**A**

**Seminar report**

**On**

# Computer Peripheral

Submitted in partial fulfillment of the requirement for the award of degree of Bachelor of Technology in Computer Science

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# Acknowledgement

I would like to thank respected Mr…….. and Mr. ……..for giving me such a wonderful opportunity to expand my knowledge for my own branch and giving me guidelines to present a seminar report. It helped me a lot to realize of what we study for.

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Last but clearly not the least, I would thank The Almighty for giving me strength to complete my report on time.

# Preface

I have made this report file on the topic **Computer Peripheral** ; I have tried my best to elucidate all the relevant detail to the topic to be included in the report. While in the beginning I have tried to give a general view about this topic.

My efforts and wholehearted co-corporation of each and everyone has ended on a successful note. I express my sincere gratitude to ………….who assisting me throughout the preparation of this topic. I thank him for providing me the reinforcement, confidence and most importantly the track for the topic whenever I needed it.

# TABLE OF CONTENTS

## 1. INTRODUCTION

A computer words comes from 'compute', which means 'to calculate'.

**What is computer?**

Computer is an electronic device, which can deal both arithmetical and logical operation. Even though the size, shape, performance, reliability and cost of computers have been changing over the years. All computer systems perform the following five basic operations for converting raw input data into useful information and presenting it to a user:

- **Inputting** Process of entering data and instructions into a computer system.
- **Storing** Saving data and instructions to make them readily available for initial or additional processing as and when required.
- **Processing** Performing arithmetic operations (add, subtract, multiply, divide etc.) or logical operations (comparisons like equal to, less than, greater than, etc.**)** on data to concert them into useful information.
- **Outputting** Process of producing useful information or results for a user, such as printed report or visual display.
- **Controlling** Directing the manner and sequence in which the above operations are performed.

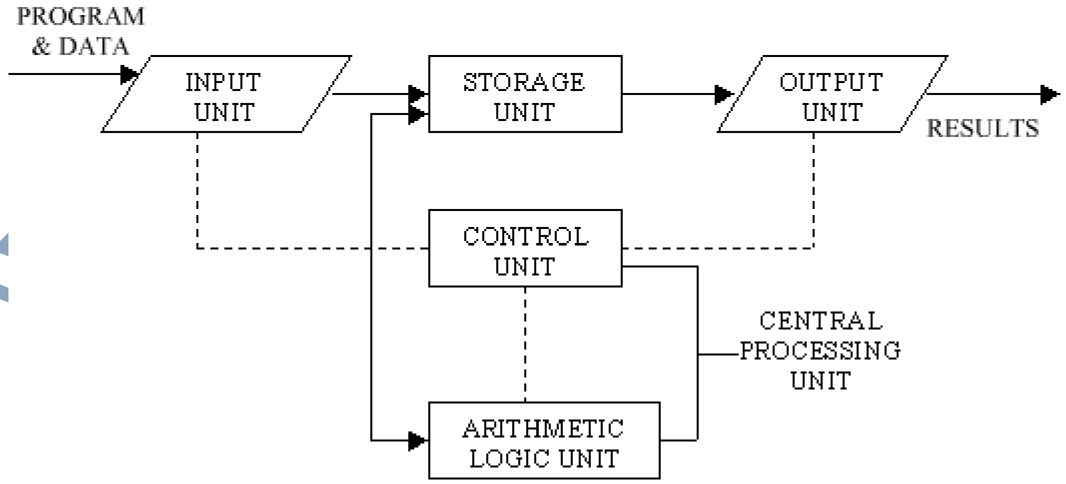



Fig 1.1 **Basic computer Operations**

So, over here we are talking about output devices.

## 2. OUTPUT DEVICES

Output devices perform the reverse operation of that of an input device. It supplies information obtained from data processing to outside world. Hence, it links a computer with its external environment. As computer work with binary code, results produced are also in binary form. Therefore, before supplying the results to outside world, the system must convert them to human acceptable form. Units called out put interfaces accomplish this task. Output interfaces match the unique physical or electrical characteristics of output devices to the requirements of an external environment.

An output unit performs following functions;

1. It accepts the results produced by a computer, which are in coded form and hence, we cannot easily understand them.
2. It converts these coded results to human readable form.
3. It supplies the converted results to outside world.

There are three types of output:

1. **Hard copy output.**
2. **Soft copy output.**
3. **Audio output.**

## *3.* Hard Copy Output

The physical form of output is known as hard copy. In general, it refers to the recorded information copied from a computer onto paper or some other durable surface, as microfilm. Hard copy output is permanent and a relatively stable form of output. This type of output is also highly portable. Paper is one of the most widely used hard copy output media. The principal examples are printouts, whether text or graphics, form printers. There are two types of hard copy output devices:

- **Printer**
- **Plotter**

### *3.1 Printer:*

A printer prints information and data from the computer on to a paper. Some printer produces only textual information whereas others can produce graphical as well.

Printers are divided two basic categories one is Impact printer and other is Non-impact printer.

**Printer**

Impact Printer | Non-Impact Printer

### *3.1.1 Impact printer:*

Impact printers work by physically striking a head or needle against an in ribbon to make a mark on the paper. For example:

**a. Dot Matrix Printer**
**b. Daisy Wheel Printer**
**c. Drum Printer**
**d. Chain/Band printer**

### *a. Dot Matrix Printer:*

In the 1970s and 1980s, dot matrix impact printers were generally considered the best combination of expense and versatility, and until the 1990s they were by far the most common form of printer used with personal computers

Dot-matrix printers can be broadly divided into two major classes:

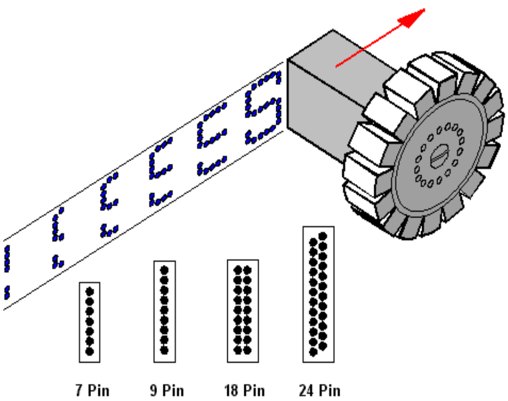
- Ballistic wire printers
- Stored energy printer

Dot matrix printers can either be character-based or line-based (that is, a single horizontal series of pixels across the page), referring to the configuration of the print head.

At one time, dot matrix printers were one of the more common types of printers used for general use — such as for home and small office use. Such printers would have either 9 or 24 pins on the print head. 24-pin print heads were able to print at a higher quality. Once the price of inkjet printers dropped to the point where they were competitive with dot matrix printers, dot matrix printers began to fall out of favor for general use.

Some dot matrix printers, such as the NEC P6300, can be upgraded to print in color. This is achieved through the use of a four-color ribbon mounted on a mechanism (provided in an upgrade kit that replaces the standard black ribbon mechanism after installation) that raises and lowers the ribbons as needed. Color graphics are generally printed in four passes at standard resolution, thus slowing down printing considerably. As a result, color graphics can take up to four times longer to print than standard monochrome graphics, or up to 8-16 times as long at high resolution mode.

Dot matrix printers are still commonly used in low-cost, low-quality applications like cash registers, or in demanding, very high volume applications like invoice printing. The fact that they use an impact printing method allows them to be used to print multi-part documents using carbon copy paper (like sales invoices and credit card receipts), whereas other printing methods are unusable with paper of this type. Dot-matrix printers are now (as of 2005) rapidly being superseded even as receipt printers.



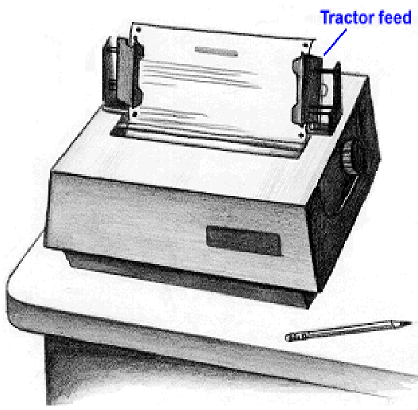



Fig. 3.1.1 Dot Matrix Mechanism

Fig. 3.1.2 Dot Matrix Printer

## *How Dot matrix printer works?*

The technology behind dot matrix printing is quite simple. The paper is pressed against a rubber-coated cylinder and is pulled forward as printing progresses. The printer consists of an electro-magnetically driven print head, which is made up of numerous print wires. The characters are formed by moving the electro-magnetically driven print head across the paper, which strikes the printer ribbon situated between the paper and print head pin. As the head stamps onto the paper through the inked ribbon, a character is produced that is made up of these dots. These dots seem to be very small for the normal vision and appear like solid human-readable characters.

## *Advantages and disadvantages of dot matrix printer*

- ***Advantages***

Dot matrix printers, like any impact printer, can print on multi-part stationery or make carbon-copies. Impact printers have one of the lowest printing costs per page. As the ink is running out, the printout gradually fades rather than suddenly stopping partway through a job. They are able to use continuous paper rather than requiring individual sheets, making them useful for data logging. They are good, reliable workhorses ideal for use in situations where printed content is more important than quality. The ink ribbon also does not easily dry out, including both the ribbon stored in the casing as well as the portion that is stretched in front of the print head; this unique property allows the dot-matrix printer to be used in environments where printer duty can be rare, for instance, as with a Fire Alarm Control Panel's output.

- ***Disadvantages***

Impact printers are usually noisy, to the extent that sound dampening enclosures are available for use in quiet environments. They can only print low resolution graphics, with limited color performance, limited quality and comparatively low speed. While they support fanfold paper with tractor holes, single-sheet paper usually has to be wound in and aligned by hand, which is relatively inconvenient and time-consuming. While far better suited to printing on labels than a laser printer or an inkjet printer, they are prone to bent pins (and therefore a destroyed print head) caused by printing a character half-on and half-off the label; for text-only labels (i.e. mailing labels), a daisy wheel printer offers most of the advantages of a dot matrix, with better print quality and a lesser chance of being damaged.

# Future of dot-matrix printers

The main use of dot-matrix printers is in areas of intensive transaction-processing systems that churn out quite a lot of printing. Many companies who might have started off with dot-matrix printers are not easily convinced to go for printers based on other technologies because of the speed advantage of dot-matrix printers.

## b. Daisy wheel printer

Daisy wheel printing is an impact printing technology invented in 1969 by David S. Lee at Diablo Data Systems. It uses interchangeable pre-formed type elements, each with 96 glyphs, to generate high-quality output comparable to premium typewriters such as the IBM "Golf ball" Selectric, but three times faster. Daisy-wheel printing was used in electronic typewriters, word processors and computer systems from 1972.
By 1980 daisy-wheel printers had become the dominant technology for high-quality print. Dot-matrix impact or thermal printers were used where higher speed was required and poor print quality was acceptable. Both technologies were rapidly superseded for most purposes when dot-based printers—in particular laser printers—that could print any characters or graphics rather than being restricted to a limited character set became able to produce output of comparable quality. Daisy-wheel technology is now found only in some electronic typewriters.

### Description of daisy wheel printer

The heart of the system is an interchangeable metal or plastic "daisy wheel" holding an entire character set as raised characters moulded on each "petal". In use a servo motor rotates the daisy wheel to position the required character between the hammer and the ribbon. The solenoid-operated hammer then fires, driving the character type on to the ribbon and paper to print the character on the paper. The daisy wheel and hammer are mounted on a sliding carriage similar to that used by dot matrix printers.
Different typefaces and sizes can be used by replacing the daisy wheel. It is possible to use multiple fonts within a document: font changing is facilitated by printer driver software which can position the carriage to the center of the platen and prompt the user to change the wheel before continuing printing. However, printing a document with frequent font changes and thus required frequent wheel changes was still an arduous task.
Many daisy wheel machines offer a bold type facility, accomplished by double- or triple-striking the specified character(s); servo-based printers advance the carriage fractionally for a wider (and therefore blacker) character, while cheaper machines perform a carriage return without a line feed to return to the beginning of the line, space through all non-bold text, and restrict each bolded character. The inherent imprecision in attempting to restrict on exactly the same spot after a carriage return provides the same effect as the more expensive servo-based printers, with the unique side effect that as the printer ages and wears, bold text becomes bolder.

### History of daisy wheel printer

In 1972 a team at Diablo Systems led by engineer David S. Lee developed the first commercially successful daisy-wheel printer, a device that was faster and more flexible than IBM's golf-ball devices, being capable of 30 cps (characters per second), whereas IBM's Selectric operated at 10 cps.

Xerox acquired Diablo that same year, following which Lee departed to set up Qume Corporation in 1973. Xerox's Office Product Division had already been buying diablo printers for its Redactron text editors. After 7 years trying to make Diablo profitable, the OPD focused on developing and selling the Diablo 630 which was mostly bought by companies such as Digital

Equipment Corporation. The Diablo 630 was capable of producing letter quality output that was as good as that produced by an IBM Selectric or Selectric-based printer, but at a lower cost. A further advantage over the Selectric-based printers was that it supported the entire ASCII printing character set. Its servo-controlled carriage also permitted the use of proportional spaced fonts, where characters occupy a different amount of horizontal space according to their width.

The Diablo 630 was sufficiently successful that virtually all later daisy wheel printers, as well as many dot matrix printers and even the original Apple LaserWriter either copied its command set or could emulate one. Daisy wheel printers from Diablo and Lee's 1973 company Qume were the dominant high-end output technology for computer and office automation applications by 1980, though high speed non-impact techniques were already entering the market (e.g. IBM 6640 inkjet, Xerox 2700 and IBM 6670 laser). From 1981 onwards the IBM PC's introduction of "Code page 437" with 254 printable glyphs (including 40 shapes specifically for drawing forms), and development of Xerox Star-influenced environments such as the Macintosh, GEM and Windows made bit-mapped approaches more desirable, driving cost reductions for laser printing and higher resolution for impact dot matrix printing.

***How Daisy wheel printer works?***

These printers have print heads composed of metallic or plastic wheels. A raised character is placed on the tip of each of the daisy wheels ‘petals’. Each petal has an appearance of a letter (upper case and lower case), number or punctuation mark on it. To print, the print wheel is rotated around until the desired character is under the print hammer. The petal is then struck from behind by the print hammer, which strikes the character, pushing it against the ink ribbon, and onto the paper, creating the character.

# ***Advantages and disadvantages***

***Advantages***

Different typefaces and sizes can be used by replacing the daisy wheel. It is possible to use multiple fonts within a document. It produces high-resolution output and more reliable than dot matrix printers.

***Disadvantages***

Like all other impact printers, daisy wheel printers are noisy. It is slower and more expensive than dot matrix. It can not print graphics.

Fig.3.1.3. Metal Daisy Wheel for Xerox & Diablo printers

### *c. Chain printer*

An early line printer that used type slugs linked together in a chain as its printing mechanism. The chain spins horizontally around a set of hammers. When the desired character is in front of the selected print column, the corresponding hammer hits the paper into the ribbon and onto the character in the chain. Chain and train printers gave way to band printers in the early 1980s. It is line printers that print one line at a time. It consists of a metallic chain band on which all characters of the character set supported by the printer are embossed. A standard character set may have 48, 64 or 96 characters. In order to enhance printing speed, the characters in the character set are embossed several times on the chain. For example, the chain of a 64 character set printer may have four sets of 64 characters each embossed on it. In this case, the chain will have altogether 256 characters embossed on it.

The printer has a set of hammers mounted in front of the chain in a manner that an inked ribbon and paper can be placed between the hammers and chain. The total number of hammers is equal to the total number of print positions. Therefore, a printer supporting 132 print positions will have 132 hammers.

#### *How chain printer works?*

The chain in the chain printer rotates at a high speed. A character is printed at a desired print position by activating the appropriate hammer when the character embossed on the chain passes below it. Since the character set is repeated several times on the chain, it is not necessary to wait for the chain to make a complete revolution to position the desired character in the correct print position.

