

## Unit 5: Memory Organizations

### Introduction

This unit considers the organization of a computer's memory system. The characteristics of the most important storage technologies are described in detail. Basically memories are classified as main memory and secondary memory. Main memory with many different categories are described in Lesson 1. Lesson 2 focuses the secondary memory including the details of floppy disks and hard disks.

### Lesson 1: Main Memory

#### 1.1 Learning Objectives

On completion of this lesson you will be able to :

- describe the memory organization
- distinguish between ROM, RAM, PROM, EEPROM and
- other primary memory elements.

#### 1.2 Organization

Computer systems combine binary digits to form groups called words. The size of the word varies from system to system. Table 5.1 illustrates the current word sizes most commonly used with the various computer systems. Two decades ago, IBM introduced their 8-bit PC. This was followed a few years later by the 16-bit PC AT microcomputer, and already it has been replaced with 32- and 64-bit systems. The machine with increased word size is generally faster because it can process more bits of information in the same time span. The current trend is in the direction of the larger word size.

*Memory Organization*

*Several types of semi-conductor memories.*

Microcomputer main memories are generally made up of many individual chips and perform different functions. The ROM, RAM, PROM, and EEPROM memories are used in connection with the primary memory of a microcomputers. The main memory generally store computer words as multiple of bytes; each byte consisting of eight bits.

## ROM

ROM (or read only memory) is used for storing program and data for applications. The data and programs required for such applications are permanently stored in the chip. Thus a user may read a program or data from ROM but may not write on ROM. The content of ROM is not

Table 5.1 Typical computer word lengths

WORD SIZE (BITS)	MICROCOMPUTERS	MINICOMPUTERS	MAINFRAME COMPUTER SYSTEMS
8	Many	None	None
12	None	A few	None
16	Many	A few	A few
18	None	A few	A few
24	A few	A few	A few
32	Most common	Most common	Most common
64	A few	A few	Many

*ROM (or read only memory) is used for storing program and data for applications.*

altered when power is removed from the computer. It is therefore referred to as nonvolatile memory. ROM is generally used to store programs, routines, and language interpreters for immediate access by the user of the system. Such programs usually supplied by the manufacturer referred to as firmware. For example, many microcomputers are supplied with ROM chips that contain the BASIC language. Now C/C+ is also used for ROM.

## RAM

RAM (or random-access memory) is general storage that can be read from or written into by the user. RAM is used primarily to store user programs and data. The contents of RAM are generally volatile, and is lost when power is removed. When the system is powered up, programs and data to be used must be read into RAM through an input device. Access time for data stored in RAM generally range from a microsecond to a few nanoseconds.

*RAM stores user programs and data.*

Some laptop microcomputers utilize special MOS chips that draw almost no power and preserve their contents indefinitely using an internal battery. However, these low-power chips are more expensive than their high-power counterparts.

## PROM

*PROM (Programmable Read Only Memory).*

PROMs (or programmable read only memory) are blank chips which have nothing recorded on them. Once a series of instructions or data are recorded into the chip by a special programming device, the PROM chip permanently stores this information like ROM. The programming of the PROM chip is generally done by the manufacturer of the computer systems. PROM chips are used primarily to provide special purpose programs such as games and graphics, which can be plugged into the main computer board.

## EPROM

*EPROM (Erasable Programmable Read Only Memory).*

EPROM (or erasable programmable read only memory) chips can be programmed, as the PROM chips. But they can be erased and reprogrammed by a special programming device should it becomes necessary. The contents of an EPROM chip can be erased by exposing it to ultraviolet light. The light passing through a quartz window in the plastic container exposes the silicon chip that contains memory cells storing information.

## EEPROM

*EEPROM (Electrically Erasable Programmable Read Only Memory).*

EEPROM (or electrically erasable programmable read only memory) is similar to EPROM except that it is erased by applying electrical pulses to the chip. It is possible to reprogram an EEPROM chip via keyboard commands without removing the chip from the computer.

