Image Processing

'M' Scheme Syllabus

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IMAGE PROCESSING

PREFACE

This book of Image Processing covers all the topics in a clear and organized format for the Second year Diploma in Printing Technology students as prescribed by the Directorate of Technical Education, Chennai, Tamilnadu. It is confidently believed that this book furnishes the students the necessary study material. The topics covered were neatly illustrated for better understanding of the students.

The book is prepared step-by-step lessons in large, eye pleasing calligraphy make it suitable for both direct one-to-one tutoring and regular classroom use. The highlight of this book is its simple English with clear and easy explanation of each topic.

All the topics are explained with supporting diagram for diploma level students to understand effectively.

This book majorly deals with Originals and Colour, Digital Reproduction Techniques, Line and Halftone Photography, Film Processing and Offset Plate Processing etc.

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UNIT - I - ORIGINALS & COLOUR

1.1. ORIGINALS

Any copy whether it is a mechanical, artwork or other material from which reproductions are to be made is called as a Original. Original is a term which can include camera ready artwork, drawings, paintings, photographs, transparencies, black-and white or colour prints and even three-dimensional objects. The term original commonly refers to photographs used for haftones or to original line art.

Types of Originals

There are two types of originals:

1. Reflection Originals and

2. Transmission Originals

1. Reflection Originals

Any original copy which is to be reproduced that exists on an opaque substrate (such as photographic print) is called as Reflection Original. Reflection Originals must be scanned by reflecting light from their surface. Photographic color prints, paintings, wash drawings are termed reflection originals.

2. Transmission Originals

Any original copy which is to be reproduced that exists on a transparent substrate (such as photographic transparency) is called as Transmission Original. Transmission Originals must be scanned by transmitting light through their surface. Color transparencies are termed as transmission originals.

1.2. CLASSIFICATION OF ORIGINALS

The process of graphic reproduction, whether through traditional or digital means, starts with an assessment of originals. Originals may be monochrome, for single-colour reproduction, or colored for multi-coloured reproduction.

Originals can be further classified as follows:

1. Line originals.

2. Tone or Continuous Tone originals.

3. Color originals.

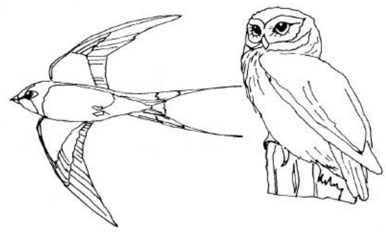
4. Halftone originals.

5. Merchandise Samples.

1. Line originals

Line originals have no gradation of tone - that is, they possess no intermediate tones. The image is produced by clear distinct lines, or other shapes of uniformly solid areas. Text or artwork containing no tonal values or shades of gray and which can be imaged and printed without the need for halftone screens are called as line originals.

Examples of line originals include: paper paste-up from phototypesetters, typewritten or laser-printed line copy, dry transfer lettering; pen and ink effect drawings (in black ink on white paper or board): or their digital equivalent, produced electronically as described previously, using a word processing or similar based program, also draw or paint software program on a host computer system



Line Original

TYPES OF LINE ORIGINALS

i) Monochrome line originals

Line originals prepared for single color are called as monochrome line originals. Typical examples of monochrome originals are technical drawings, figure drawings, architectural plans, etc.

When produced traditionally, it was generally accepted that flat artwork should be prepared in a size larger than that of the finished size, probably 1.5 to 2 times, as photographic reduction gave a sharper result and any minor irregularities tended to be lost. Excessive reduction if required should be avoided, since this causes loss - of details. For example, fine lines can fill in on thin type reversed out of a solid area.

At present line originals are reproduced using graphic software packages and/ or word processing software, which allow relatively simple and Straightforward graphic forms to be created: an alternative is the use of clipart or similar systems. These software packages allow the operator to view originals on screen, at for example 200% and 400%, and thus ensure at least relatively fine definition and correct butting up of line edges, etc. These can then be checked and adjusted, so that when reproduced at the correct size, the desired results are achieved without visible imperfections.

ii) Colour line originals

Line illustrations may be produced for printing in two, three, four or more colours, with a separate colour split for each colour are called as color line originals.

Different techniques are used to isolate, or separate, the original into the required number of colours. Traditionally, using flat artwork, this would take the form of a coloured original, or a key drawing with the different colour areas indicated on an overlay or series of overlays. In computer-generated illustrations, the illustrator/operator will simply highlight or mask off the coloured original by use of the cursor, or pressure pen and pad system, tracing around the required areas, and instructing the software program in use to split for colour as requested.

2. Continuous Tone Originals

Continuous tone originals, consist of a variety of gradations between highlights (lightest areas), mid tones (neutral/mid-way areas) and solids (darkest areas).

Tone originals may be,

1. Monochrome Tone Originals (eg. Black and White Photographs)

2. Color Tone Originals (eg. Color Transparencies, Color Prints or Color artwork)

Continuous tone is a photographic image that is not composed of halftone dots, or in other words, an image that consists of tone values ranging from some minimum density (such as white area) to maximum density (such as dark area). An example of a continuous tone image is a photograph or a color transparency.

Other examples of continuous tone originals include: photographic prints and transparencies: plus wash drawings, pencil, charcoal and crayon sketches - all of which are increasingly prepared and reproduced by electronic means.

Continuous Tone Originals

Transparencies are still one of the most popular mediums for colour reproduction of continuous tone originals, although digital media such as Photo CD and digital picture libraries are increasing in popularity and use. Ideally, transparencies should be sharp and with a fine grain structure - that is, free from excessive grain - without colour bias or cast, and with good tonal and density range (from 1.8 to 2.8).

Photographic colour prints, paintings, wash drawings and the like, are termed reflection copy. If they are to be reproduced on a colour scanner, ideally they should be of an overall size small enough to fit comfortably on the desktop flatbed platen or drum scanner's analyse unit; and flexible enough to bend, when a drum scanner is used. Cleanliness in handling continuous tone originals is even more important than in line originals because smudges and stains, like tones, will be reproduced.

Originals with uneven surfaces, such as drawings or paintings on heavy grained paper, board or canvas, require careful lighting and in such cases it is often worth getting a commercial photographer to produce a transparency or photograph, which will constitute a more suitable original for reproduction.

3. Color Originals

Pictures representing line and tone in color are called color originals. Eg: Color Transparencies, Color Prints, Color Paintings, Color Line Drawings. The type of original used for a given purpose depends upon the degree of realism or abstraction desired by the designer. Photographs are generally preferred when a high degree of realism is required. The more abstract design usually employs hand drawn artwork, although some photographs also can be used for this purpose. For the ultimate in realism, the actual object or piece of merchandise may be submitted for use as an original.

Figure: Photographic originals: (A) 4x5-inch color transparency; (B) 35-mm color negative; (C) 35 mm color transparency.

i) Photographic Color Prints

The Photographic color print is commonly used for reflective color reproduction originals. One form of this material consists of a paper base that is coated with red, green, and blue-sensitive layers that form, during processing, cyan, magenta, and yellow dye layers. This is known as the dye coupling process. Depending on the film type and the processing technique, tripack materials can be used to make prints from color negatives, color transparencies, or directly from the original scene in the case of “instant” photography. The dye bleach process, on the other hand, consists of predyed emulsion layers that are selectively removed in processing. The prints can be made only from transparencies in this process.

One possible problem that can be encountered when reproducing color prints is due to the fluorescence of the substrate, a factor that can affect the reproduction of light tones. Substrate fluorescence can be countered by mounting UV absorbers over the illuminating light source.

It may be desirable to use prints instead of transparencies when the photographer has no control over the lighting of the original scene. It is possible to make adjustments when making the color print in order to make it conform more closely to the desired appearance. The print is, furthermore, a reflection original with a contrast range and gamut close to the photo mechanical printing processes. Such originals are, therefore, generally easy to match. Customer comparisons of original to reproduction are relatively uncomplicated when color prints have been supplied.

ii) Photographic Color Transparencies

Color transparency films all have integral tripack types of emulsions coated onto film bases. Unlike photographic print materials, color transparency materials vary greatly in terms of resolution, sharpness, graininess, speed, and color rendition. In general, the lower the speed the higher the image quality.

The creative demands of the job may determine the color transparency format. Large-format 8XI0-inch. (20X25-cm) cameras cannot be used satisfactorily for high speed action photography. The 35-mm camera with its light weight and motor drive is preferred in these situations. On the other hand, 35-mm cameras are not suitable for architectural photography. The swings and tilts of large-format cameras must be used to overcome the converging parallels common with 35-mm and other fixed plane cameras.

Films that are designed for viewing by projection in a darkened room, such as 35-mm transparencies, tend to have a higher-contrast range than sheet film transparencies. All transparency materials, however, have a range greater than 3.0 optical density. Each individual color film distorts the original colors in its own way. No one color film can be selected as the best for all photographic assignments, but whenever possible, the same fIlm should be used throughout a given job.

Transparencies have several advantages over prints. Higher resolution, higher sharpness, and the ability to wrap around a scanner drum (a factor if supplied prints are mounted on a rigid base) are the more important factors.

iii) Artist's Color Originals / Paintings

Artist's originals exist either as fine art, which is created with no thought of reproduction, or as commercial art, which is created specifically to be reproduced. A wide varies of artist's mediums is available as a carrier and binder for the pigments.

The medium chosen to produce a given piece of art depends upon the creative intent of the artist. Certain materials convey a particular mood, sensation, or color more successfully than other materials. Some problems may arise, however, when trying to reproduce artwork that has been prepared using a given technique.

The heavy intensities and saturations of oil paintings may be difficult to reproduce. Especially if there is a lot of dark shadow detail. The clear, light colors of pastels also may cause problems in reproduction, especially when coarser halftone screens are used. Extra colors may have to be used to achieve satisfactory reproductions.

Nongamut colors should not exist in commercial artwork. The graphic artist or designer should understand the gamut restrictions of average process inks on coated and uncoated papers. The colors that are selected for the artwork in question must fall within the range that is reproducible by the production conditions. If some colors outside the gamut are chosen, these colors will be reproduced at lower saturation. Those other colors within the gamut will be reproduced correctly; therefore, with some correct and some incorrect colors in the final reproduction, the designer's original intent becomes distorted.

