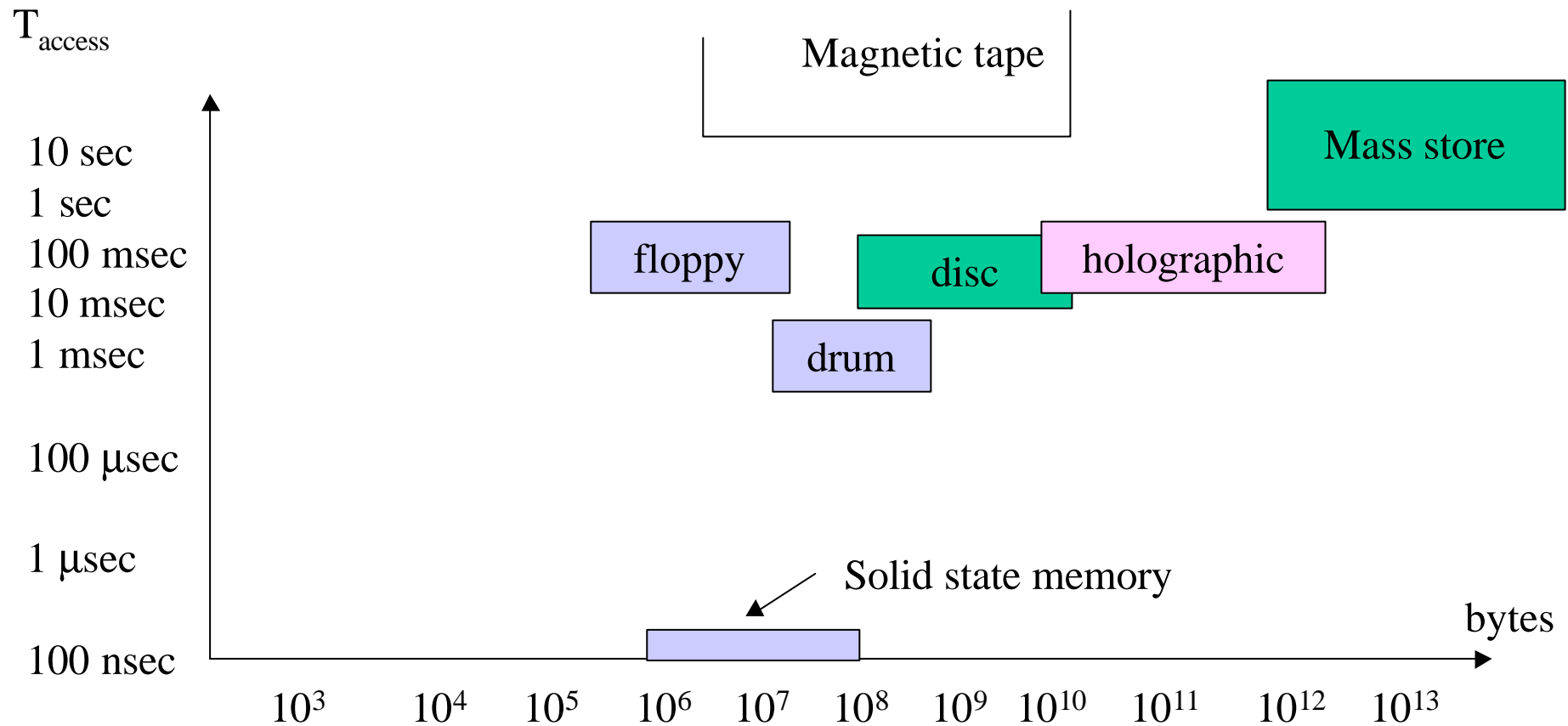


Secondary Store Ms



Secondary Store Ms Tape

From the 1950s

* NOT random access:

```
if last record accessed = record[n-1]
  then  $T_{\text{access}}(\text{record}[n]) = 1\text{msec};$ 
  else  $T_{\text{access}}(\text{record}[n]) \gg 1\text{msec};$ 
```