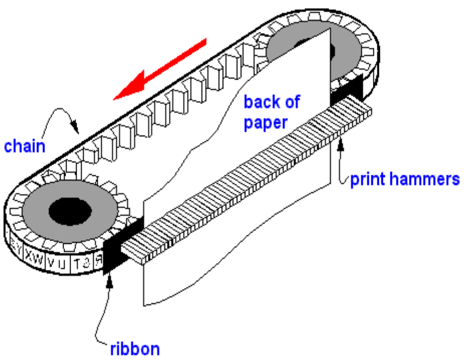



**Fig. 3.1.4 Chain printer Mechanism**

**Fig. 3.1.5 Chain printer**

# *Advantages and disadvantages*

***Advantages***

It is line printers that print one line at a time. Its cost is low. It can be print multiple copy.

***Disadvantages***

Like all other impact printers, chain printers are also noisy in operation and often use a cover to reduce the noise level.

## *d. Drum printer*

In a typical **drum printer** design, a fixed font character set is engraved onto the periphery of a number of print wheels, the number matching the number of columns (letters in a line) the printer could print. The wheels, joined to form a large drum (cylinder), spin at high speed and paper and an inked ribbon are stepped (moved) past the print position. As the desired character for each column passes the print position, a hammer strikes the paper from the rear and presses the paper against the ribbon and the drum, causing the desired character to be recorded on the continuous paper. Because the drum carrying the letterforms (characters) remains in constant motion, the strike-and-retreat action of the hammers had to be very fast. Typically, they were driven by voice coils mounted on the moving part of the hammer.

Often the character sequences are staggered around the drum, shifting with each column. This obviates the situation whereby **all** of the hammers fire simultaneously when printing a line that consists of the same character in all columns, such as a complete line of dashes ("----").

Lower-cost printers did not use a hammer for each column. Instead, a hammer was provided for every other column and the entire hammer bank was arranged to shift left and right, driven by another voice coil. For this style of printer, two complete revolutions of the character drum were required with one revolution being used to print all the "odd" columns and another revolution being used to print all of the "even" columns. But in this way, only half the number of hammers, magnets, and the associated channels of drive electronics was required.

Data products were a typical vendor of drum printers, often selling similar models with both a full set of hammers (and delivering, for example 600 lines-per-minute of output) and a half set of hammers (delivering 300 LPM).

***How Drum printer works?***

The basic of a line printer like drum printer is similar to those of a serial printer, except that multiple hammers strike multiple type elements against the paper almost simultaneously, so that an entire line is printed in one operation. A typical arrangement of a drum printer involves a large rotating drum mounted horizontally and positioned in front of a very wide, inked ribbon, which in turn is positioned in front of the paper itself. The drum contains characters mounded onto its surface in columns around its circumference; each column contains a complete set of characters (letters, digits, etc.) running around the circumference of the drum. The drum spins continuously at high speed when the printer is operating. In order to print a line, hammers positioned behind the paper ram the paper against the ribbon and against the drum beyond it at exactly the right instant, such that the appropriate character is printed in each column has been printed, the paper is advanced upward so that the next line can be printed.

## *Advantages and disadvantages*

### *Advantages*

It is line printers that print one line at a time. Its cost is high than dot matrix printer. It can be print multiple copies. Its speed is high than dot matrix and daisy wheel printer.

### *Disadvantages*

Like all other impact printers, drum printers are also noisy in operation. It is very expensive and its character fonts cannot be changed.



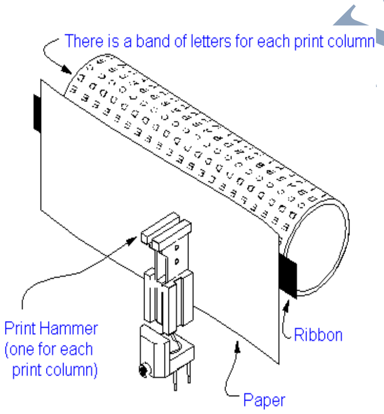



Fig. 3.1.6 Drum printer Mechanism

Fig. 3.1.7 Drum printer

### *3.1.2 Non-Impact printer:*

Non-Impact printers work by using techniques other than physically striking the page to transfer ink onto the page. For example:

a. **Laser Printer.**
b. **Inkjet Printer.**
c. **Thermal Printer.**

### *a. Laser printer*

A **laser printer** is a common type of computer printer that rapidly produces high quality text and graphics on plain paper. As with digital photocopier and multifunction printer (MFPs), laser printers employ a xerographic printing process but differ from analog photocopiers in that the image is produced by the direct scanning of a laser beam across the printer's photoreceptor.

#### *Overview*

A laser beam projects an image of the page to be printed onto an electrically charged rotating drum coated with selenium. Photoconductivity removes charge from the areas exposed to light. Dry ink (toner) particles are then electrostatic ally picked up by the drum's charged areas. The drum then prints the image onto paper by direct contact and heat, which fuses the ink to the paper.

Laser printers have many significant advantages over other types of printers. Unlike impact printers, laser printer speed can vary widely, and depends on many factors, including the graphic intensity of the job being processed. The fastest models can print over 200 monochrome pages per minute (12,000 pages per hour). The fastest color laser printers can print over 100 pages per minute (6000 pages per hour). Very high-speed laser printers are used for mass mailings of personalized documents, such as credit card or utility bills, and are competing with lithography some commercial applications.

The cost of this technology depends on a combination of factors, including the cost of paper, toner, and infrequent drum replacement, as well as the replacement of other consumables such as the fuser assembly and transfer assembly. Often printers with soft plastic drums can have a very high cost of ownership that does not become apparent until the drum requires replacement.

A duplexing printer (one that prints on both sides of the paper) can halve paper costs and reduce filing volumes. Formerly only available on high-end printers, duplexers are now common on mid-range office printers, though not all printers can accommodate a duplexing unit. Duplexing can also give a slower page-printing speed, because of the longer paper path.

In comparison with the laser printer, most inkjet printers and dot-matrix printer simply take an incoming stream of data and directly imprint it in a slow lurching process that may include pauses as the printer waits for more data. A laser printer is unable to work this way because such a large amount of data needs to output to the printing device in a rapid, continuous process. The printer cannot stop the mechanism precisely enough to wait until more data arrives, without creating a visible gap or misalignment of the dots on the printed page.

### *History*

The laser printer was invented at Xerox in 1969 by researcher Gary Starkweather, who had an improved printer working by 1971and incorporated into a fully functional networked printer system by about a year later. The prototype was built by modifying an existing xerography copier. Starkweather disabled the imaging system and created a spinning drum with 8 mirrored sides, with a laser focused on the drum. Light from the laser would bounce off the spinning drum, sweeping across the page as it traveled through the copier. The hardware was completed in just a week or two, but the computer interface and software took almost 3 months to complete.

The first commercial implementation of a laser printer was the IBM model 3800 in 1976, used for high-volume printing of documents such as invoices and mailing labels. It is often cited as "taking up a whole room," implying that it was a primitive version of the later familiar device used with a Personal computer. While large, it was designed for an entirely different purpose. Many 3800s are still in use.

The first laser printer designed for use with an office setting was released as the Xerox star 8010 in 1981. Although it was innovative, the Star was an expensive ($17,000) system that was purchased by only a relatively small number of businesses and institutions. After Personal computer became more widespread, the first laser printer intended for a mass market was the HP Leaser jet 8ppm, released in 1984, using a Canon engine controlled by HP software. The HP LaserJet printer was quickly followed by laser printers from Brother Industries, IBM, and others. First-generation machines had large photosensitive drums, of circumference greater than the paper length. Once faster-recovery coatings were developed, the drums could touch the paper multiple times in a pass, and could therefore be smaller in diameter.

### *How it works*

There are typically seven steps involved in the laser printing process:

#### *1. Raster image processing*

Generating the raster image data.

Each horizontal strip of dots across the page is known as a raster line or scan line. Creating the image to be printed is done by a Raster Image Processor (RIP), typically built into the laser printer. The source material may be encoded in any number of special page description languages such as Adobe PostScript (PS) , HP Printer Command language (PCL), or Microsoft XML Page Specification (XPS) , as well as unformatted text-only data. The RIP uses the page description language to generate a bitmap of the final page in the raster memory. Once the entire page has been rendered in raster memory, the printer is ready to begin the process of sending the rasterized stream of dots to the paper in a continuous stream.

#### *2. Charging*

Applying a negative charge to the photosensitive drum.

A corona wire (in older printers) or a primary charge roller projects an electrostatic charge onto the photoreceptor (otherwise named the photoconductor unit), a revolving photosensitive drum or belt, which is capable of holding an electrostatic charge on its surface while it is in the dark.

An AC bias is applied to the primary charge roller to remove any residual charges left by previous images. The roller will also apply a DC bias on the drum surface to ensure a uniform negative potential. The desired print density is modulated by this DC bias.

Numerous patents describe the photosensitive drum coating as a silicon sandwich with a photo charging layer, a charge leakage barrier layer, as well as a surface layer. One version uses amorphous silicon containing hydrogen as the light receiving layer, Boron nitride as a charge leakage barrier layer, as well as a surface layer of Doped Silicon, notably silicon with oxygen or nitrogen which at sufficient concentration resembles machining Silicon nitride; the effect is that of a light chargeable diode with minimal leakage and a resistance to scuffing.

**3. *Exposing***

How the bitmap is written to the photosensitive drum.

The laser is aimed at a rotating polygonal mirror, which directs the laser beam through a system of lenses and mirrors onto the photoreceptor. The beam sweeps across the photoreceptor at an angle to make the sweep straight across the page; the cylinder continues to rotate during the sweep and the angle of sweep compensates for this motion. The stream of rasterized data held in memory turns the laser on and off to form the dots on the cylinder. (Some printers switch an array of light emitting diode spanning the width of the page, but these devices are not "Laser Printers".) Lasers are used because they generate a narrow beam over great distances. The laser beam neutralizes (or reverses) the charge on the white parts of the image, leaving a static electric negative image on the photoreceptor surface to lift the toner particles.

A beam detects (BD) sensor is used to synchronize the laser sweeping process at the end of each sweep cycle.

***4. Developing***

The surface with the latent image is exposed to toner, fine particles of dry plastic powder mixed with carbon black or coloring agents. The charged toner particles are given a negative charge, and are electrostatically attracted to the photoreceptor's latent image, the areas touched by the laser. Because like charges repel, the negatively charged toner will not touch the drum where the negative charge remains.

The overall darkness of the printed image is controlled by the high voltage charge applied to the supply toner. Once the charged toner has jumped the gap to the surface of the drum, the negative charge on the toner itself repels the supply toner and prevents more toner from jumping to the drum. If the voltage is low, only a thin coat of toner is needed to stop more toner from transferring. If the voltage is high, then a thin coating on the drum is too weak to stop more toner from transferring to the drum. More supply toner will continue to jump to the drum until the charges on the drum are again high enough to repel the supply toner. At the darkest settings the supply toner voltage is high enough that it will also start coating the drum where the initial unwritten drum charge is still present, and will give the entire page a dark shadow.

**5. *Transferring***

The photoreceptor is pressed or rolled over paper, transferring the image. Higher-end machines use a positively charged transfer roller on the back side of the paper to pull the toner from the photoreceptor to the paper.

***6. Fusing***

Melting toner onto paper using heat and pressure. The paper passes through rollers in the fuser assembly where heat (up to 200 Celsius) and pressure bond the plastic powder to the paper.

One roller is usually a hollow tube (heat roller) and the other is a rubber backing roller (pressure roller). A radiant heat lamp is suspended in the center of the hollow tube, and its infrared energy uniformly heats the roller from the inside. For proper bonding of the toner, the fuser roller must be uniformly hot.

The fuser accounts for up to 90% of a printer's power usage. The heat from the fuser assembly can damage other parts of the printer, so it is often ventilated by fans to move the heat away from the interior. The primary power saving feature of most copiers and laser printers is to turn off the fuser and let it cool. Resuming normal operation requires waiting for the fuser to return to operating temperature before printing can begin.

Some printers use a very thin flexible metal fuser roller, so there is less mass to be heated and the fuser can more quickly reach operating temperature. This both speeds printing from an idle state and permits the fuser to turn off more frequently to conserve power.

If paper moves through the fuser more slowly, there is more roller contact time for the toner to melt, and the fuser can operate at a lower temperature. Smaller, inexpensive laser printers typically print slowly, due to this energy-saving design, compared to large high speed printers where paper moves more rapidly through a high-temperature fuser with a very short contact time.

**7. Cleaning**

When the print is complete, an electrically neutral soft plastic blade cleans any excess toner from the photoreceptor and deposits it into a waste reservoir, and a discharge lamp removes the remaining charge from the photoreceptor.

Toner may occasionally be left on the photoreceptor when unexpected events such as a paper jam occur. The toner is on the photoconductor ready to apply, but the operation failed before it could be applied. The toner must be wiped off and the process restarted.

Waste toner cannot be reused for printing because it can be contaminated with dust and paper fibers. A quality printed image requires pure, clean toner. Reusing contaminated toner can result in splotchy printed areas or poor fusing of the toner into the paper. There are some exceptions however, most notably some Brother and Toshiba laser printers, which use a patented method to clean and recycle the waste toner.

***Multiple steps occurring at once***

Once the raster image generation is complete all steps of the printing process can occur one after the other in rapid succession. This permits the use of a very small and compact unit, where the photoreceptor is charged, rotates a few degrees and is scanned, rotates a few more degrees and is developed, and so forth. The entire process can be completed before the drum completes one revolution.

## *Advantages and disadvantages*

***Advantages***

Its print quality is very good. It can print a page in a minute.

***Disadvantages***

It is very expensive.



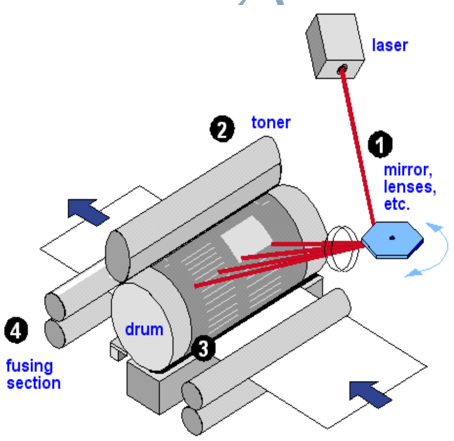



Fig. 3.1.2.1 Laser printer Mechanism Fig.3.1.2.2. Laser printer

## *b. Inkjet printer*

A printer that propels droplets of ink directly onto the medium. Today, almost all inkjet printers produce color. Low-end inkjets use three ink colors (cyan, magenta and yellow), but produce a composite black that is often muddy. Four-color inkjets (CMYK) use black ink for pure black printing. Inkjet printers run the gamut from less than a hundred to a couple hundred dollars for home use to tens of thousands of dollars for commercial poster printers.

### *Technologies*

There are three main technologies in use in contemporary inkjet printers: thermal, piezoelectric, and continuous.

**1. *Thermal inkjets***

Most consumer inkjet printers (Lexmark, Hewlett-Packard, and Canon) use print cartridges with a series of tiny electrically heated chambers constructed by photolithography. To produce an image, the printer runs a pulse of current through the heating elements causing a steam explosion in the chamber to form a bubble, which propels a droplet of ink onto the paper. The ink's surface tension as well as the condensation and thus contraction of the vapor bubble, pulls a further charge of ink into the chamber through a narrow channel attached to an ink reservoir.

The ink used is known as *aqueous* (i.e. water-based inks using pigments or dyes) and the print head is generally cheaper to produce than other inkjet technologies. The principle was discovered by Canon engineer Ichiro Endo in August 1977.

Note that thermal inkjets have no relation to thermal printers, which produce images by heating thermal paper, as seen on older fax machines, cash register, ATM receipt, and lottery ticket printers.