### 1.3 Exercise

#### 1. Multiple choice questions

- a. Word of a computer system is a combination of
  - (i) Bytes
  - (ii) Bits
  - (iii) Characters
  - (iv) Symbols.
  
- b. Which one is the permanent primary storage?
  - (i) RAM
  - (ii) EPROM
  - (iii) ROM
  - (iv) CPU.
  
- c. Which of the following statement is true for EPROM?
  - (i) Electrically programmable read only memory.
  - (ii) Erasable programmable read only memory.
  - (iii) Extended programmable read only memory.
  - (iv) Extended programmable write only memory.

#### 2. Questions for short answers

- a. What is meant by computer word?
- b. What is the basic difference between.
  - (i) ROM and RAM
  - (ii) EPROM and EEPROM?

#### 3. Analytical question

- a. Describe different primary storage of computer systems.

## Lesson 2: Secondary Memory

### 2.1 Learning objectives

On completion of this lesson you will be able to

- understand the importance of the requirements of secondary storage
- know the characteristics of different secondary storage.

### 2.2 Secondary Memory

Secondary storage is nonvolatile that is information stored in it is not lost when power is turned off. It is also cost-efficient. It is possible to have a lot of secondary storage for the cost of a little RAM.

*Secondary storage is nonvolatile that is information stored in it is not lost when power is turned off.*

One reason for this cost differences is speed. A computer transfers instructions and data between the CPU and RAM. These exchanges of instructions and data takes place continually as the computer is used. The computer also transfer instructions and data between RAM and secondary storage. However, these transfers are far less frequent, and hence they do not directly affect the overall performance of the system. Transfers between the CPU and RAM are generally measured in nanoseconds, whereas transfers between secondary storage and RAM are generally measured in milliseconds.

### Magnetic Tape, Cassettes and Cartridges

Magnetic medium is one of the popular storage as secondary storage. A magnetic medium used with or personal computer is the tape cassette or cartridge. Computer audio cassettes are virtually the same as the standard variety of audio cassette. They differ only in the sense that computer cassettes generally do not have a leader that is nonmagnetically coated beginning segment. Many microcomputers are equipped with standard interfaces to convert the cassette audio signals to computer-acceptable binary signals. Thus virtually any cassette player/recorder can be connected to a microcomputer to record data into or retrieve data from a cassette.

*A magnetic medium is the tape, cassette or cartridge.*

These devices are capable of sending and receiving data at different rates, called the baud rate. If the signal is changed 300 times in a second, for example, the baud rate is 300. Baud rates of 500, 1,200, 2,400 and 9,600 are used.

Some microcomputers utilize digital cassettes. The digital cassette differs from the audio cassette only in the way data are recorded on it. Audio cassette records data in the form of audio tones, whereas, digital cassettes record data in the form of magnetic spots representing binary 1s and 0s. The storage capacity and cost of a digital cassette can be several times that of an audio cassette. The principal use of digital cassettes is a back up medium for high-capacity hard (or fixed) disk storage units.

For a magnetic medium such as a cassette or cartridge some degree of protection is provided against accidental erasure. Data stored on a magnetic medium can be lost if exposed to a strong magnetic field. Thus the magnetic media should be kept away from such fields. It is possible that a cassette or cartridge could be accidentally inserted into a cassette recorder player and written on. To allow some degree of protection against accidental erasure, it can be file protected. A small tab is provided on all cassette and cartridges, the tab should be broken to prevent it from being written on. Once this tab is removed, the cassette or cartridge may only be read and cannot be written on.

The main advantages of the tape medium is simplicity and low cost. On the other hand, its disadvantages include low speed, and that it can only read and write sequentially.