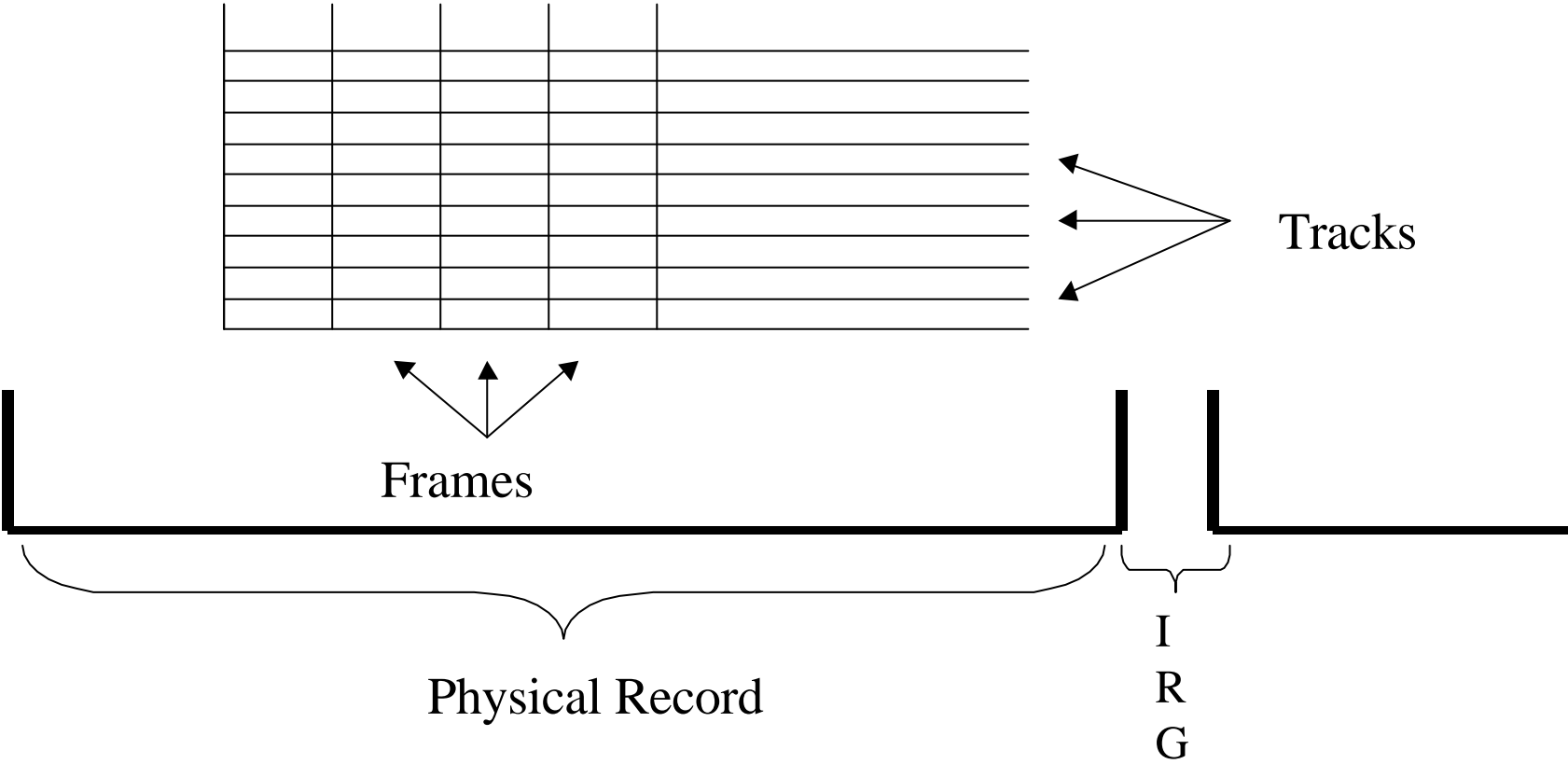
(sequential access)