***2. Piezoelectric inkjets***

Most commercial and industrial ink jet printers use a piezoelectric material in an ink-filled chamber behind each nozzle instead of a heating element. When a voltage is applied, the piezoelectric material changes shape or size, which generates a pressure pulse in the fluid forcing a droplet of ink from the nozzle. This is essentially the same mechanism as the thermal inkjet but generates the pressure pulse using a different physical principle. Piezoelectric (also called Piezo) ink jet allows a wider variety of inks than thermal or continuous ink jet but the print heads are more expensive. Piezo inkjet technology is often used on production lines to mark products - for instance the use-before date is often applied to products with this technique; in this application the head is stationary and the product moves past. Requirements of this application are a long service life, a relatively large gap between the print head and the substrate, and low operating costs. There is a drop-on-demand process, with software that directs the heads to apply between zero to eight droplets of ink per dot and only where needed. As of November 2008, the fastest cut-sheet inkjet printer on the market is the RISO HC5500, which prints 120 full-color pages per minute (92 ppm in duplex mode).

### *3. Continuous inkjets*

The continuous ink jet method is used commercially for marking and coding of products and packages. The idea was first patented in 1867, by Lord Kelvin and the first commercial devices (medical strip chart recorders) were introduced in 1951 by Siemens.

In continuous ink jet technology, a high-pressure pump directs liquid ink from a reservoir through a gun body and a microscopic nozzle, creating a continuous stream of ink droplets via the Plateau-Rayliegh instability. A piezoelectric crystal creates an acoustic wave as it vibrates within the gun body and causes the stream of liquid to break into droplets at regular intervals – 64,000 to 165,000 drops per second may be achieved. The ink droplets are subjected to an electrostatic field created by a charging electrode as they form, the field varies according to the degree of drop deflection desired. This results in a controlled, variable electrostatic charge on each droplet. Charged droplets are separated by one or more uncharged “guard droplets” to minimize electrostatic repulsion between neighboring droplets.

The charged droplets pass through an electrostatic field and are directed (deflected) by electrostatic deflection plates to print on the receptor material (substrate), or allowed to continue on undeflected to a collection gutter for re-use. The more highly charged droplets are deflected to a greater degree. Only a small fraction of the droplets is used to print, the majority being recycled.

The ink system requires active solvent regulation to counter solvent evaporation during the time of flight (time between nozzle ejection and gutter recycling) and from the venting process whereby air that is drawn into the gutter along with the unused drops is vented from the reservoir. Viscosity is monitored and a solvent (or solvent blend) is added in order to counteract the solvent loss.

## *Inkjet Inks*

The basic problem with inkjet inks are the conflicting requirements for a coloring agent that will stay on the surface and rapid dispersement of the carrier fluid.

Desktop inkjet printers, as used in offices or at home, tend to use **aqueous inks** based on a mixture of water, glycol and dyes or pigments. These inks are inexpensive to manufacture, but are difficult to control on the surface of media, often requiring specially coated media. Aqueous inks are mainly used in printers with thermal inkjet heads, as these heads require water in order to perform. While aqueous inks often provide the broadest color gamut and most vivid color, most are not waterproof without specialized coating or lamination after printing. Most dye-based inks, while usually the least expensive, are subject to rapid fading when exposed to light. Pigment-based aqueous inks are typically more costly but provide much better long-term durability and Ultraviolet resistance. Inks marketed as “Archival-quality” are usually pigment-based.

Some professional wide format printers use aqueous inks, but the majority in professional use today employ a much wider range of inks, most of which require piezo inkjet heads and extensive maintenance:

- ***Solvent inks:*** The main ingredient of these inks is Volatile Organic Compounds (VOCs), organic chemical compounds that have high vapor processor. Color is achieved using pigments rather than dyes for excellent fade-resistance. The chief advantage of solvent inks is that they are comparatively inexpensive and enable printing on flexible, uncoated vinyl substrates, which are used to produce vehicle graphics, billboards, banners and adhesive decals. Disadvantages include the vapour produced by the solvent and the need to dispose of used solvent. Unlike most aqueous inks, prints made using solvent-based inks are generally waterproof and Ultra-resistant (for outdoor use) without special over-coatings. The high print speed of many solvent printers demands special drying equipment, usually a combination of heaters and blowers. The substrate is usually heated immediately before and after the print heads apply ink.

- ***Dye sublimation inks:*** These inks contain special sublimation dyes and are used to print directly or indirectly on to fabrics which consist of a high percentage of polyesters fibers. A heating step causes the dyes to sublimate into the fibers and create an image with strong color and good durability.

### *Inkjet head design*

There are two main design philosophies in inkjet head design: **fixed-head** and **disposable head**. Each has its own strengths and weaknesses. Most inkjets are used for photo printing.

- ***Fixed head***

The **fixed-head** philosophy provides an inbuilt print head (often referred to as a *Gaither Head*) that is designed to last for the life of the printer. The idea is that because the head need not be replaced every time the ink runs out, consumable costs can be made lower and the head itself can be more precise than a cheap disposable one, typically requiring no calibration. On the other hand, if the head is damaged, it is usually necessary to replace the entire printer. These print heads are available in consumer products and are typically more accurate in dot placement than comparable thermal printers.

Other fixed head designs are more likely to be found on industrial high-end printers and large format plotters and use piezo inkjet heads. Because development of these heads requires a large investment in research and development, there are only a few companies offering them: Kodak Versamark, Trident, Xaar, Spectra (Dimatix), Hitachi / Ricoh, HP Scitex, Brother, Konica Minolta, Seiko Epson, and ToshibaTec (a licensee of Xaar).

Hewlett-Packard has introduced a fixed-head thermal inkjet printer with its newer printer models such as the HP Photo smart 3310.

- ***Disposable head***

The **disposable head** philosophy uses a print head which is supplied as a part of replaceable ink cartage. Every time a cartridge is exhausted, the entire cartridge and print head are replaced with a new one. This adds to the cost of consumables and makes it more difficult to manufacture a high-precision head at a reasonable cost, but also means that a damaged print head is only a minor problem: the user can simply buy a new cartridge. Hewlett-Packard has traditionally favored the disposable print head, as did Canon in its early models. This type of construction can also be seen as an effort by printer manufacturers to stem third party ink cartridge assembly replacements, as these would-be suppliers don't have the ability to manufacture specialized print heads.

An intermediate method does exist: a disposable ink tank connected to a disposable head, which is replaced infrequently (perhaps every tenth ink tank or so). Most high-volume Hewlett-Packard inkjet printers use this setup, with the disposable print heads used on lower volume models.

Canon now uses (in most models) replaceable print heads which are designed to last the life of the printer, but can be replaced by the user if they should become clogged. For models with "Think Tank" technology, the ink tanks are separate for each ink color.



## *Advantages and disadvantages of inkjet printer*

### *Inkjet advantages*

Compared to earlier consumer-oriented color printers, inkjets have a number of advantages. They are quieter in operation than impact dot matrix or daisywheel printer. They can print finer, smoother details through higher print head resolution, and many consumer inkjets with photographic-quality printing are widely available.

In comparison to more expensive technologies like thermal vex, dye sublimations, and laser printer, inkjets have the advantage of practically no warm up time and lower cost per page (except when compared to laser printers).

For some inkjet printers, monochrome ink sets are available either from the printer manufacturer or third-party suppliers. These allow the inkjet printer to compete with the silver-based photographic papers traditionally used in black-and-white photography, and provide the same range of tones – neutral, "warm" or "cold". When switching between full-color and monochrome ink sets, it is necessary to flush out the old ink from the print head with a cleaning cartridge.

### *Inkjet disadvantages*

Inkjet printers may have a number of disadvantages:

1. The ink is often very expensive. (For a typical OEM cartridge priced at $15, containing 5 ml of ink, the ink effectively costs $3000 per liter—or $8000 per gallon.) According to the BBC (2003).
2. Many "intelligent" ink cartridges contain a micro chip that communicates the estimated ink level to the printer; this may cause the printer to display an error message, or incorrectly inform the user that the ink cartridge is empty. In some cases, these messages can be ignored, but some inkjet printers will refuse to print with a cartridge that declares itself empty, in order to prevent consumers from refilling cartridges.
3. The lifetime of inkjet prints produced by inkjets using aqueous inks is limited; they will eventually fade and the color balance may change. On the other hand, prints produced from solvent-based inkjets may last several years before fading, even in direct sunlight, and so-called "archival inks" have been produced for use in aqueous-based machines which offer extended life.
4. The very narrow inkjet nozzles are prone to clogging with dried ink. The ink consumed cleaning them - either during cleaning invoked by the user, or in many cases, performed automatically by the printer on a routine schedule - can account for a significant proportion of the total ink installed in the machine.



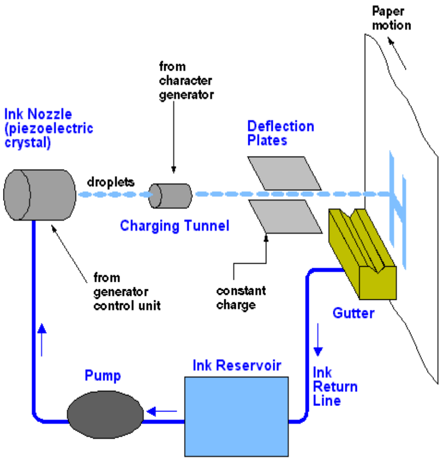



Fig. 3.1.2.3 Inkjet printer Mechanism

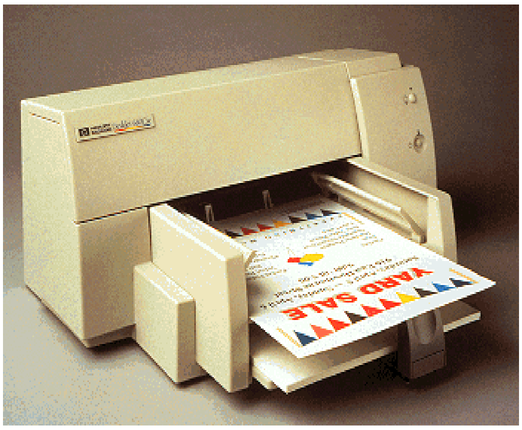


Fig. 3.1.2.4 Inkjet printer

## *c. Thermal printer*

A **thermal printer** (or **direct thermal printer**) produces a printed image by selectively heating coated thermochromic paper, or thermal paper as it is commonly known, when the paper passes over the thermal print head. The coating turns black in the areas where it is heated, producing an image. Two-color direct thermal printers are capable of printing both black and an additional color (often red), by applying heat at two different temperatures.

Thermal transfer printing is a related method that uses a heat-sensitive ribbon instead of heat-sensitive paper.

## *Essential mechanisms*

A thermal printer comprises these key components:

- Thermal head — generates heat; prints on paper
- Platen — a rubber roller that feeds paper
- Spring — applies pressure to the thermal head, causing it to contact the thermo-sensitive paper
- Controller boards — for controlling the mechanism

In order to print, one inserts thermo-sensitive paper between the thermal head and the platen. The printer sends an electrical current to the heating resistor of the thermal head, which in turn generates heat in a prescribed pattern. The heat activates the thermo-sensitive coloring layer of the thermo-sensitive paper, which manifests a pattern of color change in response. Such a printing mechanism is known as a **thermal system** or **direct system**.

The paper is impregnated with a solid-state mixture of a dye and a suitable matrix; a combination of a fluoran leuco dye and an octadecylphosphonic acid is an example. When the matrix is heated above its melting point, the dye reacts with the acid, shifts to its colored form, and the changed form is then conserved in metastable state when the matrix solidifies back quickly enough..

Controller boards are embedded with firmware to manage the thermal printer mechanisms. The Firmware can manage multiple bar code types, graphics and logos. They enable the user to choose between different resident fonts (also including Asian fonts) and character sizes.

Controller boards can drive various sensors like paper low, paper out, door open, top of form etc., and they are available with the most commonly used interfaces, such as RS-232, parallel, USB or wireless. For point of sale application some boards can also control the cash drawer.

## *Applications*

Thermal printers print faster and quieter than dot matrix printers. They are also more economical since their only consumable is the paper itself. There is some question if this is true since thermal printers are a new technology and there is a developed market for dot matrix print cartridges. Thermal printer paper is more expensive than average paper but the printers can be rapidly refilled. Commercial applications of thermal printers include filling station pumps, information kiosks, point of sale systems, voucher printers in slot machines, and for recording live rhythm strips on hospital cardiac monitors.

Through the 1990s, many fax machines used thermal printing technology. Toward the beginning of the 21st century, however, thermal wax transfer, laser, and inkjet printing technology largely supplanted thermal printing technology in fax machines in order to allow plain-paper printouts.

The Game Boy Printer, made in 1998, was a small thermal printer used to print out certain elements from some Game Boy games.

Early formulations of the thermo-sensitive coating used in thermal paper were sensitive to incidental heat, abrasion, friction (which can cause heat, thus darkening the paper), light (which can fade printed images), and water. However, more modern thermal coating formulations have resulted in exceptional image stability; *theoretically*, thermally-printed text should remain legible at least 50 years.

Hospitals commonly record fetal ultrasound scan images on thermal paper. This can cause problems if the parents wish to preserve the image by laminating it using a traditional laminator, as the heat will cause the entire page to darken. It is advisable to test the laminator using thermal fax paper, or an unwanted thermal POS receipt to see if this happens. As before, an option is to make a permanent ink duplicate of the image, and laminate that, testing first to ensure that the copying process won't darken the image either.

## *Advantages and disadvantages*

***Advantages***

Its print quality is very good. Thermal printers print faster and quieter than dot matrix printers..

***Disadvantages***

Thermal printer paper is more expensive than average paper


Fig. 3.1.2.5 Thermal printer

## 3.2 *PLOTTER*

A plotter is a pen-based output device that is attached to a computer for making vector graphics, that is, images created by a series of many straight lines. It is used to draw high-resolution charts, graphs, blueprints, maps, circuit diagrams, and other line-based diagrams. Plotters are similar to printers, but they draw lines using a pen. As a result, they can produce continuous lines, whereas printers can only simulate lines by printing a closely spaced series of dots. Multicolor plotters use different-colored pens to draw different colors. Color plots can be made by using four pens ( cyan, magenta, yellow, and black ) and need no human intervention to change them. The plotter was the first output device to print graphics and large engineering drawings.

### *Overview*

Traditionally, printers are primarily for printing text. This makes it fairly easy to control, simply sending the text to the printer is usually enough to generate a page of output. This is not the case of the line art on a plotter, where a number of printer control languages were created to send the more detailed commands like "lift pen from paper", "place pen on paper", or "draw a line from here to here". The two common ASCII-based plotter control languages are Hewlett-Packard's HPGL2 or Houston Instruments DMPL with commands such as "PA 3000, 2000; PD".
Programmers using FORTRAN or BASIC generally did not program these directly, but used software packages such as the Calcomp library, or device independent graphics packages such as Hewlett-Packard's AGL libraries or BASIC extensions or high end packages such as DISSPLA. These would establish scaling factors from world coordinates to device coordinates, and translating to the low level device commands. For example to plot X*X in HP 9830 BASIC, the program would be

```
10 SCALES -1, 1, 1, 1
20 FOR X =-1 to 1 STEP 0.1
30 PLOT X, X*X
40 NEXT X
50 PENS
60 ENDS
```

Early plotters (e.g. the Calcomp 565 of 1959) worked by placing the paper over a roller which moved the paper back and forth for X motion, while the pen moved back and forth on a single arm for Y motion. Another approach (e.g. Computer vision's Interact I) involved attaching ball-point pens to drafting pantographs and driving the machines with motors controlled by the computer. This had the disadvantage of being somewhat slow to move, as well as requiring floor space equal to the size of the paper, but could double as a digitizer. A later change was the addition of an electrically controlled clamp to hold the pens, which allowed them to be changed and thus create multi-colored output.

Hewlett Packard and Tektronix created desk-sized flatbed plotters in the late 1970s. In the 1980s, the small and lightweight HP 7470 used an innovative "grit wheel" mechanism which moved only the paper. Modern desktop scanners use a somewhat similar arrangement. These smaller "home-use" plotters became popular for desktop business graphics, but their low speed meant they were not useful for general printing purposes, and another conventional printer would be required for those jobs. One category introduced by Hewlett Packard's MultiPlot for the HP 2647 was the "word chart" which used the plotter to draw large letters on a transparency. This was the forerunner of the modern PowerPoint chart. With the widespread availability of high-resolution inkjet and laser printers, inexpensive memory and computers fast enough to rasteriz color images, pen plotters have all but disappeared.