Figure: Fine art originals may contain colors that fall outside the color gamut of the reproduction system.

4. Halftone Originals

Originals in which detail and tone values are represented by a series of evenly spaced dots of varying size and shape, the dot areas varying in direct proportion to the intensity of the tones they represent are called as halftone originals.

i. Black-and-White Halftone Originals

A black-and-white halftone original consists of a pattern of black dots of various sizes that represent tones of gray. Examples of halftone originals are printed pictures in newspapers or magazines. Small dots with ample white space between them produce an illusion of a light tone or highlight. Large dots that are close together produce the illusion of dark tones or shadow areas. Because the dots are all the same tone (black), halftone originals can be copied as line originals. This type of original can also be copied as a continuous-tone original, depending on the use of the final product.

ii. Color Halftone Originals

Color photographs printed in magazines, newspapers, or books consist of a series of dots in cyan, magenta, yellow, and black (CMYK) that fool the eye into seeing the millions of colors that make up the original image.

iii. Digital Halftones

When using scanned images or images from a digital camera, you can produce digital halftones direct from the software to the printer. Digital halftoning depends on the lpi (lines per inch, or screen frequency) and the resolution of your output device (printer). The screen used may be specified in your printers PPD (PostScript Printer Driver) or set specifically in your software program.

5. Merchandise (Product) Samples

In those cases where a very accurate color match is required, an actual sample of the product is sometimes supplied for use as an original. Examples are paint chips, fabric swatches, linoleum squares, or upholstery samples.

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HANDLING OF ORIGINALS

- Any dust, finger marks, scratches, or other defects on an original have to be avoided during the reproduction, as they will be magnified during printing.
- Care should be taken in handling all originals, preferably keeping them in mounts or sleeves except when they are being scanned.
- A quick wipe over the surface of an original before scanning can save a great deal of time pixel cloning later in an image-editing program.
- On some scanners , transparencies are mounted in oil to improve the contact with the scanner drum and reduce the likelihood of scratches and Newton's rings appearing on the scanned image. If scratches or other marks appear on an image they can be removed in an image-editing application

Other requirements of good originals include good tonal gradation and good tonal separation between areas of detail (bearing in mind that this tonal separation will be compressed when the image is scanned).

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1.3. LIGHT AND COLOR

To understand the process of color reproduction, it is first necessary to gain an appreciation of the phenomenon of color. To do this, we must examine the nature of light, without which color would not exist.

What is Light?

Light is radiant energy that is visible to the average human eye. For the purposes of this discussion it can be assumed that light travels in wave motion, with the color of light varying according to the length of the wave. The wavelengths can be measured and classified along with other forms of energy on the electromagnetic or energy spectrum. Light can either be a wave as was first proposed by Christian Huygens, or as a series of discrete particles as was first proposed by Sir Isaac Newton. Eventually it was decided that light could be both a wave and a series of particles.

The intensity (or luminosity) of a light source is measured in candles. The intensity of light reflected from a surface (or luminance) is measured in candles per square meter, or foot candles or foot lamberts.

<u>What is color?</u>

The term color refers to the quality of light possessing certain dominant wavelengths.

Color is a complex visual sensation that is influenced by the physical properties of the illuminant and sample, but it is determined largerly by the physiological characteristics of the individual observer. Insights into the process of color perception may be gained through examinations of these distinct elements (illuminant, sample, human observer) and the manner in which they interact.

Color is an optical phenomenon, a sensory impression conveyed by the eye and the brain. Light reflected or transmitted by an object is received by our eyes and transformed into nervous impulses, which trigger the colour sensation in our brain. Color is not a physical variable, accordingly it has no physical unit. An object is not colored, but the sensation of color is produced as a result of irradiation by light, Sunlight, which appears to be white, radiates on to an object and is partially reflected. Consequently an object that reflects the red area of the spectrum appears colored. An object that reflects completely in the entire visible spectrum usually appears to be white and a completely absorbent body appears to be black.

When perceiving and describing colors, physical and physiological effects are always involved. The physical components are measurable, where as the physiological components are not measurable.

The mixing of certain basic colors produces all of the colors we can perceive. There are three categories of colors: *primary colors, secondary colors,* and *tertiary colors.* Primary colors are those that are not formed by mixing of any other colors and can be said to be “pure” colors. Secondary colors are those formed by the mixing of two or more primary colors. Tertiary colors are those produced by mixing of two or more secondary colors. What constitutes a primary color differs depending on whether one is talking about light or pigments.

Interestingly, according to Hope and Walch in *The Color Compendium,* polls have consistently found that in Western Europe and North America over half of the adults surveyed name “blue” as their favorite color, while children under eight consistently name “red” as their favorite. (In Japan, however, over half of the people surveyed named either white or black as their favorite color).

Color preferences tend to vary by culture, not unexpectedly. This may seem like a trivial matter, but it is an important consideration in planning multinational advertising campaigns, designing products such as clothing for other markets, and other such endeavors. It also manifests itself in appropriate dress when visiting other cultures; white is not universally accepted as the bride's dress color at a wedding, for example, nor is black universally appropriate for funerals or other mourning rites. In other words, color is a cultural specific concept; various colors are symbolic of different things, and these symbols are not universally consistent.

Seeing and Measuring Colors

Here, the biological vision of human beings is contrasted with the process of physical measurement, as performed by a measuring system. Light falls on a sample. The sample absorbs part of the light, while the rest is reflected or re-emitted as diffused radiation.

We perceive this re-emitted light with our, eyes. In the process of seeing, cones in the retinas of our eyes are stimulated. Different cones are sensitive to blue, green, and red. The stimuli are transformed into excited states, in turn, causing signals to be sent along the optic nerve to the brain, which interprets them as colour.

This same process can be emulated in a measuring instrument. One such measuring instrument is the spectrophotometer. Of course, a measuring instrument cannot actually perceive anything, but it is able to perform calculations on predefined and measured values.

Thus, during the measuring process light also falls on the printed sample. The reflected light, also known as spectral reflectance, passes through a series of lenses to strike a detector. This then relays the values it registers to the computer. There, digital filters that simulate the visual sensitivity of our eyes are used to calculate values, referred to as standard stimuli, or tristimulus values.

The standard stimuli are equivalent to the excitation of cones in our eyes. These tristimulus values are then converted and mapped onto a colorimetric system. With the aid of the figures thus determined, a colour can be precisely described and compared with other colors. This, in very simplistic terms, is the measurement principle underlying a colorimetric instrument.

Principles of colour

Colour is a very complex issue and there are many factors which need to be considered in order to understand how we perceive and reproduce it.

Colour as a wavelength

We can see the visible wavelengths between 380 and 760nm (one nanometre equals one millionth of a millimeter). If one particular wavelength dominates or, more specifically, the spectral power distribution is unequal we see a particular colour - if there is a balanced distribution of all wavelengths we see white or gray - i.e. - neutral. Light with a wavelength of 380nm appears as violet, 760nm 'as red and 570nm as green. Colour, as we know it, can be in the form of a 'physical' solid, such as printing ink or colored toner; or in the form of an energy light source, such as with a TV or computer colour monitor.

The human perception of colour

The sensation of colour is the effect of light upon the eye interpreted by the brain. White light is composed of a mixture of all colours of the rainbow or spectrum, and most objects are visible by the light reflected or transmitted from them, depending upon whether the object is opaque or transparent. The colors of the visible spectrum include (in order of increasing wavelength) violet, indigo, blue, green, yellow, orange and red.

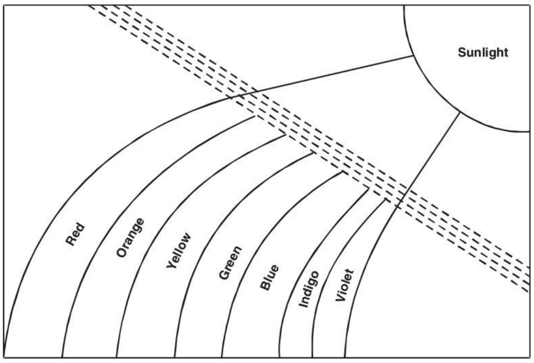


Figure: White light is composed of all the colours of the rainbow / visible spectrum

White light appears to have no color because all the wavelengths are present in equal amounts, effectively “cancelling” each other out. Objects appear colored because they reflect or transmit some parts of the spectrum and absorb the others. For example, a red object appears red as it reflects the red light and absorbs most of the violet, blue, green and yellow lights. White objects reflect or transmit almost all parts of the spectrum, while tones of gray absorb equal proportions of all its constituents and black absorbs almost the whole of it.

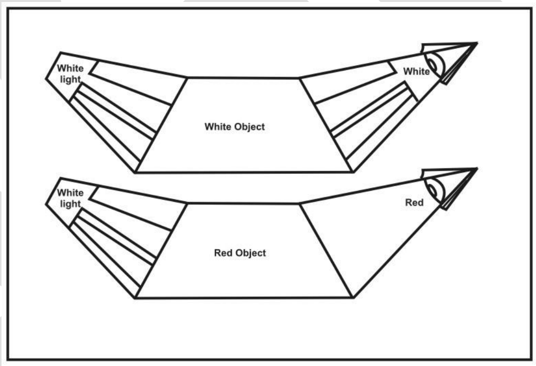


Figure: How different coloured objects filter out and reflect different colours - thus a red object reflects only red

The perception or sensation of color, despite attempts to objectively quantity it, is a highly subjective phenomenon. We speak of, for example, a “red apple,” but the redness of the apple is more dependent on our own peculiar visual systems than any inherent “redness” in the apple. (To organisms with different types of photoreceptors, it could appear to possess a much different color.) Even among different humans, the redness perceived is not absolute, varying according to minute physiological differences in visual acuity or according to the illumination used.

1.4. THE PROPERTIES OF COLOUR

The ***co*lorimetric properties** of color are those that describe its three dimensions: *hue, saturation,* and *lightness.*

Hue

- **Hue** is the name given to a specific colour, to differentiate it from any other.The hues blue, green and red; yellow, magenta and cyan form the familiar colour wheel- see Figure Color Wheel.