* organized as

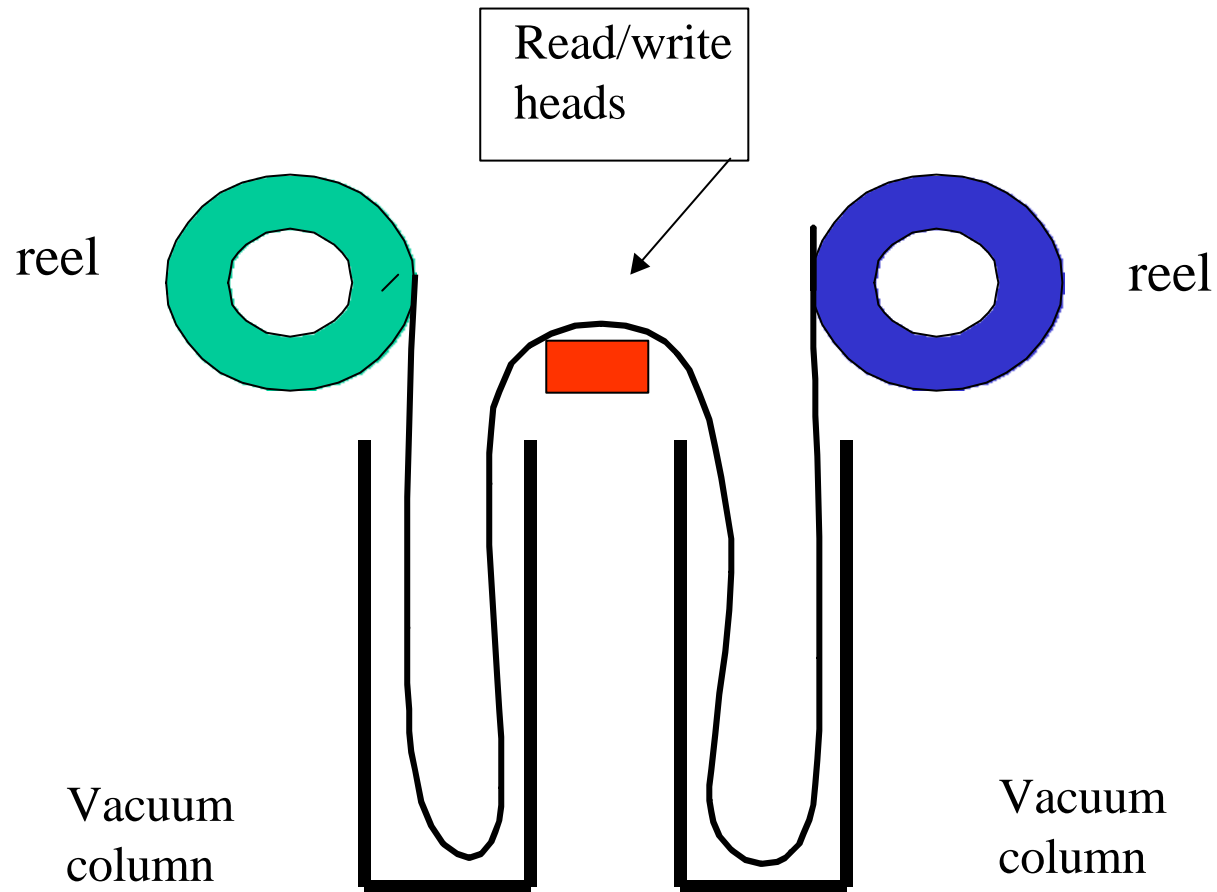
1600 bits/inch
2400 feet/reel
is common

Tape

9-Track tape:
1 byte / frame + parity



How they work



High-performance 1987 Tape drive



- name : IBM 3480 Tape Subsystem
- (controller and 8 drives)
-

IBM 3480

- dollar cost:
 - system is about 7 years old.
- - Replacement cost would be about \$20,000.
 - newer 3490 would cost about \$120,000.

IBM 3480 tape

- capacity in Mbyte:
 - Approximately 260 Mb per reel
 - drive data rate is 3.0 Mb/sec.
- Reading data in 20,000 byte blocks,
 - 1.3 Mb/sec.

IBM 3480 tape

- transfer rate:
 - controller can transfer on the parallel channel
 - at 4.5 Mb/sec.
 - drive data rate is 3.0 Mb/sec
 - Reading data in 20,000 byte blocks,
 - 1.3 Mb/sec.

Lo-octane tape drive DECtape TU-16 (1975)

- 1600 bpi, 9 track
- < 40 Mbytes/reel
- 72 Kbyte/s transfer rate
- tape speed 45 inches/sec
- IRG > 0.5 inch
- parity bit per byte plus CRC per record