### **Floppy Disks**

The principal advantage of the floppy disk, or diskette, over the magnetic tape, cassette or cartridge is that the disk can be accessed directly. Any item of data or program stored on it can be accessed without accessing information stored previously. Floppy disk consists of a piece of magnetically coated mylar enclosed in a plastic or cardboard jacket (Figure 5.1). Floppy disks are generally available in either a 5.25 inch diameter or a 3.5 inch floppy diskette. The 5.25 inch diameter floppy disk, is sometimes referred to as a mini-floppy. The 3.5 inch disk is called a micro-floppy. Other than their outward appearance they are very similar.

*Floppy Disks*

The floppy disk is held in the center of a disk drive by a motor-driven shaft that spins the disk within its protective jacket at 300 to 360 rotations per minute (Figure 5.2). Data are read from or written onto the disk by a read/write head. This head moves in or out over the head-access slot in the jacket to access different tracks on the surface of the disk.

Like the magnetic tape cassettes, floppy disks can also be file protected. Figure 5.1 illustrates a mini-floppy diskette with a small rectangular

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cutout used for this purpose. If the cutout is left open, the floppy is not file protected and can be read and written onto. If, this cutout is covered by a small piece of self-adhering foil or paper, the floppy is file protected and can be read but cannot be written on. A self-contained plastic slide is used to file protect 3.5 inch micro-floppy diskettes.

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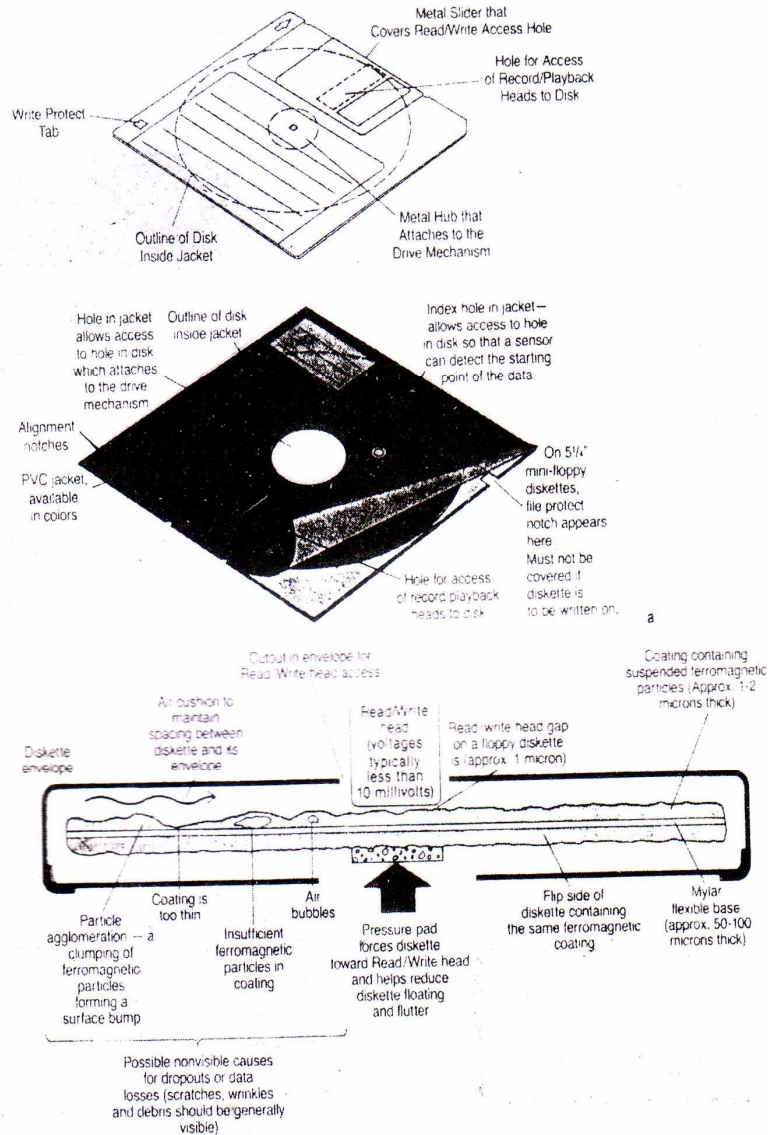


Figure 5.1: (a) Magnetic floppy disk physical characteristics.  
(b) Composition of a floppy disk.