The **hue** identifies whether a color is red, blue, green, yellow, or some combination term as greenish yellow or bluish red. Such other terms as magenta or crimson are often used as hue names. Hue may have an infinite number of steps, or variations, within a color circle. A circle displays all the hues that exist; indeed, it can be said that any reproduction process is capable of matching any given hue.

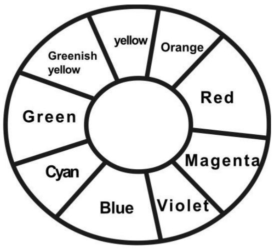


Figure: The hue component of color shown on an abridged color circle. The divisions are illustrative. The circle is a modified version of a structure suggested by Frederick T. Simon.

Saturation

- **Saturation**, similar to **chroma**, indicates the purity of a colour. It refers to the strength of a colour, - i.e. - how far it is from neutral gray.

A gray-green, for example, has low saturation, whereas an emerald green has higher saturation. A color gets purer or more saturated as it gets less gray. In practice this means that there are fewer contaminants of the opposite hue present in a given color. To illustrate this concept, imagine mixing some magenta pigment with a green pigment (the opposite hue). The green will become less and less saturated until eventually a neutral gray will be produced. A gray scale has zero saturation. The figure below shows the magenta-green saturation continum. Magenta becomes desaturated by the addition of green in the same way green becomes desaturated by the addition of magenta.

As a color becomes less saturated, it is said to be dirtier or duller, and as it becomes more saturated, it is described as cleaner or brighter. There is a limit to how desaturated a color can be (it will always reach neutral gray) and there are practical limits in reproduction processes to how saturated a color may appear. These practical limitations in printing are due to the characteristics of the chosen ink-substrate combination.

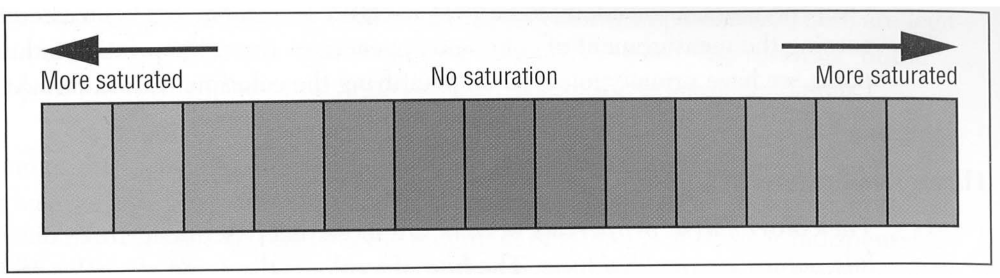
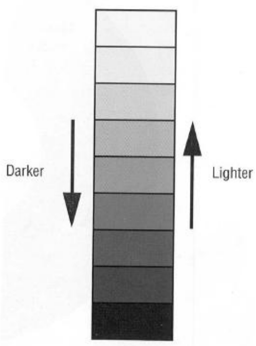


Figure: The saturation component of color for the magenta-green hue axis.

Brightness / Lightness

- **Brightness**, similar to **lightness, luminance** or **value**, describes how light or dark a colour is, indicating whether a colour is closer to white or to black: brightness does not affect the hue or saturation of a colour. Grey is a neutral 'colour' between white and black - to lighten a colour the brightness or lightness element is changed.

In fact, the terms lightness and darkness are synonymous. Lightness or darkness of a solid color may be changed by mixing either white or black ink with the color. In process-color printing this is achieved by printing a color at various halftone percentages from 0 to 100 (mixing with white), then overprinting the 100% solids with increasing percentages of black (mixing with black). The figure below shows the lightness aspect of color.



In practice both lightness and darkness have limits. In printing, the lightness of a color is limited by the properties of the substrate. It is generally possible, for example, to achieve lighter colors on a good coated paper than on newsprint or uncoated recycled paper. The darkness of a printed color is limited by the gloss of the substrate and the ink, and the amount of ink (and pigment) that can be physically transferred to the substrate. Drying, trapping, dot spread, and economic factors restrict the thickness and number of ink films that can be sequentially printed.

- **Neutral colours** do not possess the properties of hue or saturation but are described according to their lightness - white, black and gray are neutral 'colours'.

Violet	Cyan 0%	0% Gray
Green	Very Light Blue (Cyan 25%)	Light Gray (25 % Gray)
Red	Lighter Blue (Cyan 50%)	Gray (50% Gray)
Yellow	Blue (Cyan 100%)	Black (Black 100%)
Hue	**Saturation**	**Brightness**

Table: Variations of hue, saturation and lightness

A simplified illustration of how hue, saturation and lightness operates is shown opposite:

- four different hues or colours - yellow, red, green and blue
- four different saturations of one colour -cyan as 100%,50%,25% and 0%
- four different levels of lightness - black,50% gray, 25% gray and pure white

- **Neutral subtractive 'colour'** - when yellow, magenta and cyan printing inks or toners are present in equal amounts, the coloured result appears gray or black.

- **Neutral additive 'colour'** - when blue, green and red lights are present in equal amounts, the colored result appears gray or white.
- **Opposite colour pairs** - colours which appear opposite to each other when combined together, form a 'neutral' colour - e.g:' red + cyan, green + magenta, yellow + blue (blue/violet).

Reproduced below is a colour wheel, showing the additive primary colours of blue, green and red as well as the subtractive primary colours of yellow, magenta and cyan - note blue, green and red; yellow, magenta and cyan appear opposite to each other on the colour wheel.

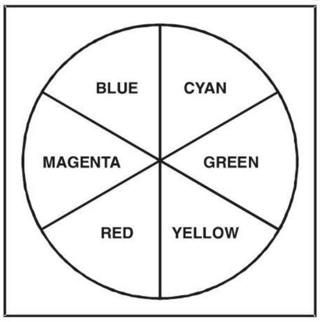
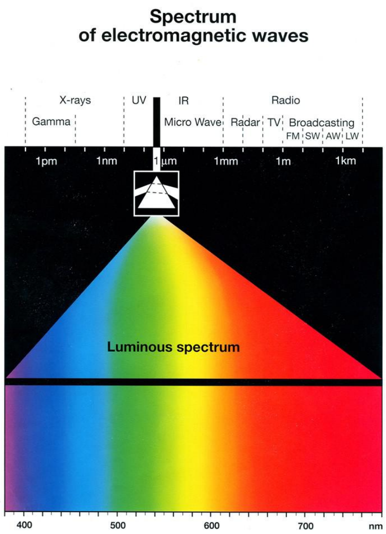


Figure: Colour wheel illustrating blue, green, red, plus yellow, magenta, cyan and their relationship/position to each other on the wheel

1.5. THE ELECTROMAGNETIC SPECTRUM

Of the overall spectrum of electromagnetic waves, the human eye is only able to perceive a narrow band between 380 and 780 nanometers (nm). This visible spectrum is situated between, ultraviolet and infrared light. If the light of this visible range is passed through a prism, then the individual spectral colors can be seen.

However, light is not absolute. For example, if a printed image is compared with a proof under artificial light, the two may seem identical, but regarded in daylight, differences may suddenly appear.



Wave length (in Nanometers)

The Visible Spectrum

Light is a small portion of the much larger *electromagnetic spectrum,* a broad range of different types of generated energy, ranging from radio waves and electrical oscillations, through microwaves, infrared, the visible spectrum, ultraviolet radiation, gamma rays, and high-energy cosmic rays. All of these sources of electromagnetic radiation exist as waves, and it is the variations in wavelength and frequency that determine the precise nature of the energy. These wavelengths range in size from many meters (such as radio waves) to many billionths of a meter (gamma and cosmic rays). Visible light is technically defined as electromagnetic radiation having a wavelength between approximately 400 and 780 *nanometers* (one nanometer is equal to one billionth of a meter).

The electromagnetic spectrum ranges from the extremely short waves of gamma rays emitted by certain radioactive materials to the radio waves, the longest of which can be miles in length. Light, the visible spectrum, ranges from about 400 to 700 nm (nanometers, or billionths of a meter) in length. Some sources suggest that the visible spectrum could range from about 380 to 770 nm, but the exact limits will depend on the visual system of a given observer. Below 400 nm are the ultraviolet rays, which are important when dealing with fluorescent materials. Above 700 nm are the infrared rays, which have significance in certain kinds of photography or image capture.

The visible spectrum occurs in nature as a rainbow. It can be duplicated in a laboratory by passing a narrow beam of white light through a glass prism. The spectrum appears to be divided into three broad bands of color-blue, green, and red-but in fact is made up of a large number of colors with infinitesimal variations between 400 and 700 nm. The colors in the spectrum are physically the purest colors possible. The splitting of white light into the visible spectrum, and the recombining of the spectrum to form white light, was first demonstrated and reported by the English scientist Sir Isaac Newton in 1704.

The reason that a spectrum can be formed by passing white light through a prism has to do with the refraction of light as it passes from one medium (air) to another(glass).The prism bends light of the shorter wavelengths more than light of the longer wavwlengths, thus speading the light out into the visible spectrum. In nature, drops of rain act in a manner similar to that of a prism: when a beam of sunlight breaks through the clouds it is refracted by by moisture in the air and a rainbow is formed.

Color Reproduction Principles

Color Reproduction Terminology

Color reproduction is the process of making color images of an original scene or object. Generally speaking, it involves the use of an optical system, a light-sensitive material, an image processing method, and an electronic or colorant-based rendition system.

In the case of the printing industry, the process typically involves making reproductions from existing photographs or artists' originals. Electronic camera images also are commonly used as the starting point for the printed color reproduction process.

Originals in full colour, such as transparencies and colour photographs, are mainly reproduced by four-colour process, using yellow, magenta, cyan and black printing inks. A separate screened negative/positive, printing ‘plate, cylinder or stencil is required for each colour, so that the printing combination of colours reproduce the full effect of the original. For the most faithful reproduction possible, special colours may be necessary, particularly in packaging and labels, where they may be used for overall solids or house colours. These are often specified as a PANTONE Matching System (PMS) reference.

There are two types of colour reproduction - 1. Additive Color Theory.

