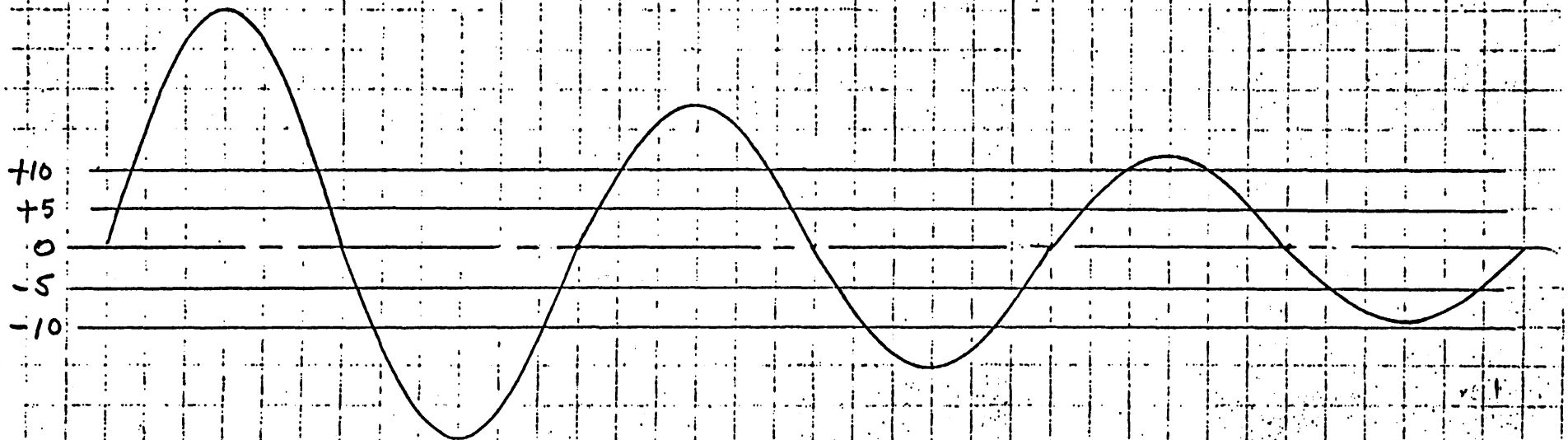
FIGURE 17: Recovery Mode Timing

23

SEEK SETTLING (RING DETECTION).

+10
+5
0
-5
-10

NOISE SPIKE QUALIFY BY PREVIOUS REAL RING
WINDOW. IF SPIKE SMALLER THAN RING HI, DISCARD.

—RING ±10

NOISE SPIKE < 200 μ SEC ; DISCARD.

—RING ±5

T1

START
HARDWARE
TIMER

$$FORMULA = 800\,\mu\,sec + \frac{T_1\,\mu\,sec}{2}$$

280 μ sec EVEN
140 μ sec ODD

(2 DAMPING PULSES MAX)

DAMPING PULSE

RINGOUT JNK.