Plotters were also used in the Create-A-Card kiosks that were available for a while in the greeting card area of supermarkets that used the HP 7475 6 pen plotter.
Plotters are used primarily in technical drawing and CAD applications, where they have the advantage of working on very large paper sizes while maintaining high resolution. Another use has been found by replacing the pen with a cutter, and in this form plotters can be found in many garment and sign shops.

Unlike other printer types, pen plotter speed is measured by pen speed and acceleration rate instead of by page printing speed. A pen plotter's speed is primarily limited by the type of pen used, so the choice of pen is a key factor in pen plotter output speed.

One type of plotter pen uses a cellulose fiber rod inserted through a circular foam tube saturated with ink, with the end of the rod sharpened into a conical tip. As the pen moves across the paper surface, capillary wicking draws the ink from the foam, down the rod, and onto the paper. As the ink supply in the foam is depleted, the migration of ink to the tip begins to slow down, resulting in faint lines. Slowing the plotting speed will allow the lines drawn by a worn-out pen to remain dark, but the fading will continue until the foam is completely depleted. Also as the fiber tip pen is used, the fiber tip slowly wears away from rubbing against the media, wearing down the thin conical tip into a thicker smudged line.

Ball-point plotter pens with refillable clear plastic ink reservoirs are available. They do not have the fading or wear effects of fiber pens, but are generally more expensive and uncommon. Also, conventional ball-point pens can be modified to work in most pen plotters.

### *Vinyl Sign Cutter*

A vinyl sign cutter (sometimes known as a cutting plotter) is used by professional poster and billboard sign-making businesses to produce weather-resistant signs, posters, and billboards using self-colored adhesive-backed vinyl film that has a removable paper backing material. The vinyl can also be applied to car bodies and windows for large, bright company advertising and to sailboat transoms. A similar process is used to cut tinted vinyl for automotive windows.
Colors available are generally limited only by the collection of vinyl on hand. To prevent creasing of the material, it is stored in rolls. Typical vinyl roll sizes are 24-inch and 36-inch width.
Once the letters or designs have been cut out, there are two methods for handling the application.

### *The most common method:*

- From the front surface, peel off the surround and unwanted areas of shapes from the letters or design.
- Apply a slightly tacky carrier film over the letters or design (this film is similar to masking tape though clear carrier films are also used.

- Cut out the area which includes the desired design, including the carrier film, vinyl and vinyl backing material.
- Apply a small piece of masking tape to the sides of the resulting sandwich to ease positioning.
- Ensuring that the area to which the vinyl is to be applied is clean, position the sandwich. When it is in the desired position, apply a hinge of masking tape to the lower edge. Remove the two side pieces of masking tape and the sandwich will fold down along the hinge.
- Carefully remove the backing paper by peeling sideways, not away from the letters or design.
- The cut vinyl is now held in position by the carrier film.
- With a small plastic wiper (a credit card will also do), sweep the cut vinyl into contact with the mounting surface, stroking upwards and outwards, taking care to leave no air bubbles.
- When all parts of the cut vinyl is in contact with the mounting surface, gently peel off the front paper sideways, and apply final pressure to the front face of the cut vinyl to produce a weather-resistant sign.

***An older method:***

- Once the vinyl has been cut, the individual cut-out pieces are peeled off the backing paper and carefully assembled by hand on the mounting surface to form the final image.
- A heat gun may be used to melt/bond the vinyl pieces to the substrate.

***Static Cutting Table***

A sign cutter typically functions like a traditional roll-fed or sheet-fed plotter, in that the media to be cut is kept rigid by a backing sheet as pieces of vinyl are cut out. As the letters are cut, the backing keeps the material properly aligned in the moving rollers. This does not work when cutting a non-rigid material with no backing, such as fabric textiles or leather. Cutting a hole or slit will cause the unsupported material to droop and fall out of alignment.

The static cutting table uses a large flat vacuum cutting table instead of a roll feed. The surface of the table has a series of small pinholes drilled in it. Material is placed on the table, and a sheet of plastic overlaid onto the fabric. A vacuum pump is turned on, and air pressure pushes down on the plastic cover sheet to hold the fabric in place. The table then operates like a normal vector plotter, using various cutting tools to cut holes or slits into the fabric. The plastic overlay is also cut, which leads to a slight loss of vacuum, but this loss is usually not significant.

This configuration allows static cutting tables to cut flexible and non-rigid materials that are difficult or impossible to cut with roll-fed plotters. Static cutters are also capable of cutting much thicker and heavier materials than a typ.

There are two different types of plotters.

**(a) Drum Plotters**

(b) **Flatbed Plotters**

### *a. Drum Plotters:*

In drum plotters, the paper on which the design is to be printed is placed over a drum. These plotters consist of one or more pen that is mounted on a carriage which is horizontally placed across the drum. The drum can rotate in either clockwise or anticlockwise direction under the control of plotting instruction s sent by computer. In case, a horizontal line is to be drawn, the horizontal movement of a pen is combined with the vertical movement of a page via the drum. Moreover, plotters can draw curves by creating a sequence of very short straight lines. In these plotters, each pen can have ink of different color to produce multicolor designs.

In 1959, the Cal Comp Model 565 was the world's first drum plotter. It had one pen and could handle media up to 11" wide.

***Use of Drum Plotters:***

Drum plotters are used to produce continuous output, such as plotting earthquake activity, or for long graphic output, such as tall building structures.

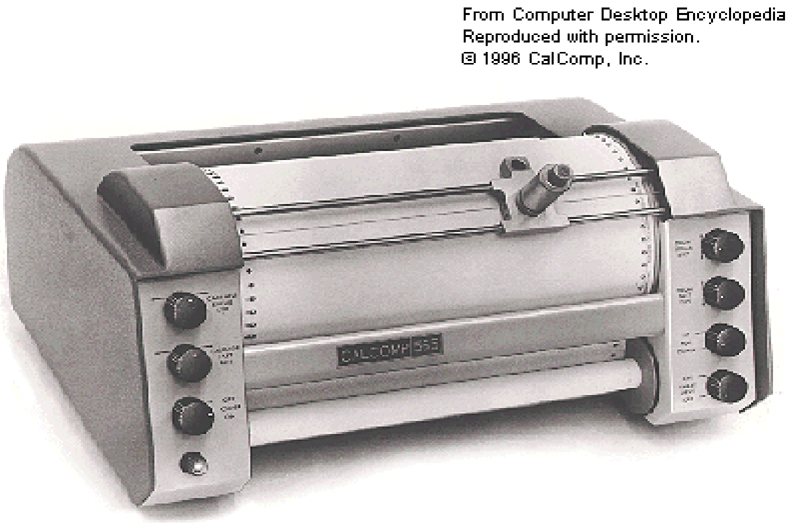
### *b. Flatbed Plotters:*

Flatbed plotters consist of a stationary horizontal plotting surface on which paper is fixed. The pen is mounted on a carriage, which can move horizontally, vertically leftwards or rightwards to draw lines. In flatbed potters, the paper does not move, the pen-holding mechanism provides all the motion. These plotters are instructed by the computer on the movement of pens in the x-y coordinates on the page. These plotters are capable of working on any standard, that is, from A4 size paper to some very big beds. The major disadvantage of this potter is that it is a slow output device and can take hours to complete a complex drawing.

**Use of Flatbed Plotters:**
Depending on the size of the flatbed surface, these are used in designing of ships, aircrafts, buildings, and so on.

### How Plotters works?

The heart of the plotter is the printer head assembly, consisting of a horizontal bar and the pen in use, attached to the dead assembly holding. The pen can be positioned horizontally by moving the pen assembly along the bar. Vertical positioning is achieved by either moving the bar (Flatbed plotters) or the paper (Drum plotter). Combinations of horizontal and vertical movement are used to draw arbitrary lines and curves in a single action, in contrast to printers, which usually scan horizontally across the page. Plotters create plots by moving a pen under computer control over a drafting paper. The instructions that a plotter receives from a computer consist of a color, beginning and end coordinates for a line. When an image is to be drawn, a specially designed holder picks up a pen, and takes it over to the start position. The pen is pushed down onto the paper and dragged over the surface to produce straight or curved lines. If the product is to be in color, the pen is then replaced with a new pen, the process continues until the image is complete.



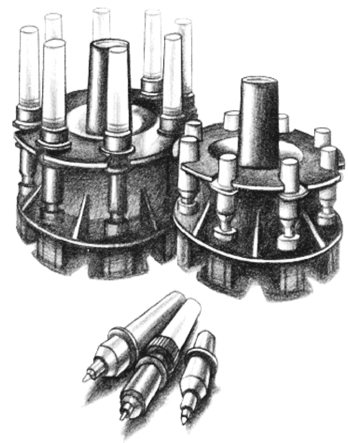



**Fig.3.2.2 Plotters pen**

**Fig.3.2.1. First Drum Plotter**

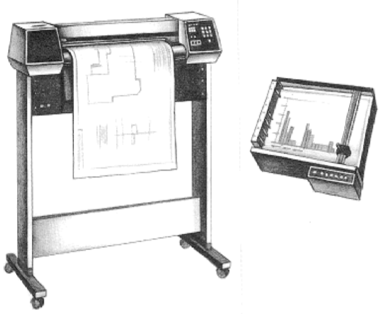


**Fig.3.2.3 Drum & Flatbed Plotter**

## 4. Soft copy output:

The electronic version of an output, which usually resides in computer memory and/or disk, is known as soft copy. Unlike hard copy, soft copy is not permanent form of output. It is transient and is usually displayed on the screen. This kind of output is not tangible, that is, it cannot be touched. Soft copy output includes audio and visual form of output, which is generated using a computer. In addition, textual or graphical information displayed on computer monitor is also a soft copy for of output.

***Monitor:***

***Computer Display (Monitors)***

A computer display is also called a *display screen* or *video display terminal (VDT)*. A monitor is a screen used to display the output. Images are represented on monitors by individual dots called *pixels*. A pixel is the smallest unit on the screen that can be turned on and off or made different shades. The density of the dots determines the clarity of the images, the resolution.

- **Screen resolution:** This is the degree of sharpness of a displayed character or image. The screen resolution is usually expressed as the number of columns by the number rows. A 1024x768 resolution means that it has 1024 dots in a line and 768 lines. A smaller screen looks sharper on the same resolution. Another measure of display resolution is a dot pitch.

- **Interlaced/Non-interlaced:** An *interlaced* technique refreshes the lines of the screen by exposing all odd lines first then all even lines next. A *non-interlaced* technology that is developed later refreshes all the lines on the screen form top to bottom. The non- interlaced method gives more stable video display than interlaced method. It also requires twice as much signal information as interlaced technology.

There are two forms of display: Liquid crystal display (LCD) and Cathode-ray tubes (CRTs).

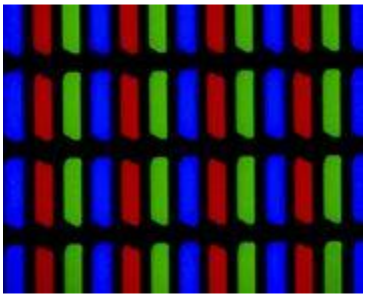
## a. Liquid crystal display (LCD)

Liquid-crystal display monitor (LCD) is **color** sets that use **LCD** technology to produce images. LCD monitor are thinner and lighter than **CRTs** of similar display size, and are available in much larger sizes as well. This combination of features made LCDs more practical than CRTs for many roles, and as manufacturing costs fell their.
Eventual dominance of the monitor market was all but guaranteed.
In spite of the LCD's many advantages over the CRT technology they displaced, LCDs also have a variety of disadvantages as well. A number of other technologies are vying to enter the large-screen television market by taking advantage of these weaknesses, including **OLEDs**, **FED** and **SED**, but none of these have entered widespread production.

**Fig. 4.1 LCD**

LCD monitor produce a colored image by selectively filtering a white light. The light is typically provided by a series of **cold cathode fluorescent lamps** (CCFLs) at the back of the screen, although some displays use white or colored **LEDs** instead. Millions of individual LCD shutters arranged in a grid, open and close to allow a metered amount of the white light through. Each shutter is paired with a colored filter to remove all but the red, green or blue (RGB) portion of the light from the original white source. Each shutter–filter pair forms a single sub-pixel. The sub-pixels are so small that when the display is viewed from even a short distance, the individual colors blend together to produce a single spot of color, a **pixel**. The shade of color is controlled by changing the relative intensity of the light passing through the sub-pixels.
**Liquid crystals** encompass a wide range of (typically) rod-shaped polymers that naturally form into thin layers, as opposed to the more random alignment of a normal **liquid**. Some of these, the nematic liquid crystals, also show an alignment effect between the layers. The particular direction of the alignment of a nematic liquid crystal can be set by placing it in contact with an alignment layer or director, which is essentially a material with microscopic groves in it. When placed on a director, the layer in contact will align itself with the grooves, and the layers above will subsequently align themselves with the layers below, the bulk material taking on the director's alignment. In the case of an LCD, this effect is utilized by using two directors arranged at right angles and placed close together with the liquid crystal between them. This forces the layers to align themselves in two directions, creating a twisted structure with each layer aligned at a slightly different angle to the ones on either side.

***Addressing sub-pixels***



A close-up (300×) view of a typical LCD display, clearly showing the sub-pixel structure. The "notch" at the lower left of each sub-pixel is the thin-film transistor. The associated capacitors and addressing lines are located around the shutter, in the dark areas.

**Fig. 4.2 Sub-pixels of LCD**

In order to address a single shutter on the display, a series of electrodes is deposited on the plates on either side of the liquid crystal. One side has horizontal stripes that form rows; the other has vertical stripes that form columns. By supplying voltage to one row and one column, a field will be generated at the point where they cross. Since a metal **electrode** would be opaque, LCDs use electrodes made of a transparent conductor, typically **indium tin oxide**.

Since addressing a single shutter requires power to be supplied to an entire row and column, some of the field always leaks out into the surrounding shutters. Liquid crystals are quite sensitive, and even small amounts of leaked field will cause some level of switching to occur. This partial switching of the surrounding shutters blurs the resulting image. Another problem in early LCD systems was the voltages needed to set the shutters to a particular twist was very low, but that voltage was too low to make the crystals re-align with reasonable performance. This resulted in slow **response times** and led to easily visible "ghosting" on these displays on fast-moving images, like a mouse cursor on a computer screen. Even scrolling text often rendered as an unreadable blur, and the switching speed was far too slow to use as a useful television display.

In order to attack these problems, modern LCDs use an **active matrix** design. Instead of powering both electrodes, one set, typically the front, is attached to a common ground. On the rear, each shutter is paired with a **thin-film transistor** that switches on in response to widely separated voltage levels, say 0 and +5 volts. A new addressing line, the gate line, is added as a separate switch for the transistors. The rows and columns are addressed as before, but the transistors ensure that only the single shutter at the crossing point is addressed; any leaked field is too small to switch the surrounding transistors. When switched on, a constant and relatively high amount of charge flows from the source line through the transistor and into an associated **capacitor**. The capacitor is charged up until it holds the correct control voltage, slowly leaking this through the crystal to the common ground. The current is very fast and not suitable for fine control of the resulting store charge, so **pulse code modulation** is used to accurately control the overall flow. Not only does this allow for very accurate control over the shutters, since the capacitor can be filled or drained quickly, but the response time of the shutter is dramatically improved as well.

***Building a display***

A typical shutter assembly consists of a sandwich of several layers deposited on two thin glass sheets forming the front and back of the display. For smaller display sizes (under 30 inches), the glass sheets can be replaced with plastic.

The rear sheet starts with a polarizing film, the glass sheet, the active matrix components and addressing electrodes, and then the director. The front sheet is similar, but lacks the active matrix components, replacing those with the patterned color filters. Using a multi-step construction process, both sheets can be produced on the same assembly line. The liquid crystal is placed between the two sheets in a patterned plastic sheet that divides the liquid into individual shutters and keeps the sheets at a precise distance from each other.

The critical step in the manufacturing process is the deposition of the active matrix components. These have a relatively high failure rate, which renders those pixels on the screen "always on". If there are enough broken pixels, the screen has to be discarded. The number of discarded panels has a strong effect on the price of the resulting television sets, and the major downward fall in pricing between 2006 and 2008 was due mostly to improved processes.