2. Subtractive Color Theory.

Photomechanical color reproduction is the traditional term that describes the printing industry’s color reproduction production process. This process may include the production of intermediate film, plate, or cylinder images prior to the stage when the colorants are physically transferred to a substrate. Some of the processes used by the industry form the image directly from digital data without the need for intermediate film or plates.

The yellow, magenta, and cyan subtractive primaries, plus black, that are used for making printed color reproductions are known as **process colors**. The term **process color printing** is often used to mean photomechanical color reproduction, but it also means the production of flat color tones by combined process colors.

The term **color printing** is a broad one that includes flat solid color (nonpictorial) package printing and fine art printmaking, as well as the photomechanical color reproduction process. Color printing may also be used to describe the production of photographic color prints or the generation of output from computer-driven desktop color imaging systems.

Additive Color Theory

As previously mentioned it is possible to divide the spectrum of white light into three broad bands - blue/violet, green/yellow and orange/red - which appear essentially blue, green. and red to the eye: these are in effect the additive primary colours. If these colours, in the form of beams of coloured light, are in similar proportions upon a white screen then white light is created. With the overlapping primary colours of blue, green and red, the secondary colours of yellow, magenta and cyan are produced.

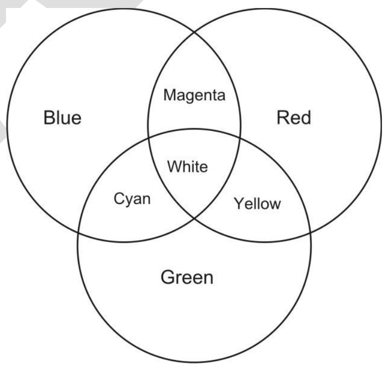


Figure: Principles of additive color theory - the three broadbands of the spectrum can be mixed to make a variety of colours

An additive mixture of colours is a superimposition of light composed of different colours. If all colours of the spectrum are added together, the colour white results. Red, green and blue are the additive primary colours. They are called one-third colors because each represents one third of the visible spectrum. The additive system starts with darkness (for example, a blank TV screen) and adds red, green and blue to achieve white.

Green + Blue	= Cyan
Red + Blue	= Magenta
Red + Green	= Yellow
Red + Green + Blue	= White
No Light	= Black

Table: Additive color combination.

The principle of additive color mixture is used in color TV and in the theaters to produce all the colors of the visible spectrum.

When wavelengths of light are combined or added in unequal proportions, we perceive new colors. This is the foundation of the **additive color reproduction process.** The primary colors of the process are red, green, and blue light.

Secondary additive colors are created by adding any two primaries:

- red and green combine to produce yellow;
- red and blue combine to produce magenta; and
- blue and green combine to produce cyan.
- The presence of all three colors will produce white, and
- the absence of all three colors will result in black.

Varying the intensity of any or all of the three primaries will produce a continuous shading of color between the limits.

Two methods for adding colors may be used: (i) red, green, and blue-light image records either overlap each other, or (ii) are placed side by side within a mosaic structure. The overlapping-primaries method of additive color reproduction has certain practical limitations that restrict its use. The side-by-side red, green, blue image element approach to additive color reproduction has, however, proved to be quite successful for certain applications.

Color television works on this basis: a magnifying glass will reveal the red, green, and blue mosaic structure of the screen (figure below). Many early color photography processes were also based upon the mosaic-structure type of additive color reproduction.

Additive color photography processes, however, have certain disadvantages when compared to subtractive methods. The drawbacks of the additive color reproduction photographic process are due to the fact that the red, green, and blue-filter mosaic absorbs two thirds of the light in the whitest areas. Additive-process transparency photographs appear to have low contrast and saturation unless they are viewed using a relatively intense light within a darkened room.

Satisfactory reflection color photographs and color printing cannot be produced by the additive process. Red, green, and blue rotating reflection disks are often used to demonstrate the principles of additive color reproduction, but it is necessary to illuminate the disk with an extremely intense light to achieve satisfactory results.

The additive color reproduction process works for television and computermonitor imaging processes because the intensity of the self-luminous display screen is sufficient to overcome the room lighting effects. For best results, however, television and monitor displays should be viewed under dim ambient lighting conditions, and the viewing distance must be sufficiently great so that the eye cannot resolve the mosaic structure of the screen.

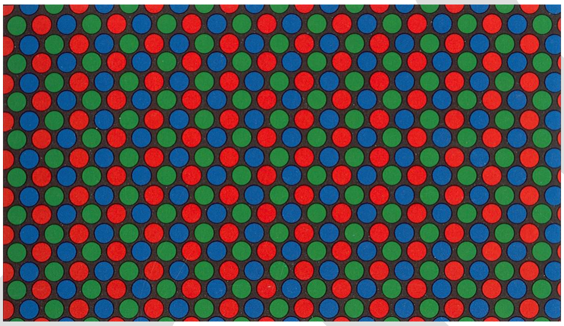


Figure: The red-, green-, and blue-filter mosaic of a color television screen. Separate elements are fused into a continuous color at the appropriate viewing distance

Subtractive Color Theory

The limitations of the additive process for reflective light viewing can be overcome with the **subtractive color reproduction process**. The subtractive system starts with white (white paper illuminated by white light, for example) and subtracts red, green, and blue to achieve black.

The majority of commercial work is printed in four, rather than three colours, adding black to the process set. Black Color is included to compensate for deficiencies in the yellow, magenta and cyan pigments, and to allow type to print in only one dense, high contrast colour. Although the way in which the black separation is made can radically affect the final result, the theory of subtractive reproduction relates to the three primary colours of yellow, magenta and cyan. Subtractive color mixing operates by “subtracting” out one or more colors of light.

In ideal subtractive colour behavior, each of the primary colours would subtract one third of the spectrum. The yellow ink would absorb the blue portion and reflect a mixture of red and green light appearing yellow to the eye, which cannot analyse it into its component parts; the magenta ink would absorb the green portion and reflect blue and red; with the cyan ink absorbing the red portion and reflecting blue and green.

The subtraction of red, green, and blue is achieved by using colorants that are their opposites.

- For red, this is a color made up of blue and green (i.e., minus red), called **cyan**.
- For green, this is a color made up of red and blue (i.e., minus green), called **magenta**.
- For blue, this is a color made up of green and red (i.e., minus blue),called **yellow**.

Colors are achieved by subtracting light away from the white paper (which reflects red, green, and blue). A combination of yellow (minus blue) and cyan (minus red) will, for example, result in green. Table below shows the possible combinations.

Green + Blue	= Cyan
Red + Blue	= Magenta
Red + Green	= Yellow
Red + Green + Blue	= White
No Light	= Black

Table: Subtractive color combinations.

A continuous blend of colors between the gamut limits is obtained by varying the quantity of any or all of the primary colorants deposited within the image. In color photography, this is achieved in a purely subtractive manner, by varying the density of the cyan, magenta, and yellow dye layers. Most color printing, however, relies upon a combination of a fixed density (ink film thickness) and a variable area coverage to adjust the quantity of ink deposited. The “halftone” structure that results from the combination of inked dot areas printed upon a white paper base is optically fused by the eye to produce a continuous-tone appearance.

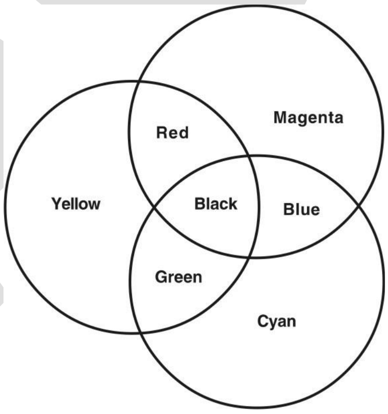


Figure 4-3. The principles of subtractive color reproduction in the digital imaging and printing industry. Yellow, magenta, and cyan colorants are superimposed upon a white substrate.

Cyan, Magenta and Yellow are the subtractive primary colors. They are called two-third colors because each represents two thirds of the spectrum. They can be produced by superimposing the light of two additive primary colours.

Process colour separations

To produce a set of four colour separations the original is scanned/input on an, electronic colour scanner using RGB (red, green, blue) light sources and output for printing purposes as CMYK (cyan, magenta, yellow, black) separations.

The figure below, illustrates the use of BGR colour lights/ separation filters to produce YMC separations or printing plates; K (black) is reproduced from a yellow / orange combination-type filter.

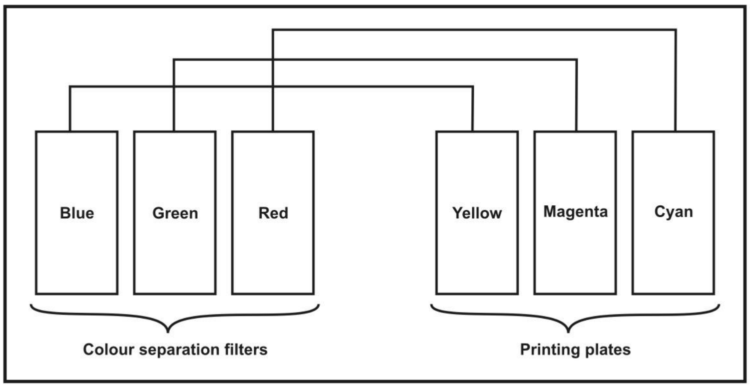


Figure: Colour separation lights/filters and their respective printing plates

The principle of colour separation is probably best considered from the traditional method, where the blue filter is dense in the areas of the image representing the parts of the original reflecting or transmitting blue, less dense where there is less blue light and transparent where there is none; the printing plate therefore produced from the blue filter is the yellow plate. On the same basis the green filter produces the magenta plate and the red filter the cyan plate.

Printed Color Reproduction

The key objective in the photomechanical color reproduction process is to produce cyan, magenta, and yellow images that are negative records of the amount of red, green, and blue in the original. This is achieved by initially photographing the original, in turn, through red, green, and blue filters. The subsequent image records or signals are adjusted as required prior to generating a halftone image that suits the chosen printing process. The images are then used to generate image carriers, which may be plates, cylinders, or stencils. Each plate is inked with its appropriate color which is sequentially transferred, in register, to a white substrate. The more direct electronic (“digital”) printing systems eliminate films, or even plates, from the production process.