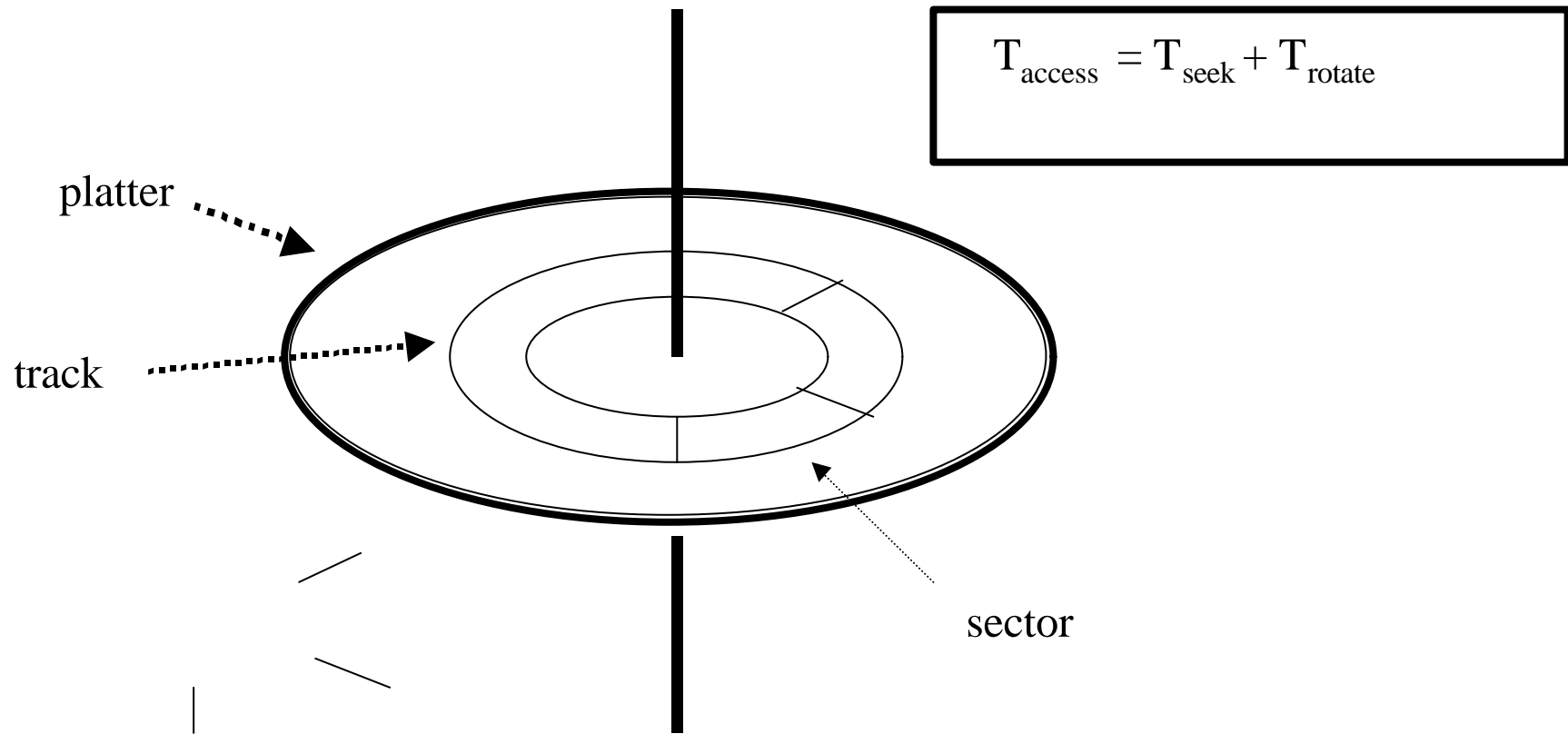
Tape performance

- Logical record (e.g. data structure instance)
- physical record (the longer the better until error probability is to high)
- blocking factor

Disc

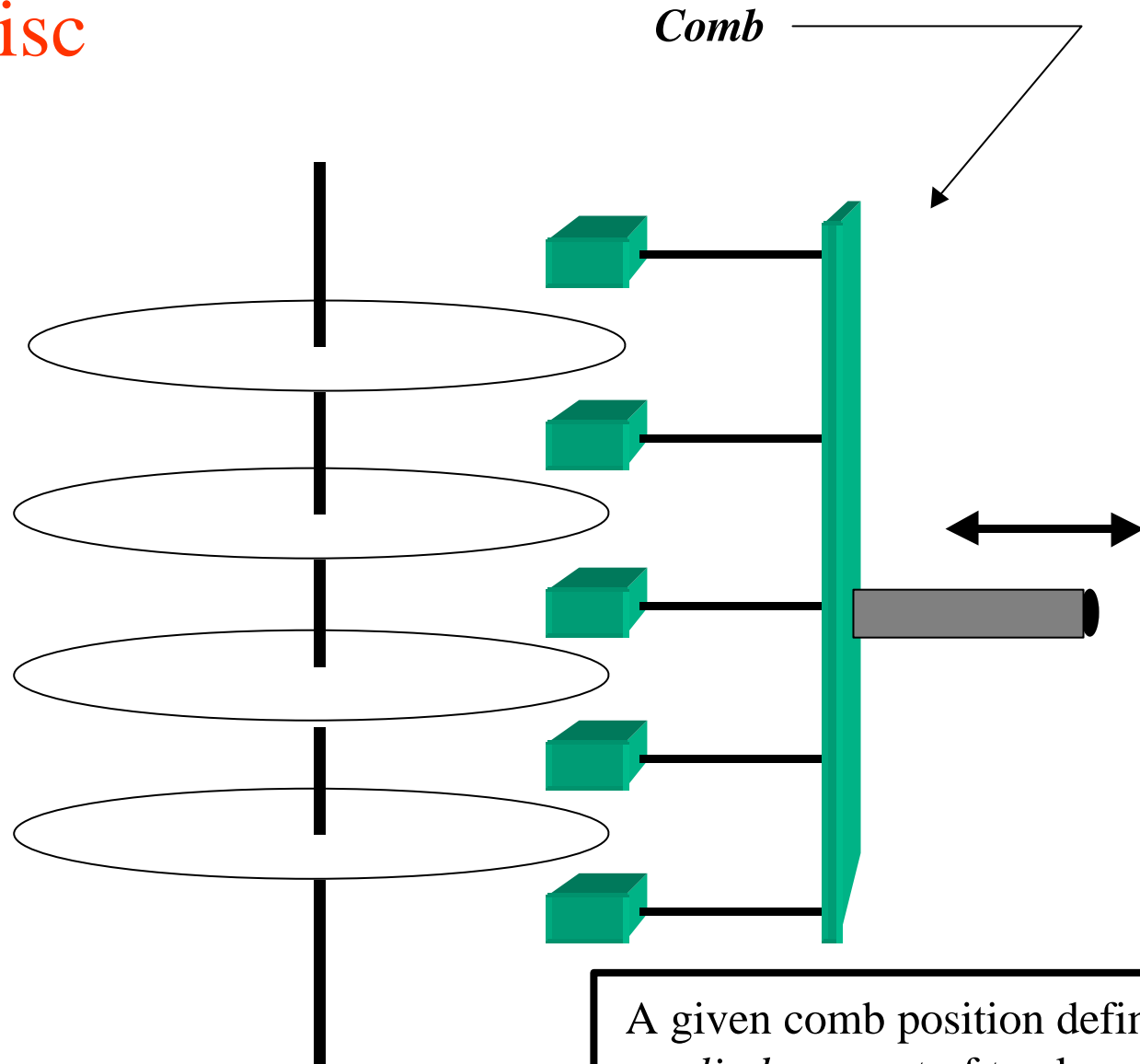
- The most popular form of Ms, by far
- steady price/performance improvements since IBM RAMAC (1962)