To produce a complete television, the shutter assembly is combined with control electronics and backlight. The backlight for small sets can be provided by a single lamp using a diffuser or frosted mirror to spread out the light, but for larger displays a single lamp is not bright enough and the rear surface is instead covered with a number of separate lamps. Achieving even lighting over the front of an entire display remains a challenge, and bright and dark spots are not uncommon.

### *History*

Passive matrix LCDs first became common in the 1980s for various portable computer roles. At the time they competed with plasma displays in the same market space. The LCDs had very slow refresh rates that blurred the screen even with scrolling text, but their light weight and low cost were major benefits. Screens using reflective LCDs required no internal light source, making them particularly well suited to laptop computers.

Refresh rates were far too slow to be useful for television, but at the time there was no pressing need for new television technologies. Resolutions were limited to **standard definition**, although a number of technologies were pushing displays towards the limits of that standard; **Super VHS** offered improved color saturation, and **DVDs** added higher resolutions as well. Even with these advances, screen sizes over 30" were rare as these formats would start to appear blocky at normal seating distances when viewed on larger screens. Projection systems were generally limited to situations where the image had to be viewed by a larger audience.

Nevertheless, some experimentation with LCD televisions took place during this period. In 1988, **Sharp Corporation** introduced the first commercial LCD television, a 14" model. These were offered primarily as boutique items for discerning customers, and were not aimed at the general market. At the same time, plasma displays could easily offer the performance needed to make a high quality display, but suffered from low brightness and very high power consumption. However, a series of advances led to plasma displays outpacing LCDs in performance improvements, starting with Fujitsu's improved construction techniques in 1979, Hitachi's improved phosphors in 1984, and AT&Ts elimination of the black areas between the sub-pixels in the mid-1980s. By the late 1980s, plasma displays were far in advance of LCDs.

### *High-definition*

It was the slow standardization of **high definition television** that first produced a market for new monitor technologies. In particular, the wider 16:9 **aspect ratio** of the new material was difficult to build using CRTs; ideally a CRT should be perfectly circular in order to best contain its internal vacuum, and as the aspect ratio becomes more rectangular it becomes more difficult to make the tubes. At the same time, the much higher resolutions these new formats offered were lost at smaller screen sizes, so CRTs faced the twin problems of becoming larger and more rectangular at the same time. LCDs of the era were still not able to cope with fast-moving images, especially at higher resolutions, and from the mid-1990s the plasma display was the only real offering in the high resolution space.

### *Environmental effects*

The production of LCD screens uses **nitrogen trifluoride** (NF3) as an etching fluid during the production of the thin-film components. NF3 is a potent **greenhouse gas**, and its extensive **half-life** may make it a potentially harmful contributor to **global warming**. A report in Geophysical Research Letters suggested that its effects were theoretically much greater than better-known sources of greenhouse gasses like **carbon dioxide**. As NF3 was not in widespread use at the time, it was not made part of the **Kyoto Protocols** and has been deemed "the missing greenhouse gas."
Critics of the report point out that it assumes that all of the NF3 produced would be released to the atmosphere. In reality, the vast majority of NF3 is broken down during the cleaning processes; two earlier studies found that only 2% to 3% of the gas escapes destruction after its use. Furthermore, the report failed to compare NF3's effects with what it replaced, **perfluorocarbon**, another powerful greenhouse gas, of which anywhere from 30% to 70% escapes to the atmosphere in typical use.

## *b. Cathode ray tube*

Cutaway rendering of a color CRT:
**1.** Three Electron guns (for red, green, and blue phosphor dots)
**2.** Electron beams
**3.** Focusing coils
**4.** Deflection coils
**5.** Anode connection
**6.** Mask for separating beams for red, green, and blue part of displayed image
**7.** Phosphor layer with red, green, and blue zones
**8.** Close-up of the phosphor-coated inner side of the screen

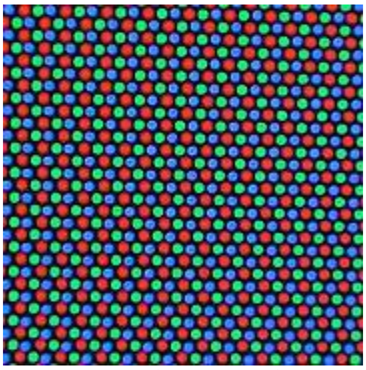


Fig 4.3 Magnified view of a shadow mask color CRT

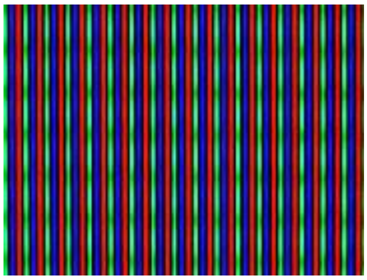


Fig 4.4 Magnified view of an aperture grille color CRT

### *History*

The earliest version of the CRT was invented by the German physicist Ferdinand Braun in 1897 and is also known as the 'Braun tube'. It was a cold-cathode diode, a modification of the Crooks tube with a phosphor-coated screen. The first version to use a hot cathode was developed by John B. Johnson (who gave his name to the term Johnson noise) and Harry Weiner Weinhart of Western Electric, and became a commercial product in 1922.

### *Overview*

The **cathode ray tube** (**CRT**) is a vacuum tube containing an electron gun (a source of electrons) and a fluorescent screen, with internal or external means to accelerate and deflect the electron beam, used to create images in the form of light emitted from the fluorescent screen. The image may represent electrical waveforms (oscilloscope), pictures (television, computer monitor), radar targets and others.

The CRT uses an evacuated glass envelope which is large, deep, heavy, and relatively fragile. Display technologies without these disadvantages, such as flat plasma screens, liquid crystal displays, DLP, OLED displays have replaced CRTs in many applications and are becoming increasingly common as costs decline.

The cathode rays are now known to be a beam of electrons emitted from a heated cathode inside a vacuum tube and accelerated by a potential difference between this cathode and an anode. The screen is covered with a crystalline phosphorescent coating (doped with transition metals or rare earth elements), which emits visible light when excited by high-energy electrons. The beam (or beams, in color CRTs) is deflected either by a magnetic or an electric field to move the bright dot(s) to the required position on the screen. External electromagnets deflect the beams magnetically, while internal plates placed near to and alongside the beam deflect it electrostatically. (Electrostatic deflection is used only for single-beam tubes.)

In television sets and computer monitors the entire front area of the tube is scanned repetitively and systematically in a fixed pattern called a *raster*. A raster is a rectangular array of closely-spaced parallel lines, scanned one at a time, from left to right (and, ever so slightly, "downhill", because the beam is moving steadily down while drawing the image frame). An image is produced by modulating the intensity of each of the three electron beams, one for each primary color (red, green, and blue) with a received video signal (or another signal derived from it). In all CRT TV receivers except some very early models, the beam is deflected by *magnetic deflection*, a varying magnetic field generated by coils (the *deflection yoke*), driven by electronic circuits, around the neck of the tube. Some commercial TV receivers up to the end of the 1940's used electrostatic deflection, many of them relying on the famous 7JP4)

Fig 4.5 Tube

***Electron gun***

The source of the electron beam is the electron gun, which produces a stream of electrons through thermionic emission, and focuses it into a thin beam. Earlier, black-and-white TV CRTs used magnetic focusing, but electrostatic focus has totally superseded focus coils. The gun is located in the narrow, cylindrical neck at the extreme rear of a CRT and has electrical connecting pins, usually arranged in a circular configuration, extending from its end. These pins provide external connections to the cathode, to various grid elements in the gun used to focus and modulate the beam, and, in electrostatic deflection CRTs, to the deflection plates. Since the CRT is a hot-cathode device, these pins also provide connections to one or more filament heaters within the electron gun. When a CRT is operating, the heaters can often be seen glowing orange through the glass walls of the CRT neck. The need for these heaters to 'warm up' causes a delay between the time that a CRT is first turned on, and the time that a display becomes visible. In older tubes, this could take fifteen seconds or more; modern CRT displays have fast-starting circuits which produce an image within about two seconds, using either briefly increased heater current or elevated cathode voltage. Once the CRT has warmed up, the heaters stay on continuously. The electrodes are often covered with a black layer, a patented process used by all major CRT manufacturers to improve electron density.

The electron gun accelerates not only electrons but also ions present in the imperfect vacuum (some of which result from outgassing of the internal tube components). The ions, being much heavier than electrons, are deflected much less by the magnetic or electrostatic fields used to position the electron beam. Ions striking the screen damage it; to prevent this the electron gun can be positioned slightly off the axis of the tube so that the ions strike the inside of the CRT neck instead of the screen. Permanent magnets (the *ion trap*) deflect the lighter electrons so that they strike the screen. Some very old TV sets without an ion trap show browning of the center of the screen, known as ion burn. The aluminum coating used in later CRTs eliminated the need for ion traps; they are no longer used.

When electrons strike the poorly-conductive phosphor layer on the glass CRT, it becomes electrically charged, and tends to repel electrons, reducing brightness (this effect is known as "sticking"). To prevent this interior side of the phosphor layer can be covered with a layer of aluminum connected to the conductive layer inside the tube, which disposes of this charge. It has the additional advantages of increasing brightness by reflecting, towards the viewer, the light emitted towards the back of the tube. The aluminum layer also protects the phosphors from ion bombardment.

***Fast events***

When displaying one-shot fast events the electron beam must deflect very quickly, with few electrons impinging on the screen, leading to a faint or invisible display. A simple improvement can be attained by fitting a hood on the screen against which the observer presses his face, excluding extraneous light, but oscilloscope CRTs designed for very fast signals give a brighter display by passing the electron beam through a micro-channel plate just before it reaches the screen. Through the phenomenon of secondary emission this plate multiplies the number of electrons reaching the phosphor screen, giving a brighter display, possibly with a slightly larger spot.

***Phosphor persistence***

The phosphors used in the screens of oscilloscope tubes are different from those used in the screens of other display tubes. Phosphors used for displaying moving pictures should produce an image which fades rapidly to avoid smearing of new information by the remains of the previous picture; i.e., they should have relatively-short persistence. An oscilloscope will often display a trace which repeats unchanged, so longer persistence is not a problem; but it is a definite advantage when viewing a single-shot event, so longer-persistence phosphors are used.

***Phosphor colors and designations***

An oscilloscope trace can be any color without loss of information, so a phosphor with maximum effective luminosity is usually used. The eye is most sensitive to green: for visual and general-purpose use the *P31* phosphor. It gives a visually bright trace, and also photographs well and is reasonably resistant to burning by the electron beam. Earlier, the green *P1* phosphor was used for the same purposes, but it burned more easily and had a somewhat shorter persistence. For displays meant to be photographed rather than viewed, the blue trace of the *P11* phosphor gives higher photographic brightness; it has a very short persistence. For extremely slow displays, such as radar PPIs, very-long-persistence phosphors such as *P7*, which produce a blue trace followed by a longer-lasting amber or yellow afterimage, are used. *P7* is a dual-layer phosphor, and the long-persistence layer is excited by the light from the blue phosphor rather than from the electron beam. Color TV CRT phosphors are collectively designated *P22*.

***Implosion protection***

Oscilloscope tubes almost never contain integrated implosion protection (see below). External implosion protection must always be provided, either in the form of an external graticule or, for tubes with an internal graticule, a plain sheet of glass or plastic. The implosion protection shield is often colored to match the light emitted by the phosphor screen; this improves the contrast as seen by the user.

***CRT resolution***

Dot pitch defines the "native resolution" of the display, assuming delta-gun CRTs (although this is not really a native resolution like on flat panel displays, because these dots aren't real sub pixels). In these, as the scanned resolution approaches the dot pitch resolution, moiré (a kind of soft-edged banding) appears, due to interference patterns between the mask structure and the grid-like pattern of pixels drawn. The term stripe pitch defines resolution of aperture grille monitors. These monitors do not suffer from vertical moiré, however, because the phosphor stripes have no vertical detail. The aperture grille is something like a picket fence, in that it has vertical slots between metal strips. In smaller CRTs, these strips maintain position by themselves, but larger aperture-grille CRTs require one or two crosswise (horizontal) support strips. However, these strips are nearly invisible on the display. Sony Trinitron CRTs use aperture grilles, and their faceplates are toroidal, although the greatly differing radii of curvature make a Trinitron CRT's faceplate seem cylindrical.

***Other types of CRTs***

***Storage CRTs***

Other graphical displays used 'storage tubes', including Direct View Bistable Storage Tubes (DVBSTs). These CRTs inherently stored the image, and did not require periodic refreshing. Some were quite large, on the order of 20-inch (51 cm) diagonals. Oscilloscopes also used storage tubes, in particular for observing (and, if needed, photographing) single events or very-slowly-changing signals. Some storage tubes have a special plate behind the phosphor display screen. The imaging electron gun *writes* its trace onto the plate, and where written, the plate permits electrons from another electron gun to pass through it onto the display screen. The latter gun, called a flood gun, covers the whole area of the plate evenly with electrons; it is not at all a focused beam.

Some storage tubes could display continuous-tone images.

Another type of storage tube, used in oscilloscopes and large-screen direct-view X-Y displays, has a special phosphor screen structure that normally blocks electrons from exciting the phosphor, but when written onto, lets the flood-gun's electrons maintain the written trace.

A typical storage CRT's image starts to deteriorate after tens of seconds to minutes; it is by no means permanent.

***Charactrons***

Some displays for early computers (those that needed to display more text than was practical using vectors, or that required high speed for photographic output) used Charactron CRTs. These incorporate a perforated metal character mask (stencil), which shapes a wide electron beam to form a character on the screen. The system selects a character on the mask using one set of deflection circuits, but that causes the extruded beam to be aimed off-axis, so a second set of deflection plates has to re-aim the beam so it is headed toward the center of the screen. A third set of plates places the character wherever required. The beam is unblanked (turned on) briefly to draw the character at that position. Graphics could be drawn by selecting the position on the mask corresponding to the code for a space (in practice, they were simply not drawn), which had a small round hole in the center; this effectively disabled the character mask, and the system reverted to regular vector behavior. Charactrons had exceptionally-long necks, because of the need for three deflection systems.

***Health concerns***

***Electromagnetic***

It has been claimed that the electromagnetic fields emitted by CRT monitors constitute a health hazard, and can affect the functioning of living cells. However, studies that examined this possibility showed no signs that CRT radiation had any effect on health. Exposure to these fields diminishes considerably at distances of 85 cm or farther according to the inverse square law, which describes the propagation of all electromagnetic radiation.

As the coils in a CRT monitor are extremely inefficient antennas, there is little electromagnetic field radiated.

***Toxicity***

CRTs may contain toxic phosphors within the glass envelope. The glass envelopes of modern CRTs may be made from heavily leaded glass, which represent an environmental hazard. Indirectly heated vacuum tubes (including CRTs) use barium compounds and other reactive materials in the construction of the cathode and getter assemblies; normally this material will be converted into oxides upon exposure to the air, but care should be taken to avoid contact with the inside of all broken tubes.

In some jurisdictions, discarded CRTs are regarded as toxic waste. In October 2001, the United States Environmental Protection Agency created rules stating that CRTs must be brought to special recycling facilities. In November 2002, the EPA began fining companies that disposed of CRTs through landfills or incineration. Regulatory agencies, local and statewide, monitor the disposal of CRTs and other computer equipment.

In Europe, disposal of CRT televisions and monitors is covered by the WEEE Directive.

***Flicker***

At low refresh rates (below 60 Hz), the periodic scanning nature of the display in most CRTs (particularly raster-oriented displays) may produce an irritating flicker that some people perceive more easily than others, especially when viewed with peripheral vision. High brightness and high contrast in the image accentuate the perception of flicker. A high refresh rate (above 72 Hz) helps to negate these effects, and computer displays and televisions with CRTs driven by digital electronics often use refresh rates of 100 Hz or more to largely eliminate any perception of flicker. Screens that reduce off-axis visibility of the screen can reduce the visibility of the CRT, and any flicker it produces, in peripheral vision (which is more sensitive to flicker than central vision) for persons not looking directly at the screen.