Floppy disks are organized into sides, tracks, and sectors referred to as the format are used with 3.5 and 5.25 inch diskettes. The surface of some

micro diskettes are subdivided into 80 concentric circular areas or tracks and each track is divided onto 9 or 18 pie-shaped segments or sectors (Figure 5.3). Each sector contains two fields: i) a sector address field containing track, side, and sector numbers etc. and ii) the data field containing the user data.

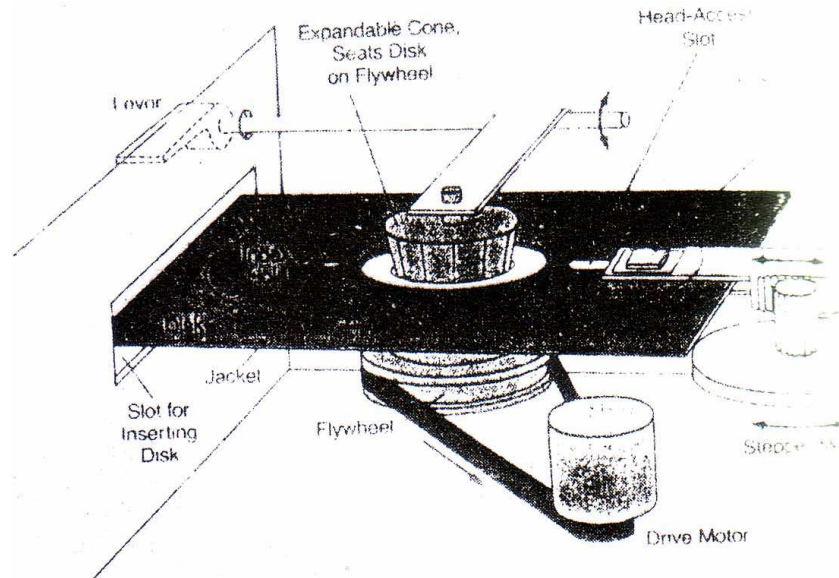


Figure 5.2 A floppy disk mounted in a floppy drive.

A number of steps are followed to access an item of data from a specific track and sector. The average access time for this process for soft-sectored mini-floppy is generally around 200 milliseconds. But this is slow when compared to access times on the microsecond and nanosecond range for RAM storage devices, but quite fast compared to the sequential access with cassettes.

### Hard Disk

For more capacity and faster access speeds than those with floppy disks, fixed or hard disk storage is used with microcomputers. The hard disk generally available for use with microcomputers (3.5 or 5.25 inch) is similar to those disks available with mini- and mainframe computer systems (usually 14-inch). However, unlike the hard disks for the larger computer systems, the hard disks for the microcomputers are generally not removable. Their storage capacity can range from hundred megabytes to several gigabytes.

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Disk cartridges, which are removable hard disks housed within a cartridge, are also available. These cartridges are in different capacities beginning with 20 megabytes.



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IBM PS and Compatibles Soft-Sector'd Double-Sided Double-Density Format 40 Tracks, 9 Sectors, 512 Bytes/ Sector