Disc how it works



disc

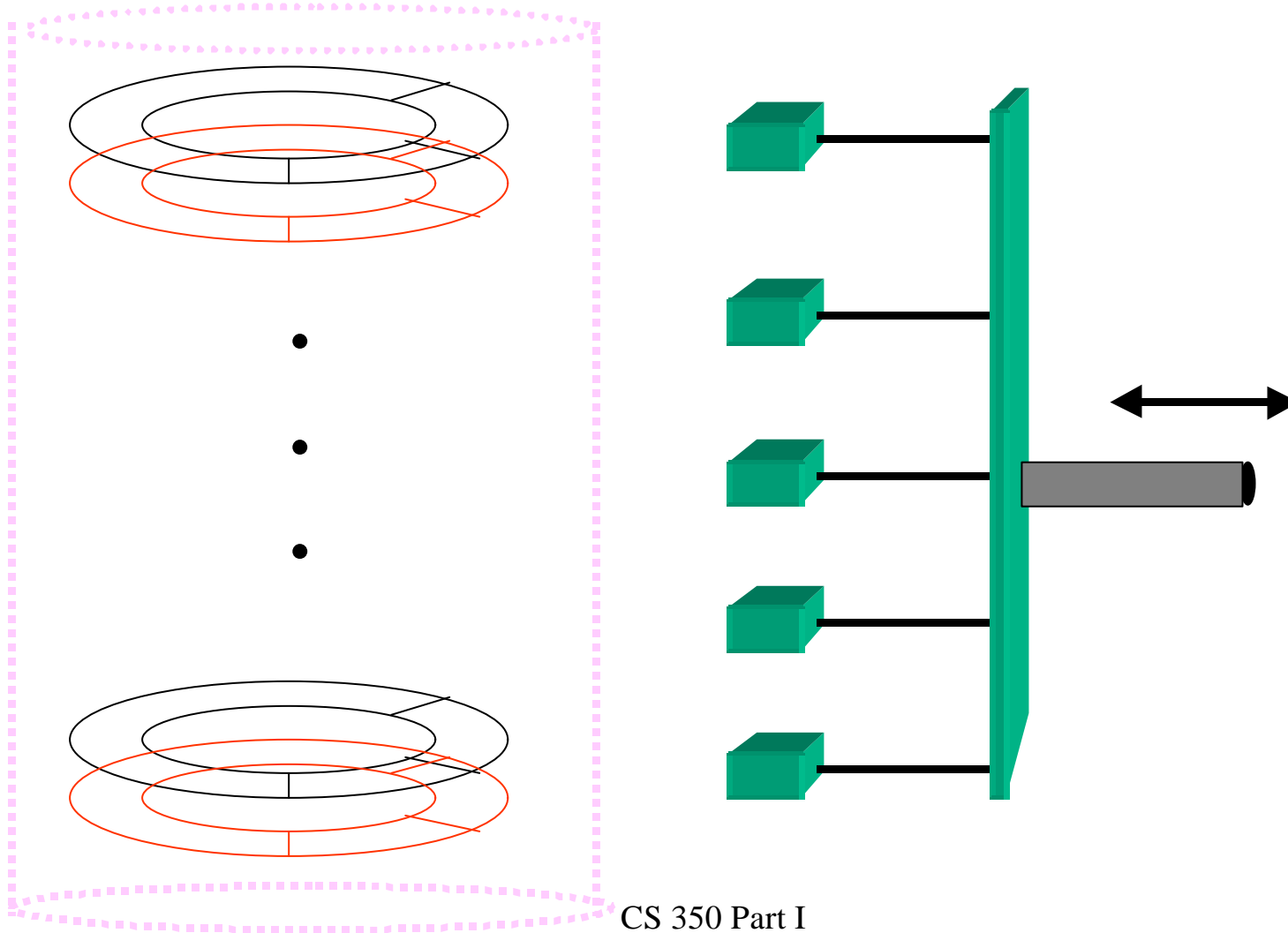
Multi platters
2 surfaces/platter
1 head / surface



Comb

A given comb position defines a *cylinder* - a set of tracks

Cylinder of disc storage



Disc flavours

- Hard platter, demountable pack
- Hard platter, not-demountable (Winchester)
- soft platter (floppy)

Disc: 1980 vs. 1995

• Name	DEC RP11 C demountable
• Vintage	1980
• Capacity	40 Mbyte
• transfer	3.75 msec / byte
• rotation	25 msec /rotation
• head move	(7.5 , 55) msec
• sfces/drive	20
• tracks/sfce	400
• sectors/trk	10
• bytes/sector	512
• bit density	2200 bpi
• price	\$20 000

• Name	London Drugs Winchester
• Vintage	1995
• Capacity	1 Gbyte
• transfer	1 msec / byte
• access time	8 - 12 msec
• sfces/drive	
• tracks/sfce	
• sectors/trk	
• bytes/sector	
• bit density	
• price	\$1500

And on to 1997 . . .