There are practical considerations that limit the thicknesses of cyan, magenta, and yellow inks that may be printed by most processes; consequently, a black printer is normally employed to compensate for the resulting loss of image contrast. The black printer is made by photographing the original sequentially through red, green, and blue filters, and then following procedures similar to the other colors. Below figure shows the complete process in schematic form. The exact nature of the printed image will depend upon the process used to form and transfer the image.

Concluding Analysis

The additive and subtractive color reproduction processes are both of interest to the printing industry: the additive because color monitors operate on this principle, and the subtractive because the printed product is produced by such means. Color fusionthe process by which discrete image elements are visually blended into a continuous color sensation is an essential aspect of these color imaging processes.

Too much is often made of the differences between additive and subtractive methods of color reproduction. In practice, if the ambient lighting is controlled, surface characteristics are neutralized, gamuts are equalized, and the viewing geometry is optimized, then an observer cannot tell whether an image is formed by RGB or CMYK processes.

Today's additive and subtractive color reproduction processes are based upon trichromatic principles. Trichromatic methods of color reproduction are, in theory, sufficient for optimum quality. In practice, however, the actual materials and processes in use do not produce the theoretical color gamut. This is the reason why a supplementary black printer is used in the color printing process and why extra chromatic colors are often desirable.

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IMAGE PROCESSING

UNIT – I - ORIGINALS & COLOR

PART – A ***2 Marks Questions***

1. What is an original? State the types of originals.

Any copy whether it is a mechanical, artwork or other material from which reproductions are to be made is called as an original.

Types: 1. Reflection originals 2. Transmission originals

2. What is Reflection original? Give some examples for Reflection originals?

Any original copy which is to be reproduced that exists on an opaque substrate (such as photographic print) is called as Reflection Original.

Eg.: Photographic color prints, paintings, wash drawings are termed reflection originals.

3. What is Transmission original? Give an example for transmission original.

Any original copy which is to be reproduced that exists on a transparent substrate (such as photographic transparency) is called as Transmission Original.

Eg.: Color Transparency is an example for Transmission original.

4. What is Line original? State some examples for line originals.

Line originals have no gradation of tones that is, they possess no intermediate tones.

Eg.: Paper paste-up from phototypesetters, typewriter or laser-printed line copy, dry transfer lettering; pen and ink effect drawings, or their digital equivalent produced electronically, Technical drawings, figure drawings, architectural plans, etc.

5. What are Monochrome line originals? Give an example for monochrome tone original.

Line originals prepared for single color are called as monochrome line originals.

Eg.: Black and white Photographs

6. What are color line originals?

Line illustrations may be produced for printing in two, three, four or more colours, with a separate colour split for each colour are called as color line originals.

7. Give an example for color tone originals.

Color Transparencies, color prints, color paintings are the examples for color tone originals.

8. What are continuous tone originals?

Continuous tone originals, consist of a variety of gradations between highlights (lightest areas), mid tones (neutral/mid-way areas) and solids (darkest areas).

Tone originals may be,

1. Monochrome Tone Originals (eg. Black and White Photographs)
2. Color Tone Originals (eg. Color Transparencies, Color Prints or Color artwork).

9. What are Colour originals?

Pictures representing line and tone in colour are called color originals.

10. What are halftone originals?

Originals in which detail and tone values are represented by a series of evenly spaced dots of varying size and shape, the dot areas varying in direct proportion to the intensity of the tones they represent are called as halftone originals.

11. What are the types of halftone originals?

- Black and White halftone originals
- Color halftone originals
- Digital halftones.

12. What are Merchandise samples?

In those cases where a very accurate color match is required, an actual sample of the product is sometimes supplied for use as an original. Examples are paint chips, fabric swatches, linoleum squares, or upholstery samples.

13. What is Light?

Light is radiant energy that is visible to the average human eye. Light travels in wave motion, with the color of light varying according to the length of the wave.

14. State the unit of light.

The intensity (or luminosity) of a light source is measured in candles. The intensity of light reflected from a surface (or luminance) is measured in candles per square meter, or foot candles or foot lamberts.

15. What is Color?

The term color refers to the quality of light possessing certain dominant wavelengths. Color is a complex visual sensation that is influenced by the physical properties of the illuminant and sample, but is determined largely by the physiological characteristics of the individual observer.

16. What are the properties of colour?

The colorimetric properties of color are those that describe its three dimensions:

- Hue
- Saturation, and
- Lightness

17. State the three (different) categories of colors.

Three categories of colors are : primary colors , secondary colors , and tertiary colors.

18. Define Primary colors.

Primary colors are those that are not formed by the mixing of any other colors and can be said to be pure colors.

Eg: Blue, Green, and Red colors

19. Define Secondary colors.

Secondary colors are those formed by the mixing of two or more primary colors.

Eg: Yellow, magenta, and cyan colors.

20.Define Tertiary colors.

Tertiary colors are those produced by the mixing of two or more secondary colors.

21. What are light or additive primaries?

Blue, Green, and Red are called as light primary colors.

22. What are printing or subtractive primaries.

Yellow , magenta, and cyan are called as printing primary colors.

23. Why do an apple appear red?

An apple appears red as it reflects the red light and absorbs most of the violet, blue, green and yellow lights.

24. Define Visible light?

Visible light is technically detined as electromagnetic radiation having a wavelength between approximately 380 nanometers and 780 nanometers.

25. What is the electromagnetic spectrum?

The electromagnetic spectrum includes a broad range of different types of generated energy, ranging from radio waves and electrical oscillations, through microwaves, infrared, the visible spectrum, ultra violet radiation, gamma rays, and high-energy cosmic rays.

26. What are process colors?

Yellow, Magenta, cyan and black colors that are used for making printed color reproductions are known as process colors.

27. What are neutral colors?

Neutral colors do not possess the properties of hue or saturation but are described according to their lightness-white, black and gray are neutral colors.

28. What are one-third colors?

Red, green, and blue are called one-third colors because each represent one third of the visible spectrum.

29. What are two-third colors?

Yellow, Magenta and cyan are the two-third colors because each represents two thirds of the visible spectrum. They can be produced by superimposing the light of two additive primary colors.

30. A black body reflects none of the incident radiation. Why?

A black body absorbs all the incident radiation that falls on the surface. Hence it will not reflect any incident radiation.

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PART – B ***3 Marks Questions***

1. State the various types and classifications of originals.

Types of Originals

There are two types of originals:

1. Reflection Originals and
2. Transmission Originals

Classification of Originals

Originals can be further classified as follows:

1. Line originals.
2. Tone or Continuous Tone originals.
3. Color originals.
4. Halftone originals.
5. Merchandise Samples.

2. Define halftone originals. State the types of halftone originals along with examples.

Halftone Originals

Originals in which detail and tone values are represented by a series of evenly spaced dots of varying size and shape, the dot areas varying in direct proportion to the intensity of the tones they represent are called as halftone originals.

i. Black-and-White Halftone Originals

Examples of halftone originals are printed pictures in newspapers or magazines.

ii. Color Halftone Originals

Color photographs printed in magazines, newspapers, or books.

iii. Digital Halftones

When using scanned images or images from a digital camera, you can produce digital halftones direct from the software to the printer.

3. How will you handle originals?

Handling of Originals

- Any dust, finger marks, scratches, or other defects on an original have to be avoided during the reproduction, as they will be magnified during printing.

- Care should be taken in handling all originals, preferably keeping them in mounts or sleeves except when they are being scanned.
- A quick wipe over the surface of an original before scanning can save a great deal of time pixel cloning later in an image-editing program.
- On some scanners, transparencies are mounted in oil to improve the contact with the scanner drum and reduce the likelihood of scratches and Newton's rings appearing on the scanned image. If scratches or other marks appear on an image they can be removed in an image-editing application

Other requirements of good originals include good tonal gradation and good tonal separation between areas of detail (bearing in mind that this tonal separation will be compressed when the image is scanned).

4. Define light.

Light is radiant energy that is visible to the average human eye. Light travels in wave motion, with the color of light varying according to the length of the wave. Light can either be a wave as was first proposed by Christian Huygens, or as a series of discrete particles as was first proposed by Sir Isaac Newton. Eventually it was decided that light could be both a wave and a series of particles.

The intensity (or luminosity) of a light source is measured in candles.

5. Define color.

Colour is an optical effect, i.e., a sensational conveyedby the eye and brain. Objects and nature itself are colorless. They get their color through light. Color is light.

The term color refers to the quality of light possessing certain dominant wavelengths.

Color is a complex visual sensation that is influenced by the physical properties of the illuminant and sample, but it is determined largerly by the physiological characteristics of the individual observer. Insights into the process of color perception may be gained through examinations of these distinct elements (illuminant, sample, human observer) and the manner in which they interact.

6. Define Hue.

Hue

- **Hue** is the name given to a specific colour, to differentiate it from any other.The hues blue, green and red; yellow, magenta and cyan form the familiar colour wheel- see Figure Color Wheel.

The **hue** identifies whether a color is red, blue, green, yellow, or some combination term as greenish yellow or bluish red. Such other terms as magenta or crimson are often used as hue names. Hue may have an infinite number of steps, or variations, within a color circle. A circle displays all the hues that exist; indeed, it can be said that any reproduction process is capable of matching any given hue.

7. How do humans perceive colors?

The human perception of colour

The sensation of colour is the effect of light upon the eye interpreted by the brain. White light is composed of a mixture of all colours of the rainbow or spectrum, and most objects are visible by the light reflected or transmitted from them, depending upon whether the object is opaque or transparent. The colors of the visible spectrum include (in order of increasing wavelength) violet, indigo, blue, green, yellow, orange and red.