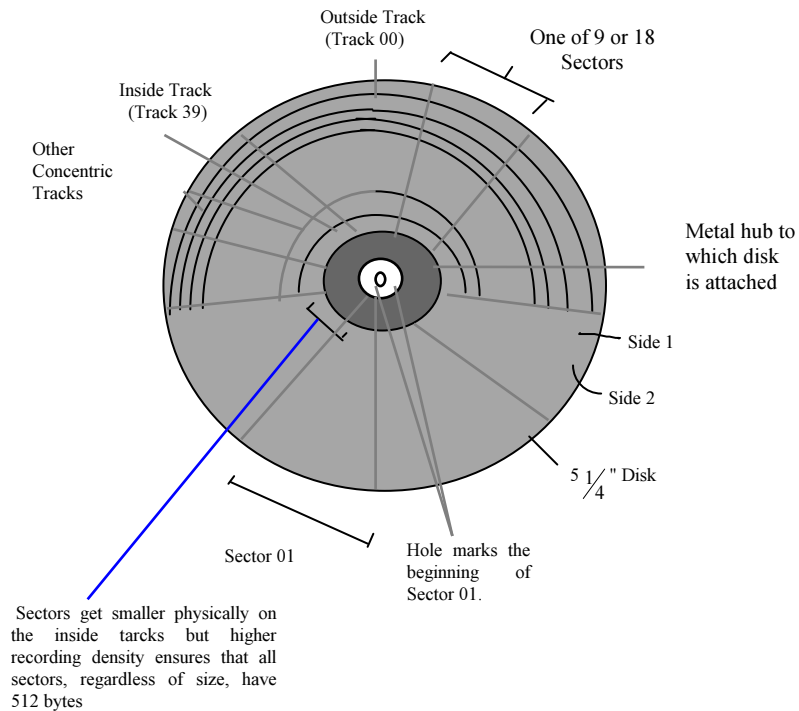


Figure 5.3: The most common 3.5 inch and 5.25 inch diskette formats are used with IBM and compatible microcomputers.

## RAM Disk

*RAM disk is a block of memory treated as a disk by the operating systems.*

Physically, a RAM disk is not a disk at all. It is a block of memory treated as a disk by the operating systems. A program used to specify the size of the memory block allocated to the RAM disk and to assign a logical drive to the RAM disk. Any read or write operation for RAM disk drive is converted by the operating system to a read or write to the designated block of memory. The RAM disk appears to be a super-fast floppy or hard disk. However, it is volatile; its contents are lost when power is removed. The contents of the RAM disk should be copied to a CD, Pendrive, floppy or hard disk before turning the computer off.