- **Name** Fujitsu
- **Winchester**
- **Vintage** 1997
- **Capacity** 9 Gbyte
- **transfer** 1 msec / byte est.
- **access** 8 - 12 msec est
- **sfces/drive**
- **tracks/sfce**
- **sectors/trk**
- **bytes/sector**
- **bit density**
- **price** \$3 000

- **Name** IBM 9394
Winchester
- **Vintage** 1995
- **Capacity** 90 Gbyte
- **transfer** 0.06 msec /byte
- **access** 4 - 16 msec
- **bit density**
- **price** \$400 000
- **note** multiple 2-Gb
drives, RAID,
cached, attached
via fibre-optic
channel

And on to 2001. . .

• Name	Fujitsu
• Winchester	
• Vintage	2001
• Capacity	5 Gb
• transfer	1 msec / byte est.
• access	8 - 12 msec est
• sfces/drive	
• tracks/sfce	
• sectors/trk	
• bytes/sector	
• bit density	
• price	\$500 [London Drugs]

- Approximately \$100 per Gigabyte or

10 cents per Megabyte

Floppy platter, demountable

- **Name** **PERSCI**
- **Vintage** **1980**
- **Capacity** **0.5 Mbyte**
- **transfer** **300 msec/ word**
- **rotation** **few msec**
- **head move** **10 - 100 msec**
- **sfces/drive** **2**
- **tracks/sfce**
- **sectors/trk**
- **bytes/sector**
- **bit density**
- **price** **\$1600**

- **Name** **generic**
- **Vintage** **1995**
- **Capacity** **1.5 Mbyte**
- **transfer** **100 msec**
- **rotation**
- **head move** **10 - 100 msec**
- **sfces/drive**
- **tracks/sfce**
- **sectors/trk**
- **bytes/sector**
- **bit density**
- **price** **\$100 - \$200**

Novel Ms: Magneto-optical

- **Name**
- **Vintage** **1995**
- **Capacity** **200 - 500 Mbyte**
- **transfer** **0.2 msec / byte**
- **access** **40 msec**
- **sfces/drive**
- **tracks/sfce**
- **sectors/trk**
- **bytes/sector**
- **bit density**
- **price**

CD - ROM

- **Name**
- **Vintage**
- **Capacity** **650 Mbyte**
- **transfer** **1 msec / byte**
- **access** **100 - 200 msec**
- **sfces/drive** **1**
- **tracks/sfce**
- **sectors/trk**
- **bytes/sector**
- **bit density**
- **price** **\$400 (1995) --> \$100 (2001)**