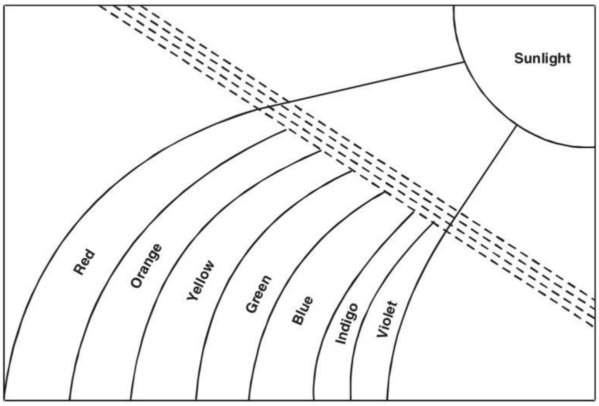

Figure: White light is composed of all the colours of the rainbow / visible spectrum

White light appears to have no color because all the wavelengths are present in equal amounts, effectively “cancelling” each other out. Objects appear colored because they reflect or transmit some parts of the spectrum and absorb the others. For example, a red object appears red as it reflects the red light and absorbs most of the violet, blue, green and yellow lights. White objects reflect or transmit almost all parts of the spectrum, while tones of gray absorb equal proportions of all its constituents and black absorbs almost the whole of it.

8. Describe saturation.

Saturation

- **Saturation**, similar to **chroma**, indicates the purity of a colour. It refers to the strength of a colour, - i.e. - how far it is from neutral gray.

A gray-green, for example, has low saturation, whereas an emerald green has higher saturation. A color gets purer or more saturated as it gets less gray. In practice this means that there are fewer contaminants of the opposite hue present in a given color. To illustrate this concept, imagine mixing some magenta pigment with a green pigment (the opposite hue). The green will become less and less saturated until eventually a neutral gray will be produced. A gray scale has zero saturation. The figure below shows the magenta-green saturation continum. Magenta becomes desaturated by the addition of green in the same way green becomes desaturated by the addition of magenta.

As a color becomes less saturated, it is said to be dirtier or duller, and as it becomes more saturated, it is described as cleaner or brighter.

9. Explain brightness.

Brightness / Lightness

- **Brightness**, similar to **lightness, luminance** or **value**, describes how light or dark a colour is, indicating whether a colour is closer to white or to black: brightness does not affect the hue or saturation of a colour. Grey is a neutral 'colour' between white and black - to lighten a colour the brightness or lightness element is changed.

In fact, the terms lightness and darkness are synonymous. Lightness or darkness of a solid color may be changed by mixing either white or black ink with the color. In process-color printing this is achieved by printing a color at various halftone percentages from 0 to 100 (mixing with white), then overprinting the 100% solids with increasing percentages of black (mixing with black).

10. Define duotones.

It is a term for a two color halftone reproduction made from a simple color original. Duotone requires two halftone films with proper screen angles. One color usually printed in dark color and the other in lighter color.

PART – C ***10 Marks Questions***

1. Define originals. Explain the various kinds of originals with examples.
2. Describe (i) Light (ii) Colour with necessary sketches.
3. Explain the principles of colour, Describe the properties of colour.
4. Explain the colorimetric properties of color.
5. Write notes on (i) Hue (ii) Saturation (iii) Brightness
6. Explain (i) The electromagnetic spectrum (ii) The visible spectrum.
7. Explain the additive color theory with sketches.
8. Explain the subtractive color theory with necessary sketches.

GLOSSARY

Achromatic: Without color or hue (black and white).

Art/Artwork: All illustration material used in preparing a job for printing. May also referred to drawings and charts specifically.

Black Printer: In color reproduction, the black plate is generated to increase contrast of dark tones and make them appear neutral.

CMY (Cyan, Magenta, Yellow): Subtractive primary colors, each of which is a combination of two additive primary colors (RGB).

CMYK (Cyan, Magenta, Yellow, and Black): The subtractive process colors used in color printing. Black (K-key color) is added to enhance color and contrast.

Color Conversion: Producing a color transparency from a color reflection original so that a flexible copy of the original can be color-separated on a rotary-drum scanner.

Color Filter: A sheet of dyed glass, gelatin or plastic, or dyed gelatin cemented between glass plates, used in photography to absorb certain colors and transmit others. The filters used for color separation are red, green, and blue.

Colorimeter: An instrument that measures and compares the hue, purity, and brightness of colors in a manner that simulates how people perceive color.

Continuous tone: An image that contains gradient tones from black to white. It has infinite tone gradations between the lightest highlights and the deepest shadows

Contone: Abbreviation for continuous tone.

Copy: Any furnished material (files, typewritten manuscript, pictures, artwork, etc.,) to be used in the production of printing.

DCS (Desktop Color Separation): In digital pre-press, a data file defined to assist in printing process color separations using desktop color systems. Using DCS, five files are created: cyan, magenta, yellow, and black image data, and a composite color preview of the color image.

Duotone: In photo-mechanics, a term for a two-color half tone reproduction from a one-color photograph.

Generation: Each succeeding stage in reproduction from the original. A copy of an original would be the second generation.

Hard copy: the permanent visual record of the output of a computer or printer on a substrate. “Soft” copy refers to images displayed on screens.

Hard proof: A proof on paper or other substrate as distinguished from a soft proof that is an image on the screen.

HSV: Acronym for Hue, Saturation, and Value (or brilliance or luminance) – a color space used in some graphic programs.

Hue: In color the main attribute of a color that distinguishes it from other colors.

Hue Error: A measure of the hue deviation from a theoretically perfect subtractive process (primary) color.

Line Images: Solid areas with no shading or tones, including type, drawings, and diagrams.

Mechanical: A term for a camera-ready paste-up of artwork. It includes type, photos, line art etc., all on one piece of artboard. It is photographed in a graphic arts camera and the resultant film is stripped into flats for platemaking.

Prepress: All printing operations prior to presswork, including page design and layout, typesetting, graphic arts photography, image assembly, and platemaking.

Process colors: In printing, the subtractive primaries: yellow, magenta, and cyan, plus black in four-color process printing. Referred to as CMYK.

Reflection copy: In photography, illustrative copy that is viewed and must be photographed by light reflected from its surface. Examples are photographs, drawings, etc.,

Reflectance: The ratio between the amount of light reflected from a given tone area and the amount of light reflected from a white area.

RGB (Red, Green, and Blue): The primary additive colors used in display devices and scanners. Commonly used to refer to the color space, mixing system, or monitor in color computer graphics.

Saturation: The degree to which a chromatic color differs from a gray of the same brightness.

Spectrophotometer: Instrument for measuring color for CIE color spaces. It is more accurate than most color colorimeters.

Spectrum: The complete range of colors in the rainbow, from short wavelength (blue) to long wavelength (red).

Subtractive primaries: Yellow, magenta, and cyan, the hues used for process color printing inks.

Transparency: Color positive film. In digital imaging, a computer capability to make graphics and images transparent so that underlying graphics and images show through.

Transparent copy: In photography, illustrative copy such as a color transparency or positive film through which light must pass in order for it to be seen or reproduced.

Ultraviolet Radiation: The range of electromagnetic radiation that lies outside the visible spectrum. In the graphic arts, UV rays are used to induce photochemical reactions.

Vignette: An illustration in which the background or image fades gradually away until it disappears by blending into areas of the unprinted paper.

Wavelength: The distance between corresponding points on two successive waves of light or sound.

UNIT - II - DIGITAL REPRODUCTION TECHNIQUES

2.1. DIGITAL CAMERA - BASICS

Since they first became popular in the late 1990s, **digital cameras** have revolutionized how professionals and ordinary people take pictures. Though operating a digital camera requires a bit more technical know-how than using a film camera, these cameras open up a world of creative expression that's impossible with conventional film photography.

What is a Digital Camera?

A digital camera is a lot like a traditional film camera, but with one major exception: rather than store photos as images on **film**, it saves them as **digital data**. An electronic **photosensitive sensor** captures light that enters the digital camera, then saves the image's data onto a removable storage device called a **memory card**. To access images stored on a digital camera's memory card, you must connect the camera (or just the memory card) to your computer. You can then view and edit the images on your computer screen and print the images through your printer or at a commercial photo lab.

By definition, a digital camera is an exceedingly practical and efficient electronic device that is used to store and capture photography by modes of an electronic or digital format as compared to the photographic films which are used extensively in conventional and normal cameras. A digital camera consists of an assortment of diverse components. Each and every part of the camera has a special specific function which it performs.

ELEMENTS OF DIGITAL CAMERA (IN BRIEF)

Nearly all entry-level digital cameras have most, if not all, of the following components:

1. **Viewfinder:** Look through this hole to compose photos, or use it instead of the LCD screen.
2. **Mode dial:** This dial toggles between the camera's main operating modes, such as photo, video, and playback (a mode that lets you the review photos you've already taken on the LCD screen).

3. **Shutter button:** Press this button to take a photo.
4. **Lens:** This piece of glass focuses the light that enters the camera and projects it onto the sensor.
5. **Flash:** This bulb emits a flash of light to illuminate dark scenes.
6. **Settings buttons:** These buttons toggle between specific shooting modes, such as flash/no flash.
7. **Menu button:** This turns the LCD into an on-screen menu that lets you access the camera's other features.
8. **LCD screen:** This small color screen shows you what your photo will look like before you shoot.
9. **Power and storage components:** These include ports for A/C power adapters and USB cables (used for transfering images), and a chamber to hold batteries and a memory card.
10. **Internal electronics:** These include an image sensor, internal memory, and other built-in electronic components.

ELEMENTS OF DIGITAL CAMERA (IN DETAIL)

Following are the various components that make up a digital camera.

The camera body

The first component, of course, is the camera body. You'll want to consider the overall weight of the camera and how it feels to hold it in your hand. Each camera is different, looks a little different, and, perhaps most important, feels a little different in your hands.

FIGURE A

Optics

The next camera component worthy of your understanding is the optical system, the lens. When choosing a camera, you're going to encounter terms like optical vs. digital zoom, auto-focus, macro modes, and more.

To a photographer, the lens is, in reality, the most important part of the camera. Key, then, to choosing a new camera is determining the picture quality of the camera's lens and how images coming into the camera and are recorded.

Looking at the outside of the camera, you can see the lens, as shown in Figure B.

FIGURE B

The lens on Denise's camera expands out when used.

It's the optical component (a piece of glass or clear acrylic material) that transfers an image into the camera. Often, more advanced cameras like SLRs (single-lens reflex) have removable lenses that have widely differing optical properties. You can see some removable lenses in Figure C.