# Computer Basics

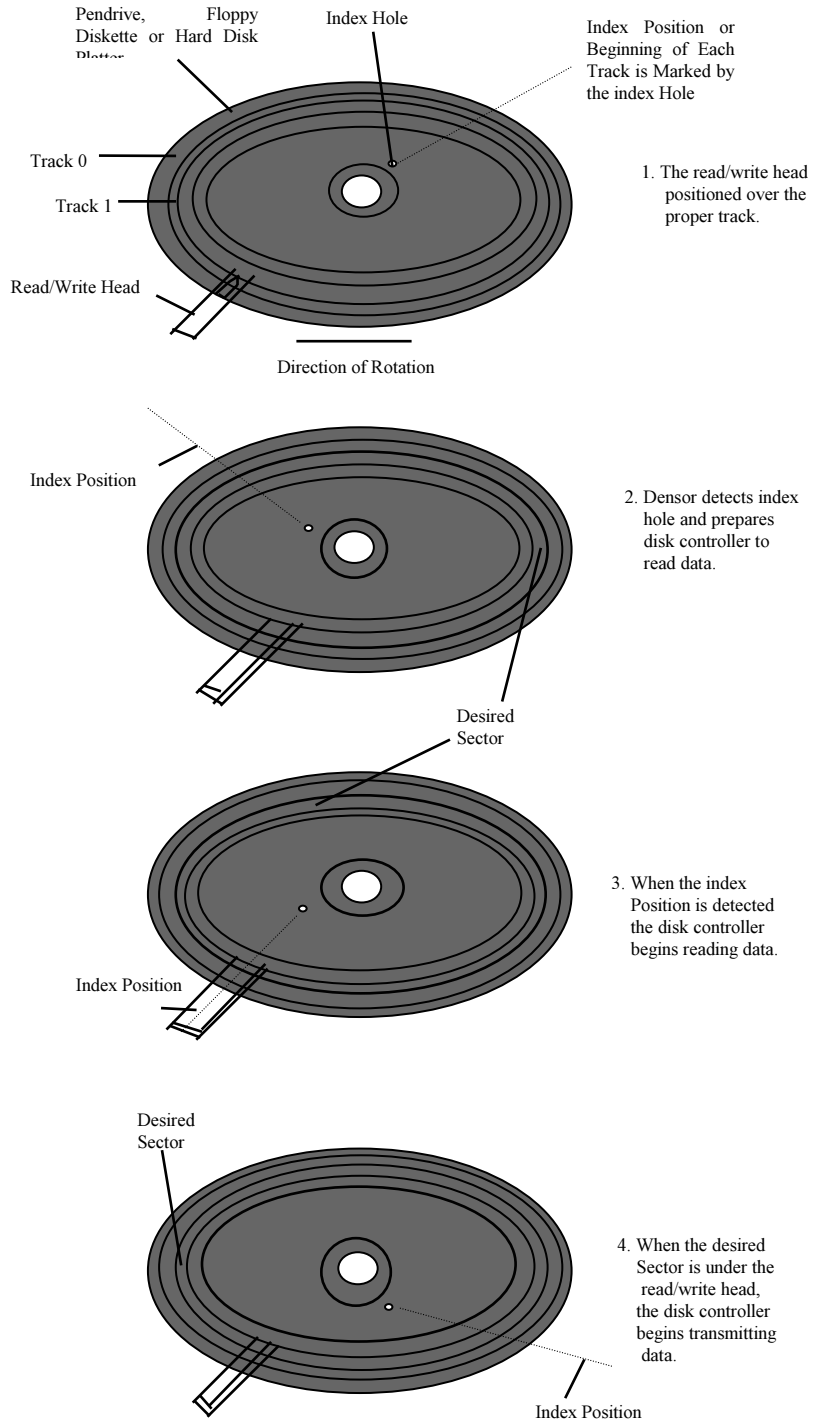


Figure 5.4: Accessing data from a particular track and sector.

## Optical Disk

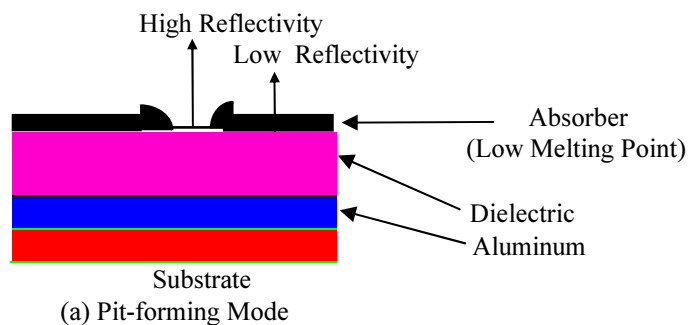
### Nonerasable Optical Disks

#### *Nonerasable Optical Disks*

Optical disks have been used for music, videos and audio recording for some time. Like the magnetic disks, data on optical disk is recorded in sectors within tracks. The recording technique commonly used with optical disks prohibits new data from being recorded over the old. This is because the physical makeup of the disk is altered during the writing process.

Writing is accomplished by momentarily directing a laser beam on the surface of the disk. The laser beam causes a change in the nature of the surface approximately one micron (millionth of an inch) in diameter. This change generally takes on two forms: it can be a small indentation in the surface of the disk, referred to as a pit, or it can be a bubble on the surface (Figure 5.5). To read an optical disk light is focused on a tiny area of the surface of the disk passing below the read head. The intensity of the light reflected from this spot is monitored by a light sensor of the read head. If the light reflected from this spot is of a high intensity, the surface contains a pit or a bubble; otherwise it is smooth.

Some optical systems allow the user to write data once and read many times. These systems are called WORM (write once read many) systems. CD-ROM (compact disk/read only memory) systems can only read prerecorded disks. These systems are practical for large and universally used common databases such as books, journal, documents and images etc.