***High-frequency noise***

In some devices using CRTs that scan in raster patterns, components of the scanning circuitry (transformers, deflection coils, etc.) may mechanically vibrate slightly at frequencies that match the scanning frequency. When these frequencies are in the range of human hearing, they can be heard by some CRT users.

CRTs used for television traditionally have operated at horizontal scanning frequencies of 15,750 Hz (for most NTSC systems) or 15,625 Hz (for most PAL systems)). These frequencies are at the upper range of human hearing and are inaudible to many people, but a significant minority of the population can hear the sounds, and will perceive a high-pitched whistling noise near an operating television CRT. A television CRT operating without a synchronization signal will have a free-running scan rate slightly below these frequencies, making the resulting noise easier to perceive, and making them seem much louder to people able to hear them (because the slight reduction in frequency greatly increases their audibility). People with good hearing may find the noise irritating.

***Security***

Under some circumstances, the signal radiated from the electron guns, scanning circuitry, and associated wiring of a CRT can be captured and used to remotely reconstruct what is shown on the CRT. When computer displays are used to display text or other characters, special fonts and display techniques that pseudo-randomize the signal can be used to reduce the possibility of the image being successfully reconstructed remotely, although complete prevention requires that the electromagnetic radiation from the CRT be completely blocked. Classified methods are used by government and other organizations to prevent this type of eavesdropping; in the United States, the term TEMPEST is used to refer to the study of these emanations and techniques for reducing or eliminating them.

***High voltage***

CRTs operate at very high voltages, which can persist long after the device containing the CRT has been switched off and/or unplugged. Residual charges of hundreds of volts can also remain in large capacitors in the power supply circuits of the device containing the CRT; these charges may persist. Modern circuits contain bleeder resistors, to ensure that the high-voltage supply is discharged to safe levels within a couple of minutes at most. These discharge devices can fail even on a modern unit and leave these high voltage charges present. The final anode connector on the bulb of the tube carries this high voltage.

***Implosion***

A high vacuum exists within all CRT monitors. If the outer glass envelope is damaged, a dangerous implosion may occur. Due to the power of the implosion, glass pieces may bounce and explode outwards. This shrapnel can travel at dangerous and potentially fatal velocities. While modern CRTs used in televisions and computer displays have epoxy-bonded face-plates or other measures to prevent shattering of the envelope, CRTs removed from equipment must be handled carefully to avoid personal injury.

## ***Comparison of LCD***

- ***Packaging***

In a CRT the electron beam is produced by heating a metal filament, which "boils" electrons off its surface. The electrons are then accelerated and focused in an electron gun, and aimed at the proper location on the screen using **electromagnets**. The majority of the power budget of a CRT goes into heating the filament, which is why the back of a CRT-based television is hot. Since the electrons are easily deflected by gas molecules, the entire tube has to be held in vacuum. The atmospheric force on the front face of the tube grows with the area, which requires ever-thicker glass. This limits practical CRTs to sizes around 30 inches; displays up

to 40 inches were produced but weighed several hundred pounds, and televisions larger than this had to turn to other technologies like **rear-projection**.
The lack of vacuum in an LCD television is one of its advantages; there is a small amount of vacuum in sets using CCFL backlights, but this is arranged in cylinders which are naturally stronger than large flat plates. Removing the need for heavy glass faces allows LCDs to be much lighter than other technologies. For instance, the Sharp LC-42D65, a fairly typical 42-inch LCD television, weighs 55 lbs including a stand, while the late-model Sony KV-40XBR800, a 40" 4:3 CRT weighs a massive 304 lbs without a stand, almost six times the weight.

LCD panels, like other **flat panel displays**, are also much thinner than CRTs. Since the CRT can only bend the electron beam through a critical angle while still maintaining focus, the electron gun has to be located some distance from the front face of the television. In early sets from the 1950s the angle was often as small as 35 degrees off-axis, but improvements, especially computer assisted convergence, allowed that to be dramatically improved and, late in their evolution, folded. Nevertheless, even the best CRTs are much deeper than an LCD; the KV-40XBR800 is 26 inches deep, while the LC-42D65U is less than 4 inches thick – its stand is much deeper than the screen in order to provide stability.

- ***Efficiency***

LCDs are relatively inefficient in terms of power use per display size, because the vast majority of light that is being produced at the back of the screen is blocked before it reaches the viewer. To start with, the rear polarizer filters out over half of the original un-polarized light. Examining the image above, you can see that a good portion of the screen area is covered by the cell structure around the shutters, which removes another portion. After that, each sub-pixel's color filter removes the majority of what is left to leave only the desired color. Finally, to control the color and luminance of a pixel as a whole, the light has to be further absorbed in the shutters. 3M suggests that, on average, only 8 to 10% of the light being generated at the back of the set reaches the viewer.
For these reasons the backlighting system has to be extremely powerful. In spite of using highly efficient CCFLs, most sets use several hundred watts of power, more than would be required to light an entire house with the same technology. As a result, LCD televisions end up with overall power usage similar to a CRT of the same size. Using the same examples, the KV-40XBR800 draws 245 W, while the LC-42D65 is only slightly better, at 235 W. Plasma displays are worse; the best are on par with LCDs, but typical sets draw much more.
Modern LCD sets have attempted to address the power use through a process known as "dynamic lighting" (originally introduced for other reasons, see below). This system examines the image to find areas that are darker, and reduces the backlighting in those areas. CCFLs are long cylinders that run the length of the screen, so this change can only be used to control the brightness of the screen as a whole, or at least wide horizontal bands of it. This makes the technique suitable only for particular types of images, like the credits at the end of a movie. Sets using LEDs are more distributed, with each LED lighting only a small number of pixels, typically a 16 by 16 patch. This allows them to dynamically adjust brightness of much smaller areas, which is suitable for a much wider set of images.

- ***Image quality***

Early LCD sets were widely derided for their poor overall image quality, most notably the ghosting on fast-moving images, poor contrast ratio, and muddy colors. In spite of many predictions that other technologies would always beat LCDs, massive investment in LCD production and manufacturing has addressed many of these concerns.

- ***Contrast ratio***

Even in a fully switched-off state, liquid crystals allow some light to leak through the shutters. This limits their contrast ratios to about 1600:1 on the best modern sets, when measured using the ANSI measurement (ANSI IT7.215-1992). Manufacturers often quote the "Full On/off" contrast ratio instead, which is about 25% greater for any given set.
This lack of contrast is most noticeable in darker scenes; in order to display a color close to black; the LCD shutters have to be turned to almost full opacity, limiting the number of discrete colors they can display. This leads to "posterizing" effects and bands of discrete colors that become visible in shadows. Which is why many reviews of LCD TV's mention the "shadow detail"? For contrast, the highest-end LCD TVs offer regular contrast ratios of 5000:1 and the highest-end plasma displays offer regular contrast ratios as high as 40,000:1. Canon's prototype 55" **SED** offered a 50,000:1 contrast ratio.
Since the total amount of light reaching the viewer is a combination of the backlighting and shuttering, modern sets can use "dynamic backlighting" to improve the contrast ratio and shadow detail. If a particular area of the screen is dark, a conventional set will have to set its shutters close to opaque to cut down the light. However, if the backlighting is reduced by half in that area, the shuttering can be reduced by half, and the number of available shuttering levels in the sub-pixels doubles. This is the main reason high-end sets offer dynamic lighting (as opposed to power savings, mentioned earlier), allowing the contrast ratio across the screen to be dramatically improved. While the LCD shutters are capable of producing about 1000:1 contrast ratio, by adding 30 levels of dynamic backlighting this is improved to 30,000:1.

- **Color gamut**

Color on an LCD television is produced by filtering down a white source and then selectively shuttering the three primary colors relative to each other. The accuracy and quality of the resulting colors are thus dependent on the backlighting source and its ability to evenly produce white light. The CCFLs used in early LCD televisions were not particularly white, and tended to be strongest in greens. Modern backlighting has improved this, and sets commonly quote a color space covering about 75% of the **NTSC 1953 color gamut**. Using white LEDs as the backlight improves this further.

## c. Projector

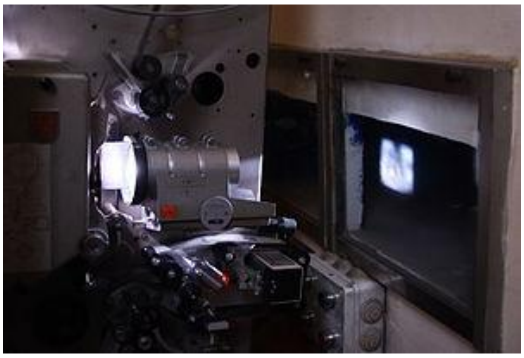


Fig 4.7 35 mm movie projector in operation

Fig 4.6 35 mm movie projector with
Enclosed type spool boxes, optical magnetic
Sound heads and Xenon lamp house.

A **movie projector** is an opto-mechanical device for displaying moving pictures by projecting them on a projection screen. Most of the optical and mechanical elements, except for the illumination and sound devices, are present in movie cameras.

### *Physiology*

According to the theory of persistence of vision, the perceptual processes of the brain and the retina of the human eye retains an image for a brief moment of time. This theory is said to account for the illusion of motion which results when a series of film images is displayed in quick succession, rather than the perception of the individual frames in the series.

Persistence of vision should be compared with the related phenomena of beta movement and phi movement. A critical part of understanding these visual perception phenomena is that the eye *is not a camera*, ie: there is no "frame rate" or "scan rate" in the eye. Instead, the eye/brain system has a combination of motion detectors, detail detectors and pattern detectors, the outputs of all of which are combined to create the visual experience.

The frequency at which flicker becomes invisible is called the flicker fusion threshold, and is dependent on the level of illumination. Generally, the frame rate of 16 frames per second (frame/s) is regarded as the lowest frequency at which continuous motion is perceived by humans. (Interestingly this threshold varies across different species; a higher proportion of rod cells in the retina will create a higher threshold level.)

It is possible to view the black space between frames and the passing of the shutter by the following technique:

Close your eyelids, then periodically rapidly blink open and closed. If done fast enough you will be able to randomly "trap" the image between frames, or during shutter motion. This will not work with television due to the persistence of the phosphors nor with LCD or DLP light projectors due to the continuity of image, although certain color artifacts may appear with some digital projection technologies.

Since the birth of sound film, virtually all film projectors in commercial movie theaters project at a constant speed of 24 frames. This speed was chosen for financial and technical reasons. When Warner Bros. and Western Electric were trying to find the proper projection speed for the new sound pictures, Western Electric went to the Warner Theater in LA and noted the AVERAGE speed at which films were projected there. They set that as the sound seed at which a satisfactory reproduction and amplification of sound could be conducted.

There are some specialist formats (e.g. Showscan and Maxivision) which project at higher rates, often 48 frame/s.

Silent films usually were not projected at constant speeds but rather were varied throughout the show at the discretion of the projectionist, often with some notes provided by the distributor. Speeds ranged from about 18 frame/s on up - sometimes even faster than modern sound film speed (24 frame/s). Contrary to received opinion, 16 frame/s - though sometimes used as a camera shooting speed - was dangerously inadvisable for projection, due to the high risk of the nitrate-base prints catching fire in the projector. (A dramatic rendition of a nitrate print fire and its potentially devastating effects is famously found in *Nuovo Cinema Paradiso*, which revolves around the goings-on of a projectionist.)

## *Principles of operation*

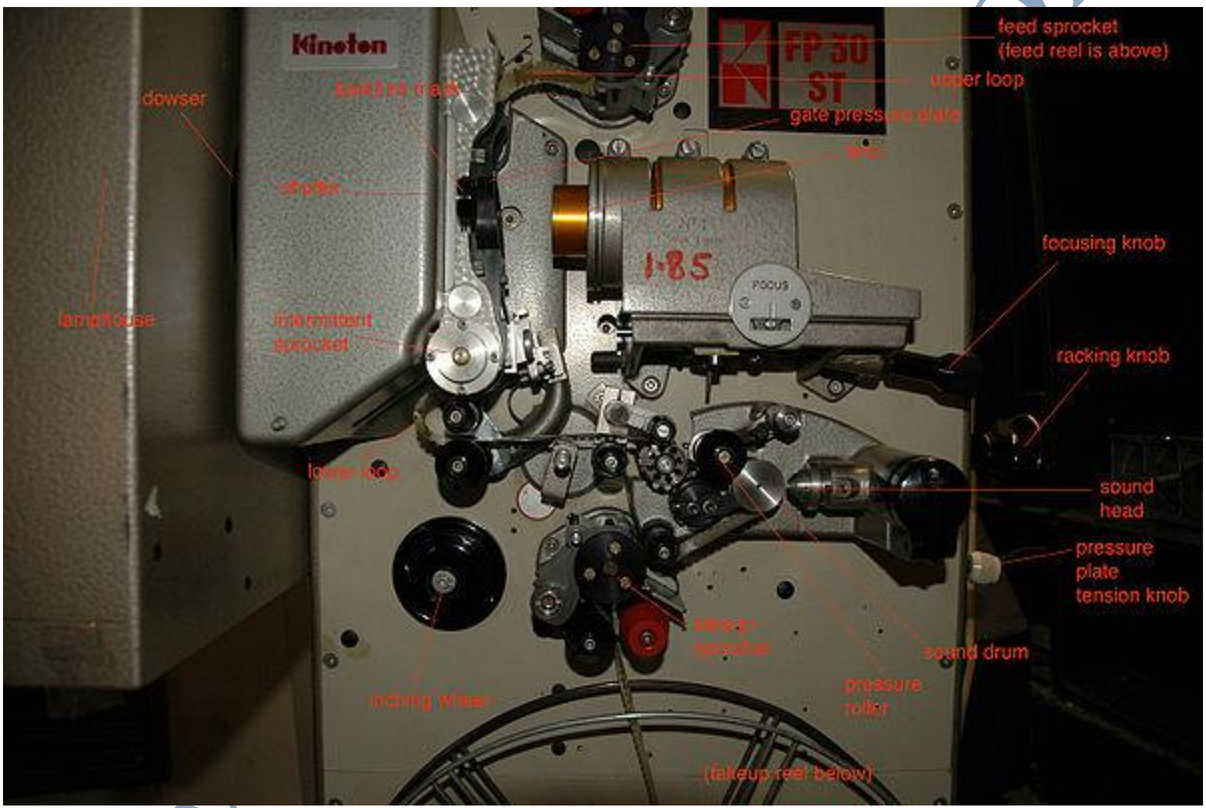



Fig 4.8. 35 mm Kinoton FP30ST movie projector, with parts labeled.



## *Projection elements*

As in a slide projector there are essential optical elements:

### *Light source*

Incandescent lighting and even limelight were the first light sources used in film projection. In the early 1900s up until the late 1960s, carbon arc lamps were the source of light in the almost all theaters in the world.

The Xenon arc lamp was introduced in Germany in 1957 and in the US in 1963. After film platters became commonplace in the 1970s, Xenon lamps became the most common light source, as they could stay lit for extended periods of time, whereas a carbon rod used for a carbon arc could last for an hour at the most.

Most lamp houses in a professional theatrical setting produce sufficient heat to burn the film should the film remain stationary for more than a fraction of a second. Because of this, care must be taken in inspecting a film so that it should not break in the gate and be damaged, particularly inflammable cellulose nitrate film stock.

***Reflector and condenser lens***

A curved reflector redirects light that would otherwise be wasted toward the condensing lens.

A positive curvature lens concentrates the reflected and direct light toward the film gate.

***Douser***

A metal or asbestos blade which cuts off light before it can get to the film. The douser is usually part of the lamphouse, and may be manually or automatically operated. Some projectors have a second, electrically-controlled douser that is used for changeovers (sometimes called a "changeover douser" or "changeover shutter"). Some projectors have a third, mechanically-controlled douser that automatically closes when the projector slows down (called a "fire shutter" or "fire douser"), to protect the film if the projector stops while the first douser is still open. Dousers protect the film when the lamp is on but the film is not moving, preventing the film from melting from prolonged exposure to the direct heat of the lamp. It also prevents the lens from scarring or cracking from excessive heat.