FIGURE C

There are also different elements of the optics system as mentioned below:

Image-recording sensors

Once an image is transfered into the inner workings of the camera via the lens, a digital camera needs to perform some action to "understand" the image and process it so it can be saved for later viewing. The first component involved in this process is the image-recording sensor.

In a digital camera, these sensors go by the acronyms CCD (charge-coupled device) and CMOS (complementary metal-oxide-semiconductor). Both of these components are integrated circuits, and CMOS is actually a very broad term describing a large class of integrated circuit types. CMOS-based sensors tend to use less power. Even more confusingly, some manufacturers describe their CCDs as CMOS-based.

In any case, the imaging sensor is the chip inside the camera that actually converts light into digital form, the core of the digital camera that converts an analog image into a digital file. By the way, it's the number of pixels the image-recording sensor can capture that determines a camera's megapixel spec.

Data from that sensor is used in two ways: it becomes the image through an LCD (liquid crystal display screen) so you can preview your shot. And, that data, if you so choose, is sent to the storage mechanism within the camera.

The viewfinder

To compose your image, you need to see what you're going to shoot. Most lower-end digital cameras have an LCD screen that provides a small-screen preview of what you're going to shoot. Most also have a tiny viewfinder as shown in Figure D.

FIGURE D

Many amateur photographers prefer the LCD screen, shown in Figure E, since they don't have to hold the camera tight against the face to take a shot. The LCD also often doubles as the camera's menuing system, allowing you to adjust your camera's settings.

FIGURE E

The LCD screen serves to help you compose the shot, review your pictures, and access the camera's menu.

Most professional photographers like to sight their shots directly through the viewfinder, since they can both get a more accurate shot and block out outside distractions while composing the photograph.

In most cases, SLR photographers like to aim their shots through the viewfinder. Those using less expensive cameras tend to aim their photos through the LCD screen, which for non-SLR cameras is more accurate.

Image storage

When you take a picture with a digital camera, the pictures you've taken are saved on a storage card, a form of non-volatile computer memory. In most cases, it'd be impractical for you to shoot a picture and have it recorded directly by a computer. Instead, you're going to need to store your pictures in an intermediate storage location, somewhere you can keep your pictures until you're ready to send them to your computer. In most digital cameras, this intermediate storage location are flash cards, which you can see in Figure F.

FIGURE F

On the left is an Secure Digital flash card, on the right is a Compact Flash card. With digital storage cards, you can reuse the cards over and over, leading to one of the biggest cost-savings in digital camera purchases.

<u>Batteries</u>

Another important element of a digital camera is the battery, the component that powers the whole system. In early digital cameras, battery life was horrible. You might get 20 or 30 minutes of shooting before the battery died. Today, battery life is much better. You can generally get a day's worth of light shooting out of a typical camera battery.

Batteries come in all shapes and sizes, like those shown in Figure G.

FIGURE G

On the left is the battery for the digital SLR, on the right is the battery for Denise's smaller Casio camera.

Most mid-level and above digital cameras use some form of removable, rechargeable battery, while cameras at the very low end sometimes use off-the-shelf AA or AAA cells, and other lowest-end cameras have non-removable batteries. Never buy a camera that has a non-removable battery.

Buttons and controls

Let's move from the inside of the camera body back into the outside, physical world and talk about buttons and controls.

In addition to the lens, LCD, and viewfinder, you need some way to tell the camera when and how to take a picture. You may need to adjust the settings, you may need to adjust the amount of light going to the lens, zoom in or out, and so forth. All your interaction with the camera's components is done through the buttons and controls on the camera, like those shown in Figure H.

FIGURE H

Given that the process of taking a picture should be a very seamless event between you and your subject, you want the controls to be intuitive, comfortable, fit where you want them to be, and not difficult to get to. In effect, you want the controls to be so natural, they seem like an extension of you.

In most cameras, the shutter release is near the top of the camera because that is where you'll naturally place your index finger while holding the camera in your hand. Obviously, if you had to fiddle with the camera and move it around to reach the shutter release, it would be very hard to hold the camera steady enough to take a picture.

Flash

Continuing our tour of the camera's outside, flash is next.

The flash is a more traditional camera term: the flash of light that illuminates your subject in a darkened environment, coming from a light-emitting device like that shown in Figure I.

FIGURE I

Accessory connections

Some digital cameras do not come with an on-board, built-in flash, while most do. The better, more professional digital cameras (usually SLRs) come with on-board flash and a way to mount an external flash device as an accessory. As you might imagine, where you aim your light and how it bounces off your subject can have a substantial impact on your final image.

Beyond the flash mount, shown in Figure J, most digital cameras have various accessory connections.

FIGURE J

Two of the most important accessory connections are the tripod mount (a threaded hole in the bottom of the camera) and a remote shutter release (allowing you to take a picture without jostling the camera), like that shown in Figure K.

FIGURE K

Moving the camera can cause it to lose focus, especially when the shutter's open for a long time. A shutter release like this can prevent that movement.

One accessory connection that's critically important is the connection between the computer and the camera. You can see the tripod mount as well as the PC connection port and battery door in Figure L.

FIGURE L

A lot of the more interesting parts of your camera are often hidden on the bottom.

Computer-transfer interface

Today, we can get to see your pictures by transfering them to a computer. Fundamentally, there are two ways to transfer your images to a computer — sending them by wire (usually Firewire or USB) or removing the storage card from the camera and inserting it into your PC.

We can just take the flash card out of the camera and place it into a card reader on the PC. We've also started to see some cameras with wireless interfaces, usually Bluetooth or WiFi. Bluetooth is a slower transmission medium and it's likely to be more frustrating than useful. WiFi, while sometimes complex to configure, has some interesting potential for image transfer. Once all the kinks are ironed out it might be possible to send your images back home or to the office by simply walking into a WiFi-enabled Internet cafe and pressing "Send" on your camera.

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2.2. IMAGE CAPTURING TECHNIQUES

DIGITAL PHOTOGRAPHY / DIGITAL CAMERA

This is the process of digitizing-or converting to digital form a photographic image at the same time as it is taken, typically by means of a digital camera. An advantage of digital photography is the elimination of the need for the intermediate step of scanning; digitally photographed images can be imported directly into a processing or page makeup program. Also, the photographs taken can be "instant," or other words viewed almost immediately after they were taken, saving time if reshooting is necessary. Images taken with a digital camera are often displayed on a small LCD monitor attached to the camera, or by means of a PCMCIA (or flash memory) card added to a laptop computer. Images obtained digitally can be stored on any computer medium (such as magnetic disks, optical discs, magneto-optical discs, CD-ROMs, etc.). Kodak's Photo CD format also allows for the archiving of digital images.

CCD vs. FILM (in photography)

There are several aspects to consider when deciding to use a digital camera instead of a conventional film-based camera. A digital camera, like a scanner, captures images by means of a charge-coupled device (CCD), or a "light sensor; many of which are assembled into an array, which can either be a linear array (all the CCDs located in a single row) or an area array (the CCDs arranged in a rectangular block).

With a linear array, an image is captured one row of pixels at a time, whereas an area array captures an entire scene. However, the latter may require up to three separate exposures to capture all color information.

There is also a trilinear array, which contains three linear arrays mounted side by side, each array coated with a colored dye to act as a color filter, enabling red, green, and blue color information to be captured simultaneously. However, since each color array is offset slightly from the others, the software driving the camera must accurately adjust the separate color images so that all color channels align perfectly upon output. However, since these types of arrays take some time to image all color information, no movement within a scene is possible.

Certain variations of the area array have been devised. Some use filter wheels, which require three separate exposures. Some, however, use mirrors or prisms to split incoming light into three separate beams, each going to a separate CCD, which can capture all three color channels simultaneously. However, with this technique, the low light Intensity resulting from splitting the incoming light can result in poor imaging of scenes that are lit less than optimally. Other configurations split a single beam of light among a single CCD, which although it allows for rapid capture of separate color channels, can result in less-than-optimal color depth.

i) DIGITAL CAMERAS

A device that can capture photographic images and store them in digital form on an integrated circuit card, a hard disc or a type of RAM. The use of digital cameras is a desirable alternative to scanning, as cost, image resolution and storage capacity of the cameras improved verymuch.

Electronic imaging technology has, in recent years, flowed backwards from prepress into all aspects of consumer-level photography and professional imaging. In many print imaging markets, digital photography is increasingly replacing the distinct processes of conventional photography and prepress scanning: the image capture of the original scene and the separation into RGB images can now be accomplished in a single step.

Reference to "digital cameras," "digital photography," and such other terms with the "digital.' prefix are popular but misleading. All image capture is analog until signals are processed through the analog-to-digital (A/D) converter. Electronic photography, cameras, printers, etc. is the proper technical descriptor, but relentless advertising seems to have ensured that "digital" is the common prefix used to distinguish these imaging technologies.

Most digital (electronic) photography is based upon charge-coupled device (CCD) technology. A CCD is a solid-state device that consists of light-sensitive elements in linearor area-array form. Light that falls on the elements is converted into an electrical signal that is, in turn, converted from analog to digital form and stored on a RAM chip, card, or disk.

Several kinds of digital (electronic) cameras are available. A hand-held digital camera suitable for photographing moving objects contains either a single area CCD with alternating red- green-, and blue-filter-covered image elements, or a three-CCD split-beam system, with each CCD covered by either a red, green, or blue filter. The former system has lower resolution, while the latter system is rather bulky.

The complementary metal-oxide semiconductor (CMOS) sensors work on the same general principle as CCDs and may be used in their place. The Foveon X3 layered CMOS, however, represents a radically new technology that does for electronic imaging what Kodachrome did for silver halide imaging; that is, it combines the image quality of the bulky three-sensor "one-shot" camera with the compact size of the single mosaic-structure sensor type of camera. The three layered or stacked CMOS sensors capture color-separated images at three times the resolution of a comparable mosaictype sensor.

Some hand-held CCD cameras are standard 35-mm cameras equipped with a special CCD back, while others are purpose-built CCD cameras. In either case, the image is stored on an internal hard drive or removable memory card.