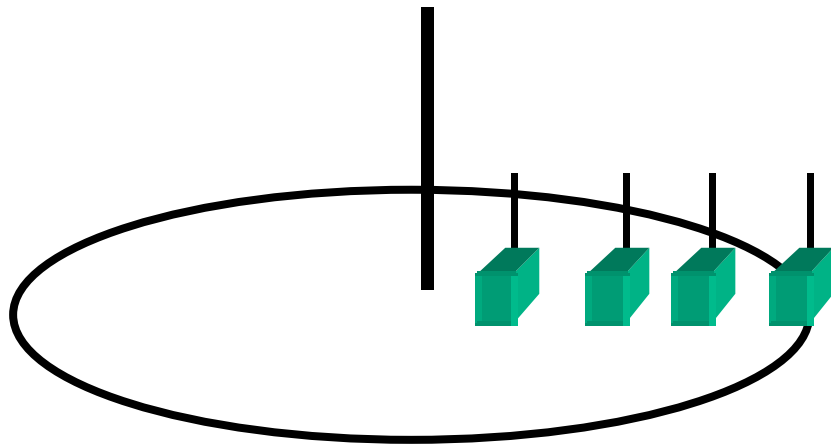
PH break

Sec 8.3

- I/O devices

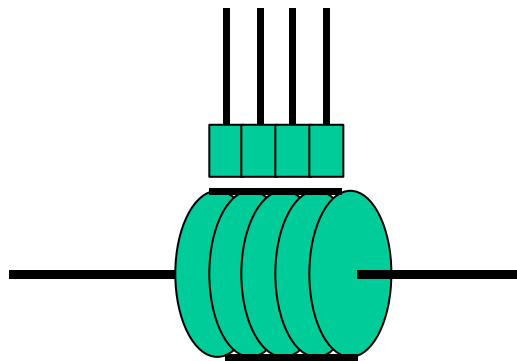
Head-per-track Disc

- One head per track
- no comb motion, so $T_{\text{seek}} = 0$



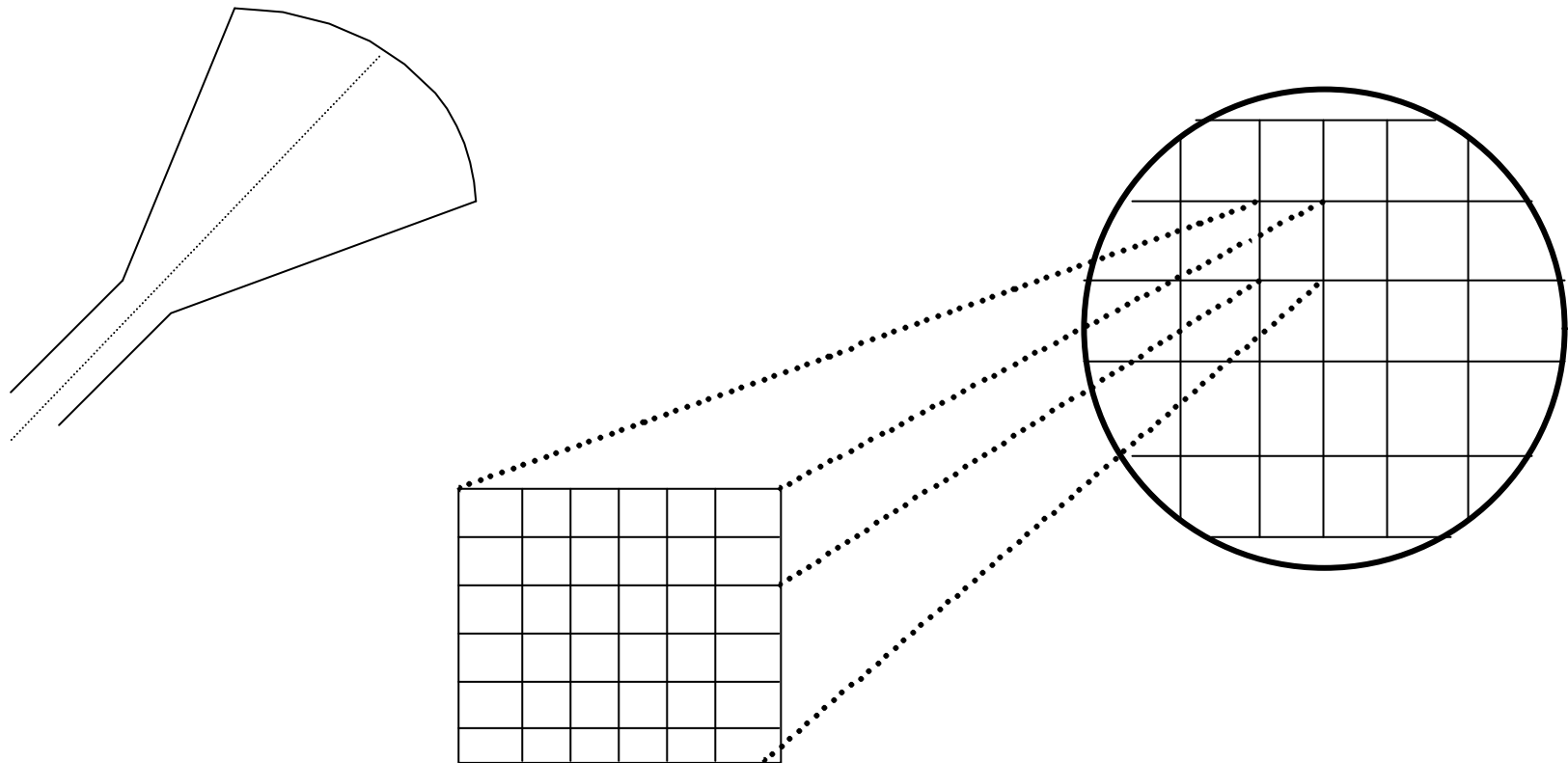
Head-per-track disc

- formerly built as a *drum*
- useful for
 - swap device for heavy cpu multiplexing
 - Ms for real-time computing



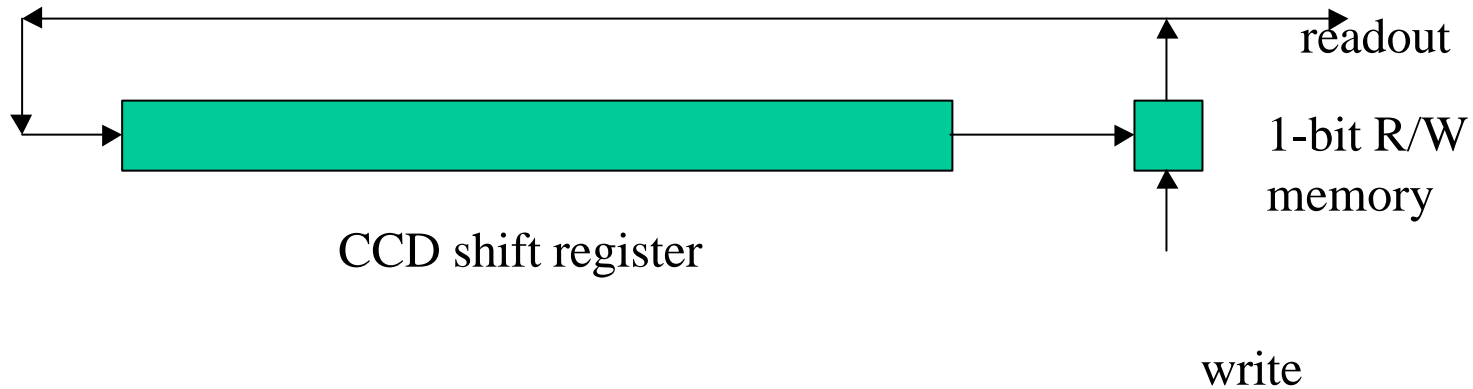
Sincere,
ingenious,
but
unsuccessful
attempts
to dethrone
magnetic secondary storage