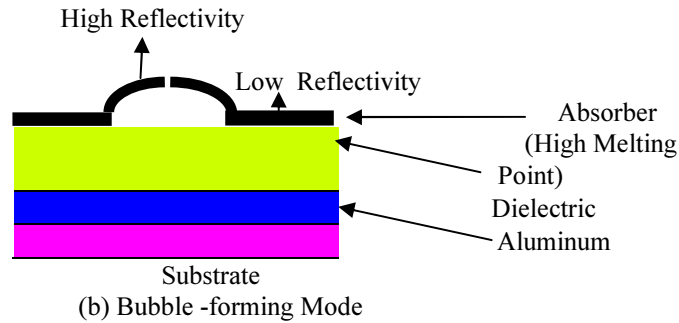


Figure 5.5: Result of laser burst in optical recording process.

The life expectancy of data stored optically is approximately three times the shelf life of magnetically recorded information. In addition since there are no heads flying above the surface, there is no possibility of heads colliding with the disk surface. Optical media have an enormous storage capacity, ten to thirty times that of magnetic media. For example, up to 100 gigabytes (1 gigabyte = 1 billion bytes) can be stored on a 14-inch disk. Optical disks are ideal for storing large volumes of relatively permanent data such as high-resolution graphics, photographic images, or huge volumes of text.

### Erasable Optical Disks

A recording technique that combines optical and magnetic technologies has produced an erasable optical disk. This technique utilizes a laser beam to heat a minute spot on the disk, altering its properties so that it can be magnetized by a magnetic field applied simultaneously. A magnetic field alone does not affect the data stored on the surface of the disk. However, applying the laser beam to the surface without a magnetic field erases the data recorded within the range of the laser beam. This device is not a replacement for magnetic media, but a replacement for microfilm, microfiche, and paper document and for the storage of massive files and databases beyond the capacity of magnetic media.

*A recording technique that combines optical and magnetic technologies has produced an erasable optical disk.*

### Magnetic Bubble and Charged-Coupled Devices

Magnetic bubble and charged-coupled memory devices are used with some microcomputers. A magnetic bubble is a negatively charged magnetic field in a positively charged magnetic film. The charged-coupled device (CCD) is made up of many microscopic capacitors capable of holding a charge for a short period of time. The presence of a charge represents a binary 1 and the absence of the charge represents a 0.

*A magnetic bubble is a negatively charged magnetic field in a positively charged magnetic film.*

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*The charged-coupled device (CCD) is made up of many microscopic capacitors.*

There are reasons for choosing these storage devices over the readily available electromechanical secondary storage devices, such as the tape cassette or floppy disk. Bubble and CCD devices are not as affected by extreme environments (heat, cold, humidity, etc.), have a much lower incidence of maintenance, and are much faster. Of the two, bubble memory is more desirable because of its greater storage capacity and nonvolatility. CCDs are volatile, but are faster than magnetic bubble devices.

High-speed data acquisition and critical program storage are the typical areas of application for these secondary-storage devices. In these applications, data can be collected and stored in the bubble. These data can then be loaded into RAM for subsequent processing, making the magnetic bubble ideally suited for use in a distributed data processing environment.

## 2.3 Exercise

### 1. Multiple choice questions

- a. Secondary storages are
  - (i) Nonvolatile
  - (ii) Volatile
  - (iii) None of them.
  
- b. In-terms of speed secondary storages as compared to primary storages are:
  - (i) Slower
  - (ii) Faster
  - (iii) Similar
  - (iv) None of them.
  
- c. Which one is true for WORM?
  - (i) write once and read many.
  - (ii) write once and record many
  - (iii) work once and read many
  - (iv) work once and result many.

### 2. Questions for short answers

1. What is the use of secondary storage in a computer system?
2. What is meant by tracks and sectors of disk?
3. What is a RAM disk?
4. What the following acronym stands for?  
(i) CD-ROM (ii). WORM (iii) CCD.

### 3. Analytical questions

1. Describe hard disk.
2. What is CD-ROM? Describe optical disk.