***Film gate and single image***

A single image of the series of images comprising the movie is positioned and held flat within an aperture called the gate. The gate also provides a slight amount of friction so that the film does not advance or retreat except when driven to advance the film to the next image.

***Shutter***

A commonly-held misconception is that film projection is simply a series of individual frames dragged very quickly past the projector's intense light source; this is not the case. If a roll of film were merely passed between the light source and the lens of the projector, all that would be visible on screen would be a continuous blurred series of images sliding from one edge to the other. It is the shutter that gives the illusion of one full frame being replaced exactly on top of another full frame. A rotating petal or gated cylindrical shutter interrupts the emitted light during the time the film is advanced to the next frame. The viewer does not see the transition, thus tricking the brain into believing a moving image is on screen. Modern shutters are designed with a flicker-rate of two times (48 Hz) or even sometimes three times (72 Hz) the frame rate of the film, so as to reduce the perception of screen flickering. (See Frame rate and Flicker fusion threshold.) Higher rate shutters are less light efficient, requiring more powerful light sources for the same light on screen.

Mechanical sequence when image is shown twice and then advanced. Outer sprockets rotate continuously while the frame advance sprockets are controlled by the mechanism shown.

***Imaging lens and aperture plate***

A lens system with multiple optical elements directs the image of the film to a viewing screen. Different lenses are used for different aspect ratios.

Aspect ratios are controlled by the lens with the appropriate aperture plate, a piece of metal with a precisely cut rectangular hole in the middle of equivalent aspect ratio. The aperture plate is placed just behind the gate, and masks off any light from hitting the image outside of the area intended to be shown. All films, even those in the standard Academy ratio, have extra image on the frame that is meant to be masked off in the projection.

***Viewing screen***

In most cases this is a reflective surface which may be either aluminized (for high contrast in moderate ambient light) or a white surface with small glass beads (for high brilliance under dark conditions). Switchable projection screen can be switched between opaque and clear by a safe voltage under 36V AC and is viewable from both sides. In a commercial theater, the screen also has millions of very small, evenly spaced holes in order to allow the passage of sound from the speakers and subwoofer which often are directly behind it.

## ***Types of projectors***

Projectors are classified by the size of the film used, i.e. the film format. Typical film sizes:

***8 mm***

Long used for home movies before the video camera, this uses double sprocketed 16 mm film, which is run through the camera twice. The 16 mm film is then split lengthwise into two 8 mm pieces that are spliced to make a single projectable film with sprockets on one side.

***Super 8***

Developed by Kodak, this film stock uses very small sprocket holes close to the edge that allow more of the film stock to be used for the images. This increases the quality of the image. The unexposed film is supplied in the 8 mm width, not split during processing as is the earlier 8 mm. Magnetic stripes could be added to carry encoded sound to be added after film development.

***9.5 mm***

Film format introduced by Pathé Frères in 1922 as part of the Pathé Baby amateur film system. It was conceived initially as an inexpensive format to provide copies of commercially-made films to home users. The format uses a single, central perforation (sprocket hole) between each pair of frames, as opposed to 8 mm film which has perforations along one edge, and most other film formats which have perforations on each side of the image. It became very popular in Europe over the next few decades and is still used by a small number of enthusiasts today. Over 300,000 projectors were produced and sold mainly in France and England, and many commercial features were available in the format. In the sixties the last projectors of this format were being produced. They are now collectors' items.

***16 mm***

This was a popular format for audio-visual use in schools and as a high-end home entertainment system before the advent of broadcast television. The most popular home content were comedic shorts (typically less than 20 minutes in length in the original release) and bundles of cartoons previously seen in movie theaters. 16 mm enjoys widespread use today as a format for short films, independent features and music videos, being a relatively economical alternative to 35 mm.

***35 mm***

The most common film size for theatrical productions during the 20th century. In fact, the common 35 mm camera, developed by Leica, was designed to use this film stock and was originally intended to be used for test shots by movie directors and cinematographers.35 mm film is typically run vertically through the camera and projector. In the mid 1950's the Vista Vision system presented wide screen movies in which the film moved horizontally, allowing much more film to be used for the image as this avoided the anamorphic reduction of the image to fit the frame width. As this required specific projectors it was largely unsuccessful as a presentation method while remaining attractive as filming, intermediate, and source for production printing and as an intermediate step in special effects to avoid film granularity, although the latter is now supplanted by digital methods.

***70 mm***

High end movie productions were often produced in this film gauge in the 1950s and 1960s and many very large screen theaters are still capable of projecting it in the 21st century. It is often referred to as 65/70, as the camera uses film 65 mm wide, but the projection prints are 70 mm wide. The extra five millimeters of film accommodated the soundtrack, usually a six track magnetic stripe. The most common theater installation would use dual gauge 35/70mm projectors.

## 5. Audio output:

Audio response is an output media, which produce either verbal or audio responses form the computer system. These sounds are pre-recorded in a computer system. Each sound has a unique code.

***Loudspeaker***

Fig-5.1. 3½-inch **speaker** Fig-5.2 High fidelity **loudspeaker system**.

A loudspeaker (or "speaker") is an electro acoustic transducer that converts an electrical signal into sound. The speaker pulses in accordance with the variations of an electrical signal and causes sound waves to propagate through a medium such as air or water.

Loudspeakers (and other electro acoustic transducers) are the most variable elements in a modern audio system and are usually responsible for most distortion and audible differences when comparing sound systems.

### *Terminology*

The term "loudspeaker" can refer to individual transducers (known as "drivers") or to complete systems consisting of an enclosure incorporating one or more drivers. To adequately reproduce a wide range of frequencies, most loudspeaker systems require more than one driver, particularly for high sound pressure level or maximum accuracy. Individual drivers are used to reproduce different frequency ranges. The drivers are named subwoofers (for very low frequencies); woofers (low frequencies); mid-range speakers (middle frequencies); tweeters (high frequencies); and sometimes *super tweeters*, optimized for the highest audible frequencies. The terms for different speaker drivers differ, depending on the application. In two-way loudspeakers, there is no mid-range driver, so the task of reproducing the mid-range sounds falls upon the woofer and tweeter. Home stereos use the designation "tweeter" for high frequencies, whereas professional audio systems for concerts may designate high frequency drivers as "HF", or "highs", or "horns". When multiple drivers are used in a system, a "filter network", called a crossover, separates the incoming signal into different frequency ranges and routes them to the appropriate driver. A loudspeaker system with *n* separate frequency bands is described as "*n*-way speakers": a two-way system will have woofer and tweeter speakers; a three-way system is either a combination of woofer, mid-range, and tweeter, or subwoofer, woofer, and tweeter.

### *History*

Johann Philipp Reis installed an electric loudspeaker in his telephone in 1861; it was capable of reproducing pure tones, but also could reproduce speech. Alexander Graham Bell patented his first electric loudspeaker (capable of reproducing intelligible speech) as part of his telephone in 1876, which was followed in 1877 by an improved version from Ernst Siemens. Nikola Tesla reportedly made a similar device in 1881, but he was not issued a patent. During this time, Thomas Edison was issued a British patent for a system using compressed air as an amplifying mechanism for his early cylinder phonographs, but he ultimately settled for the familiar metal horn driven by a membrane attached to the stylus. In 1898, Horace Short patented a design for a loudspeaker driven by compressed air; he then sold the rights to Charles Parsons, who was issued several additional British patents before 1910. A few companies, including the Victor Talking Machine Company and Pathé, produced record players using compressed-air loudspeakers. However, these designs were significantly limited by their poor sound quality and their inability to reproduce sound at low volume. Variants of the system were used for public address applications, and more recently, other variations have been used to test space-equipment resistance to the very loud sound and vibration levels that the launching of rockets produces.

The modern design of moving-coil drivers was established by Oliver Lodge in (1898). The first practical application of moving-coil loudspeakers was established by Peter L. Jensen and Edwin Pridham, at Napa, California. Jensen was denied patents. Being unsuccessful in selling their product to the phone companies, in 1915 they changed strategy to public address, and named their product Magnavox. Jensen was, for years after the invention of the loudspeaker, a part owner of The Magnavox Company.

The moving-coil principle as commonly used today in direct radiators was patented in 1924 by Chester W. Rice and Edward W. Kellogg. The key difference between previous attempts and the patent by Rice and Kellogg was the adjustment of mechanical parameters so that the fundamental resonance of the moving system took place at a lower frequency than that at which the cone's radiation impedance had become uniform. See the original patent for details.]

About this same period, Walter H. Schottky invented the first ribbon loudspeaker.

In the 1930s, loudspeaker manufacturers began to combine two and three band passes' worth of drivers in order to increase frequency response and sound pressure level. In 1937, the first film industry-standard loudspeaker system, "The Shearer Horn System for Theatres" (a two-way system), was introduced by Metro-Goldwyn-Mayer. It used four 15″ low-frequency drivers, a crossover network set for 375 Hz, and a single sectoral horn with two compression drivers providing the high frequencies. John Kenneth Hilliard, James Bullough Lansing, and Douglas Shearer all played roles in creating the system. At the 1939 New York World's Fair, a very large two-way public address system was mounted on a tower at Flushing Meadows. The eight 27″ low-frequency drivers were designed by Rudy Bozak in his role as chief engineer for Cinaudagraph. High-frequency drivers were likely made by Western Electric.

### *Driver design*

The most common type of driver uses a lightweight diaphragm, or *cone*, connected to a rigid *basket*, or *frame*, via a flexible suspension that constrains a coil of fine wire to move axially through a cylindrical magnetic gap. When an electrical signal is applied to the voice coil, a magnetic field is created by the electric current in the voice coil, making it an electromagnet. The coil and the driver's magnetic system interact, generating a mechanical force that causes the coil (and thus, the attached cone) to move back and forth, thereby reproducing sound under the control of the applied electrical signal coming from the amplifier. The following is a description of the individual components of this type of loudspeaker.

The diaphragm is usually manufactured with a cone- or dome-shaped profile. A variety of different materials may be used, but the most common are paper, plastic, and metal. The ideal material would be stiff, to prevent uncontrolled cone motions; light, to minimize starting force requirements; and well-damped, to reduce vibrations from continuing after the signal has stopped. In practice, all three of these criteria cannot be met simultaneously using existing materials; thus, driver design involves trade-offs. For example, paper is light and typically well-damped, but not stiff; metal can be made stiff and light, but it is not usually well-damped; plastic can be light, but typically, the stiffer it is made, the less well-damped it is. As a result, many cones are made of some sort of composite material. This can be a matrix of fibers, including Kevlar or fiberglass; a layered or bonded sandwich construction; or simply a coating applied to stiffen or damp a cone.

The basket, or frame, must be designed for rigidity to avoid deformation, which would change the magnetic conditions in the magnet gap and could even cause the voice coil to rub against the walls of the gap. Baskets are typically cast or stamped metal, although molded plastic baskets are becoming common, especially for inexpensive drivers. The frame also plays a considerable role in conducting heat away from the coil.

The suspension system keeps the coil centered in the gap and provides a restoring force that causes the speaker cone to return to a neutral position after moving. A typical suspension system consists of two parts: the "spider", which connects the diaphragm or voice coil to the frame and provides the majority of the restoring force, and the "surround", which helps center the coil/cone assembly and allows free piston-like motion aligned with the magnetic gap. The spider is usually made of a corrugated fabric disk, generally with a coating of a material intended to improve mechanical properties. The name comes from the shape of early suspensions, which were two concentric rings of Bakelite material, joined by six or eight curved "legs". Variations of this topology included adding a felt disc to provide a barrier to particles that might otherwise cause the voice coil to rub. A German company, Rulik, still offers a spider made of wood. The surround can be a roll of rubber or foam, or a ring of corrugated fabric (often coated), attached to the outer circumference of the cone and to the frame. The choice of suspension materials affects driver life, especially in the case of foam surrounds, which are susceptible to aging and environmental damage.

The wire in a voice coil is usually made of copper, though aluminum—and, rarely, silver—may be used. Voice-coil wire cross sections can be circular, rectangular, or hexagonal, giving varying amounts of wire volume coverage in the magnetic gap space. The coil is oriented co-axially inside the gap; it moves back and forth within a small circular volume (a hole, slot, or groove) in the magnetic structure. The gap establishes a concentrated magnetic field between the two poles of a permanent magnet; the outside of the gap being one pole, and the center post (called the pole piece) being the other. The pole piece and back plate are often a single piece, called the pole plate or yoke.

***Driver types***

Fig-5.3 Exploded view of a dome tweeter.

An audio engineering rule of thumb is that individual electrodynamic drivers provide quality performance over at most about three octaves. Multiple drivers (e.g., subwoofers, woofers, mid-range drivers, and tweeters) are generally used in a complete loudspeaker system to provide performance beyond three octaves.

***Full-range drivers***

A full-range driver is designed to have the widest frequency response possible, despite the rule of thumb cited above. These drivers are small, typically 3 to 8 inches (7.6 to 20 cm) in diameter to permit reasonable high frequency response, and carefully designed to give low-distortion output at low frequencies, though with reduced maximum output level. Full-range (or more accurately, wide-range) drivers are most commonly heard in public address systems and in televisions, although some models are suitable for hi-fi listening. In hi-fi speaker systems, the use of wide-range drive units can avoid undesirable interaction between multiple drivers caused by non-coincident driver location or crossover network issues. Fans of wide-range driver hi-fi speaker systems claim a coherence of sound, said to be due to the single source and a resulting lack of interference, and likely also to the lack of crossover components. Detractors typically cite wide-range drivers' limited frequency response and modest output abilities, together with their requirement for large, elaborate, expensive enclosures—such as transmission lines, or horns—to approach optimum performance.

Full-range drivers often employ an additional cone called a *whizzer*: a small, light cone attached to the joint between the voice coil and the primary cone. The whizzer cone extends the high-frequency response of the driver and broadens its high frequency directivity, which would otherwise be greatly narrowed due to the outer diameter cone material failing to keep up with the central voice coil at higher frequencies. The main cone in a whizzer design is manufactured so as to flex more in the outer diameter than in the center. The result is that the main cone delivers low frequencies and the whizzer cone contributes most of the higher frequencies. Since the whizzer cone is smaller than the main diaphragm, output dispersion at high frequencies is improved relative to an equivalent single larger diaphragm.

***Subwoofer***

A subwoofer is a woofer driver used only for the lowest part of the audio spectrum: typically below 120 Hz. Because the intended range of frequencies in these is limited, subwoofer system design is usually simpler in many respects than for conventional loudspeakers, often consisting of a single speaker enclosed in a suitable box or enclosure.

To accurately reproduce very low bass notes without unwanted resonances (typically from cabinet panels), subwoofer systems must be solidly constructed and properly braced; good ones are typically extraordinarily heavy. Many subwoofer systems include power amplifiers and electronic sub-filters, with additional controls relevant to low-frequency reproduction. These variants are known as "active subwoofers". "Passive" subwoofers require external amplification.

### *Woofer*

A woofer is a driver that reproduces low frequencies. Some loudspeaker systems use a woofer for the lowest frequencies, making it possible to avoid using a subwoofer. Additionally, some loudspeakers use the woofer to handle middle frequencies, eliminating the mid-range driver. This can be accomplished with the selection of a tweeter that responds low enough combined with a woofer that responds high enough that the two drivers add coherently in the middle frequencies.

### *Mid-range driver*

A mid-range speaker is a loudspeaker driver that reproduces middle frequencies. Mid-range drivers can be made of paper or composite materials, or they can be compression drivers. If the mid-range driver is cone-shaped, it can be mounted on the front baffle of a loudspeaker enclosure, or it can be mounted at the throat of a horn for added output level and control of radiation pattern. If it is a compression driver, it is invariably mated to a horn.

### *Tweeter*

A tweeter is a high-frequency driver that typically reproduces the highest frequency band of a loudspeaker. Many varieties of tweeter design exist, each with differing abilities with regard to frequency response, output fidelity, power handling, maximum output level, etc. Soft-dome tweeters are widely found in home stereo systems, and horn-loaded compression drivers are common in professional sound reinforcement. Ribbon tweeters have gained popularity in recent years, as their output power has been increased to levels useful for professional sound reinforcement, and their pattern control is conveniently shaped for concert sound.