Optical Ms (Ketchledge's Folly)

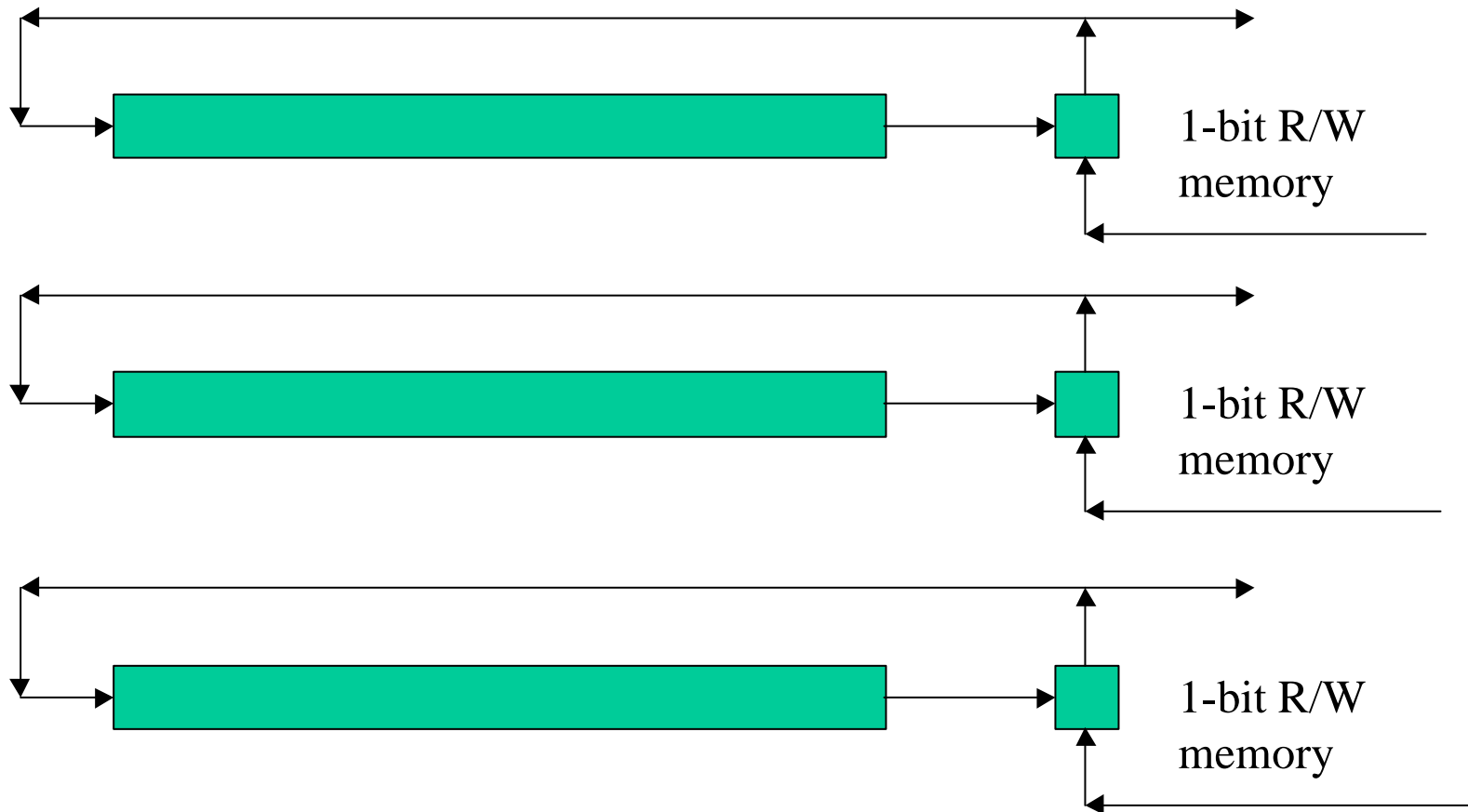


Charged-coupled Devices

- Provides cheap shift registers



Solid-state drum!



Mass Storage Systems

- What is it?
 - Capacity > 1 terabyte, i.e. 10^2 discs
 - $T_{\text{access}} < 10$ seconds

Examples

- IBM 1360 Photodigital store
 - Digital photography on chips
- Grumman Masstape robot
 - \$400K, $14 \cdot 10^9$ bytes
 - magnetic tape

Mass stores 1995

Exabyte EXB-120

- 116 tapes, 8mm, scanned helically
- capacity: 10 Gbyte/ tape => 1.16 Terabyte
- cost approx. \$200K

- how to update information?