## *Loudspeaker system design*

### *Crossover*

Used in multi-driver speaker systems, the crossover is a device that separates the input signal into different frequency ranges suited to each driver. The drivers receive only the power in their usable frequency range (the range they were designed for), thereby reducing distortion in the drivers and interference between them.

Crossovers can be *passive* or *active*. A passive crossover is an electronic circuit that uses a combination of one or more resistors, inductors, or non-polar capacitors. These parts are formed into carefully designed networks and are most often placed between the power amplifier and the loudspeaker drivers to divide the amplifier's signal into the necessary frequency bands before being delivered to the individual drivers. Passive crossover circuits need no external power beyond the audio signal itself, but do cause overall signal loss and a significant reduction in damping factor between the voice coil and the crossover. An active crossover is an electronic filter circuit that divides the signal into individual frequency bands *before* power amplification, thus requiring at least one power amplifier for each band pass Passive filtering may also be used in this way before power amplification, but it is an uncommon solution, due to its inflexibility compared to active filtering. Any technique that uses crossover filtering followed by amplification is commonly known as bi-amping, tri-amping, quad-amping, and so on, depending on the minimum number of amplifier channels. Some loudspeaker designs use a combination of passive and active crossover filtering, such as a passive crossover between the mid- and high-frequency drivers and an active crossover between the low-frequency driver and the combined mid- and high frequencies.

Passive crossovers are commonly installed inside speaker boxes and are by far the most usual type of crossover for home and low-power use. In car audio systems, passive crossovers may be in a small, separate box, necessary to accommodate the size of the components used. Passive crossovers may be simple for low-order filtering, or complex to allow steep slopes such as 18 or 24 dB per octave. Passive crossovers can also be designed to reduce undesirable characteristics of driver, horn, or enclosure resonances, and can be tricky to implement, due to component interaction. Passive crossovers, like the driver units that they feed, have power handling limits, and have about a 10% insertion loss, which is converted into heat. When high output levels are required, active crossovers may be preferable. Active crossovers may be simple circuits that emulate the response of a passive network, or may be more complex, allowing extensive audio adjustments. Active crossovers, called digital loudspeaker management systems, may include facilities for precise alignment of phase and time between frequency bands, equalization, and dynamics (compression and limiting) control.

Some hi-fi and professional loudspeaker systems now include an active crossover circuit as part of an onboard amplifier system. These designs are identifiable by their need for AC power in addition to a signal cable. This active topology may include driver protection circuits and other features of a digital loudspeaker management system. Powered speaker systems are common in computer sound (for a single listener) and, at the other end of the size spectrum, in modern concert sound systems, where their presence is significant and steadily increasing.

***Enclosures***

An unusual three-way speaker system. The cabinet is narrow in order to reduce a diffraction effect called the "baffle step".

Most loudspeaker systems consist of drivers mounted in an enclosure, or cabinet. The role of the enclosure is to provide a place to mount the drivers and to prevent sound waves emanating from the back of a driver from interfering destructively with those from the front; these typically cause cancellations (e.g., comb filtering) and significantly alter the level and quality of sound at low frequencies.

Fig-5.4

The simplest driver mount is a flat panel (i.e., baffle) with the drivers mounted in holes in it. However, in this approach, frequencies with a wavelength longer than the baffle dimensions are canceled out, because the antiphase radiation from the rear of the cone interferes with the radiation from the front. With an infinitely large panel, this interference could be entirely prevented. A sufficiently large sealed box can approach this behavior.

Since panels of infinite dimensions are impractical, most enclosures function by containing the rear radiation from the cone. A sealed enclosure prevents transmission of the sound emitted from the rear of the loudspeaker by confining the sound in a rigid and airtight box. Techniques used to reduce transmission of sound through the walls of the cabinet include thicker cabinet walls, lossy wall material, internal bracing, curved cabinet walls—or more rarely, visco-elastic materials (e.g., mineral-loaded bitumen) or thin lead sheeting applied to the interior enclosure walls.

However, a rigid enclosure reflects sound internally, which can then be transmitted back through the loudspeaker cone—again resulting in degradation of sound quality. This can be reduced by internal absorption using absorptive materials (often called "damping"), such as fiberglass, wool, or synthetic fiber batting within the enclosure. The internal shape of the enclosure can also be designed to reduce this by reflecting sounds away from the loudspeaker diaphragm, where they may then be absorbed.

Other enclosure types alter the rear radiation so it can add constructively to the output from the front of the cone. Designs that do this (including *bass reflex*, *passive radiator*, *transmission line*, etc.) are often used to extend the effective low-frequency response and increase low-frequency output of the driver.

To make the transition between drivers as seamless as possible, system designers have attempted to time-align (or phase adjust) the drivers by moving one or more drivers forward or back so that the acoustic center of each driver is in the same vertical plane. This may also involve tilting the face speaker back, providing a separate enclosure mounting for each driver, or (less commonly) using electronic techniques to achieve the same effect. These attempts have resulted in some unusual cabinet designs. The speaker mounting scheme (including cabinets) can also cause diffraction, resulting in peaks and dips in the frequency response. The problem is usually greatest at higher frequencies, where wavelengths are similar to, or smaller than, cabinet dimensions. The effect can be minimized by rounding the front edges of the cabinet, curving the cabinet itself, using a smaller or narrower enclosure, choosing a strategic driver arrangement, or using absorptive material around a driver.

## Wiring connections

Fig-5.5

Fig-5.6

***Two-way binding posts on a loudspeaker connected using banana plugs.***

A 4-ohm loudspeaker with two pairs of binding posts capable of accepting bi-wiring after the removal of two metal straps.

Most loudspeakers use two wiring points to connect to the source of the signal (for example, to the audio amplifier or receiver). This is usually done using binding posts or spring clips on the back of the enclosure. If the wires for the left and right speakers (in a stereo setup) are not connected "in phase" with each other (the + and − connections on the speaker and amplifier should be connected + to + and − to −), the loudspeakers will be out of polarity. Given identical signals, motion in one cone will be in the opposite direction of the other. This will typically cause monophonic material within a stereo recording to be canceled out, reduced in level, and made more difficult to localize, all due to destructive interference of the sound waves. The cancellation effect is most noticeable at frequencies where the speakers are separated by a quarter wavelength or less; low frequencies are affected the most. This type of wiring error doesn't damage speakers, but isn't optimal.

***Efficiency vs. sensitivity***

Loudspeaker efficiency is defined as the sound power output divided by the electrical power input. Most loudspeakers are actually very inefficient transducers; only about 1% of the electrical energy sent by an amplifier to a typical home loudspeaker is converted to acoustic energy. The remainder is converted to heat, mostly in the voice coil and magnet assembly. The main reason for this is the difficulty of achieving proper impedance matching between the acoustic impedance of the drive unit and that of the air into which it is radiating. The efficiency of loudspeaker drivers varies with frequency as well. For instance, the output of a woofer driver decreases as the input frequency decreases.

Driver ratings based on the SPL for a given input are called sensitivity ratings and are notionally similar to efficiency. Sensitivity is usually defined as so many decibels at 1 W electrical input, measured at 1 meter, often at a single frequency. The voltage used is often 2.83 $V_{RMS}$, which is 1 watt into an 8 Ω (nominal) speaker impedance (approximately true for many speaker systems). Measurements taken with this reference are quoted as dB with 2.83 V @ 1 m.

The sound pressure output is measured at (or mathematically scaled to be equivalent to a measurement taken at) one meter from the loudspeaker and on-axis (directly in front of it), under the condition that the loudspeaker is radiating into an infinitely large space and mounted on an infinite baffle. Clearly then, sensitivity does not correlate precisely with efficiency, as it also depends on the directivity of the driver being tested and the acoustic environment in front of the actual loudspeaker. For example, a cheerleader's horn produces more sound output in the direction it is pointed by concentrating sound waves from the cheerleader in one direction, thus "focusing" them. The horn also improves impedance matching between the voice and the air, which produces more acoustic power for a given speaker power. In some cases, impedance matching (via careful enclosure design) will allow the speaker to produce more power.

- Typical home loudspeakers have sensitivities of about 85 to 95 dB for 1 W @ 1 m—an efficiency of 0.5–4%.

- Sound reinforcement and public address loudspeakers have sensitivities of perhaps 95 to 102 dB for 1 W @ 1 m—an efficiency of 4–10%.
- Rock concert, stadium PA, marine hailing, etc. speakers generally have higher sensitivities of 103 to 110 dB for 1 W @ 1 m—an efficiency of 10–20%.

A driver with a higher maximum power rating cannot necessarily be driven to louder levels than a lower-rated one, since sensitivity and power handling are largely independent properties. In the examples that follow, assume (for simplicity) that the drivers being compared have the same electrical impedance; are operated at the same frequency, which is within both driver's respective pass bands; and that power compression and distortion are low. For the first example, a speaker 3 dB more sensitive than another will produce double the sound pressure level (or be 3 dB louder) for the same power input; thus, a 100 W driver ("A") rated at 92 dB for 1 W @ 1 m sensitivity will put out twice as much acoustic power as a 200 W driver ("B") rated at 89 dB for 1 W @ 1 m when both are driven with 100 W of input power. In this particular example, when driven at 100 W, speaker A will produce the same SPL, or loudness, that speaker B would produce with 200 W input. Thus, a 3 dB increase in sensitivity of the speaker means that it will need half the amplifier power to achieve a given SPL. This translates into a smaller, less complex power amplifier—and often, to reduced overall cost.

It is not possible to combine high efficiency (especially at low frequencies) with compact enclosure size and adequate low frequency response. One can, more or less, choose only two of the three parameters when designing a speaker system. So, for example, if extended low-frequency performance and small box size are important, one must accept low efficiency. This rule of thumb is sometimes called Hoffman's Iron Law (after J.A. Hoffman, the "H" in KLH).

### *Other driver designs*

#### *Bending wave loudspeakers*

Bending wave transducers use a diaphragm that is intentionally flexible. The rigidity of the material increases from the center to the outside. Short wavelengths radiate primarily from the inner area, while longer waves reach the edge of the speaker. To prevent reflections from the outside back into the center, long waves are absorbed by a surrounding damper. Such transducers can cover a wide frequency range (80 Hz to 35,000 Hz) and have been promoted as being close to an ideal point sound source. This uncommon approach is being taken by only a very few manufacturers, in very different arrangements.

#### *Flat panel loudspeakers*

There have been many attempts to reduce the size of speaker systems, or alternatively to make them less obvious. One such attempt was the development of voice coils mounted to flat panels to act as sound sources. These can then be made in a neutral color and hung on walls where they will be less noticeable than many speakers, or can be deliberately painted with patterns in which case they can function decoratively. There are two related problems with flat panel techniques: first, a flat panel is necessarily more flexible than a cone shape in the same material, and therefore will move as a single unit even less, and second, resonances in the panel are difficult to control, leading to considerable distortions. Some progress has been made using such lightweight, rigid, materials such as Styrofoam, and there have been several flat panel systems commercially produced in recent years.

***Distributed mode loudspeakers***

A newer implementation of the flat panel speaker system involves an intentionally flexible panel and an "exciter", mounted off-center in a location such that it excites the panel to vibrate, but with minimal resonances. Speakers using such techniques can reproduce sound with a wide directivity pattern (paradoxically somewhat like a point source) and have been used in some computer speaker designs and bookshelf loudspeakers.

***Plasma arc speakers***

Plasma arc loudspeakers use electrical plasma as a radiating element. Since plasma has minimal mass, but is charged and therefore can be manipulated by an electric field, the result is a very linear output at frequencies far higher than the audible range. Problems of maintenance and reliability for this approach tend to make it unsuitable for mass market use. In 1978 Alan E. Hill of the Air Force Weapons Laboratory in Albuquerque, NM, designed the Plasmatronics Hill Type I, a tweeter whose plasma was generated from helium gas. This avoided the ozone and nitrous oxide produced by RF decomposition of air in an earlier generation of plasma tweeters made by the pioneering DuKane Corporation, who produced the Ionovac (marketed as the Ionofane in the UK) during the 1950s. Currently, there remain a few manufacturers in Germany who use this design, and a do-it-yourself design has been published and has been available on the Internet.

A less expensive variation on this theme is the use of a flame for the driver, as flames contain ionized (electrically charged) gases.

***Digital speakers***

Digital speakers have been the subject of experiments performed by Bell Labs as far back as the 1920s. The design is simple; each bit controls a driver, which is either fully 'on' or 'off'.

There are problems with this design which have led to it being abandoned as impractical for the present. First, for a reasonable number of bits (required for adequate sound reproduction quality), the physical size of a speaker system becomes very large. Secondly, due to inherent analog digital conversion issues, the effect of aliasing is unavoidable, so that the audio output is "reflected" at equal amplitude in the frequency domain, on the other side of the sampling frequency, causing an unacceptably high level of ultrasonic to accompany the desired output. No workable scheme has been found to adequately deal with this.

The term "digital" or "digital-ready" is often used for marketing purposes on speakers or headphones, but these systems are not digital in the sense described above. They are conventional speakers intended for use with digital sound sources (e.g., optical media, MP3 players, etc). Rather, this is a somewhat deceptive marketing tactic, in which the manufacturer is trying to capitalize on the popularity of digital sound recordings and equipment.

## 5. Summary:

An output device is an electromechanical device, which converts machine-readable data or information into human-readable form. The printed form of output is referred as hard copy while the form of output displayed on the screen is referred as soft copy. A printer is a device that prints information from the computer on to paper. The two major categories of printer technologies are impact and non impact printers. An impact printer forms characters and graphics on a piece of paper by striking a mechanism against an ink ribbon that comes into physical contact with the paper. Printers that form characters and images without making direct contact between printing mechanism and paper are called as non impact printers. Dot matrixes printers print one character at a time. These printers can print any shape of character, which a user can describe. Daisy wheel printer is a solid-font character printer. These printers give only alphanumeric output and cannot print graphics, or change fonts unless the print wheel is physically replaced. Drum printers are one of the most commonly used line printers. It is generally used because of its speed as it uses special tractor-fed paper with pre-punched holes along each side.

Non-impact printers are categorized as ink-jet, laser and thermal printer. Inkjet or bubble jet printer forms characters and all kinds of images by having a print cartridge with a series of tiny electrically heated chambers. Leaser printers use laser beam source, photoconductive drum, and toner to form very high quality output.

Plotters are special-purpose drawing devices, which reproduce graphic images on paper using a pen whose movements are controlled by the computer. The lines drawn by these devices are continuous and very accurate. Plotters are classified as drum and flatbed plotters.

Computer monitor is used to display the keyed data and to receive messages and processed information from the computer. Aspect ratio is the ratio of the width of the display screen to the height, that is, the ratio of vertical points to the horizontal points necessary to produce equal length lines in both directions on the screen. Generally, computer displays have an aspect ratio 4:3.Resolution refers to the number of pixels in the horizontal and vertical directions on the screen. In medium resolution graphics, pixels are large, whereas in high resolution graphics pixels are small. The average CRT display is currently 800X600 or 1024X768. The color depth is color associated with each pixel on the computer monitor. Depending on the type of the monitor and video card installed, different color or video standards are produced. Cathode Ray Tube (CRT) is the most common type of monitor for the office and the home. In CRT an electron gun is used which fires electrons at groups of phosphor dots coating the inside of the screen. When the electrons strike the phosphor dots, they glow to give the colors. A color CRT monitor is used for output that contains graphics. In Liquid Crystal Display (LCD) screen, the backlight passes through the first of two polarizing filters. The polarized sight then passes through a layer that contains thousands of liquid crystal blobs aligned in tiny containers known as cells. Electric leads around the edge of the LCD create an electric field that twists the crystal molecule, which lines the light up with the second polarizing filter and allows it to pass through.

The standard computer system can talk with the addition of two components: a speech synthesizer and a screen reading software. A speech synthesizer is software that converts text information into spoken sentence. Screen reading software enables the user to control the synthesizer. It allows a user to access, or view text that is present on the screen.

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