Hand-held CCD cameras are particularly useful for remote-site (e.g., sports) photography with data transfer links to the image processing home base. Images from low-end consumer versions of this type of camera are also suitable for relatively coarsescreen reproductions that do not have to undergo significant enlargement. Professionalgrade electronic cameras match the normal graphic arts performance requirements of most conventional cameras.

Digital camera sensors are rated at a fixed “speed,” but their sensitivity can be rated at higher levels to handle challenging lighting or motion situations. The image quality will suffer when the speed rating is increased: noise (similar to grain) increases and some color shifts occur.

The studio type of digital camera is generally equipped with linear-array CCDs. Two types of systems are available-one uses a single CCD and makes three separate passes, or scans (changing the filter each time), while the other has three CCDs, each covered by either a red, green, or blue filter, that makes one scanning pass. The linear-array camera is, in effect, a flatbed color scanner configured as a camera. Such systems are capable of achieving extremely high image resolution but are suitable only for still life studio applications.

Linear-array studio cameras may require several imputes to complete the image recording process. Under such circumstances, lighting can become a significant concern. In order to avoid “banding” (stripes or bands of unevenness in smooth tones) problems, special flicker-free light sources must be chosen when using digital studio cameras

Generally, these lights generate considerable heat and do not offer the photographer the flexibility of conventional studio lighting. CCDs are quite sensitive to infrared (IR) radiation; therefore, IR-absorbing filters may have to be fitted to the CCD camera back to counter the influence of heat on the sensors. CCD camera backs are normally used on standard view cameras. A SCSI (small computer systems interface) cable connects the CCD back to a computer workstation. The image is generally stored on the computer’s internal hard disk drive or on a dedicated external drive.

One particularly good use of CCD studio cameras is for photographing reflection artwork that is too large or rigid for normal scanning. These cameras are also used with considerable success for certain types of catalog photography.

ii) SCANNER

Scanner is a device used to analyze an original image and either generate color separations and/or digitize the image and store it in a computer for later manipulation and output. Essentially, a scanner records one row of the image at a time, and converts the original into an electronic matrix of pixels (or a bitmap). Each pixel is recorded as some level of gray for each of the red, green, and blue components of an image, and the scanner then collates them back into the appropriate (or closely approximating the appropriate) color for each pixel.

One basic distinction between scanners is whether it is an image scanner or a text scanner. An image scanner images all originals as a bitmap, regardless of whether it is text or a photograph. A text scanner-utilizing optical character recognition (OCR) software-can scan text material and convert it to ASCII text. Some desktop scanners can function as both, depending on which software is used, while dedicated image or text scanners can only function as one or the other.

Another important distinction in prepress is drum scanner versus flatbed scanner. A drum scanner is a high-end machine that utilizes a highly sensitive photomultiplier tube to capture subtle variations in tone, and it is capable of digitizing images at very high resolutions.

Flatbed scanners are much less expensive, but their use of charge-coupled devices (CCDs) makes them less sensitive to subtle color variations. Drum scanners are beginning to come down in price, and flatbed scanners are beginning to improve in quality, so at some point the twain shall meet. Some flatbed scanners are also sheet fed scanners and have automatic stacking and/or document-feeding functions. Some flatbed and most drum scanners can scan transparencies rather than simply reflective copy.

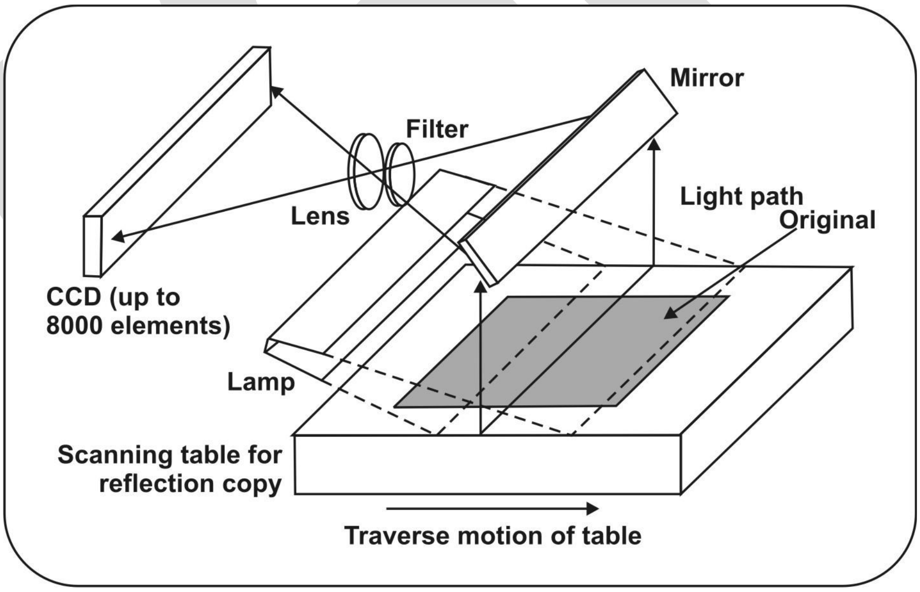

Figure: The line-by-line scanning principle of the flatbed CCD scanner.

Many scanners have the ability-through software to display previews and allow color modifications prior to scanning, enabling the operator to optimize the contrast and color attributes prior to image capture. Post-scanning image manipulation using programs such as Photoshop can be used to further refine and manipulate a scanned image.

Not all scanners feature user-selectable resolution, and thus offer only a handful of fixed resolutions (i.e., 100, 200, 300 . . . dpi), while some allow any resolution to be specified (i.e., 331 dpi). Other functions common to most scanners and scanning software include the ability to scan only a selected portion of an image and the ability to scale an image (either enlarging or reducing it) prior to scanning.

Scanning Originals

The manual process of placing an original in or on a scanner for scanning has its own share of considerations. Needless to say, flatbed scanners should have their glass platens as free of dust, dirt, and other detritus as possible. Transparencies and prints should also be inspected for dust, scratches, or other visible problems that may be magnified by the scanning process. When attaching a transparency to a drum scanner, it is important that all parts of the image be flat against the drum; if any part of the image varies in distance from the scanner optics than the rest of the image, distortions in the scanned image will be evident. Sometimes, oil mounting is performed so as to eliminate an optical problem known as Newton's rings, or haloes of color caused by refraction of light passing through a transparency. Adhering the transparency to the drum by means of a clear oil can reduce this problem.

Beyond Scanning

It has been suggested that scanning may ultimately be replaced by other forms of imaging, especially digital cameras, which capture images directly in digital form. There is widespread popularity and enthusiasm for these devices, but so far quality and price issues have impeded their widespread use. But they are gaining ground. The popularity of the Photo CD, which many perceive to be a transitional medium, is an indicator that pre press departments and other users of digital images would like to eliminate the scanning phase as much as possible.

Scanning Mode

In scanning, a term referring to whether a scanner is set to digitize photographs, line art, color, grayscale, etc.

Scanning Spot

On a scanner, the point on the surface of an image where the scanning beam used for digitizing is focused.

Scanning Velocity

In computing, the speed with which a laser reads the tracks on an optical disc, usually expressed in meters per second.

Scan Rate

Scanning, the speed (measured in seconds per page) at, which a scanner can digitize text or images. The term scan rate, when used in reference to computer monitors, is an alternate term for refresh rate.

iii) PHOTO CD (PRE-RECORDED IMAGES)

Pre-recorded images are those scanned from a conventional photographic image and recorded onto a CD-ROM. The Eastman Kodak PhotoCD system is a well-known example of this type of system. The consumer version of PhotoCD is used to record 35-mm color negative or transparency images. The resulting files have resolution sufficient for making magazine-page size reproductions at 133 or 150 lines per inch screen rulings. A professional version of PhotoCD accepts film input images up to 4X5 inches which may be used to generate fine screen reproductions up to about 16X20 inches.

For best results, PhotoCD's CCD-based scanner requires that the range of the original color negative or transparency not exceed about 2.80 density. All color negatives will certainly be suitable, but some transparencies will not.

Figure: The geometric interaction between the digital camera's ccd array and the pattern in the jacket has caused a severe moire fringe type of interference pattern.

The PhotoCD scanner uses a scene balance algorithm to correct for film type and exposure when processing image scans. The algorithm attempts to make the reproduction look like the original scene, which is a worthy goal for the consumer market, but may not work if special exposure and lighting effects have been used with professionally-created images. The problem here is akin to photofinishing of conventional film: a consumer-market photofinisher will aim to produce a generally pleasing result that may happen to distort the special requirements of professional images. Photofinishing and scanning services that are geared specifically to the needs of the professional color reproduction industry should be used for best results.

The stock photography business is based, to a considerable degree, on PhotoCD or other types of writable CD systems. In some cases, a CD serves as a catalog of available images. Once an image has been selected, a company will purchase the reproduction rights. A high-resolution image will then be sold or leased to the company. In other cases, a CD may be sold outright as a set of royalty-free stock images to be used in any way the purchaser desires.

A key image transfer issue for color separators is that the CD data are convertible into standard formats for image processing. Kodak's PhotoCD image is produced by scanning the original, converting the data into ICC color space, compressing the data, and then writing to a special PhotoCD PCD file format. The disks can be read on any extended architecture (XA) CD player linked to a computer. The YMC image may be converted to RGB or, in some cases, to CMYK color systems. The file format is converted into such systems as TIFF for image editing and color separation. Some PhotoCDs may be written directly in TIFF.

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DIGITAL CAMERA EVALUATION

Unlike scanner evaluation, camera evaluation goes well beyond the image resolution and tonal detail that usually determines equipment choice. The picture-taking circumstances must also be considered when choosing a digital camera.

Hand-held digital cameras can range from inexpensive mosaic structure types through to the high-end beam-splitter and three-CCD cameras. The choice of one over the other is based upon, like scanner choice, the scale of enlargement and the output screening resolution required for the job at hand. Coarser-screen printing and modest enlargement conditions (most editorial illustration work) will be well served by a wide range of mosaic-structure types of digital camera. Fine screen reproductions of products with finely detailed textures or embellishments will require the use of higher-end hand-held digital cameras or the scanning-back types of studio digital camera.

Outdoor action, portraits, inconvenient locations, and candid photography will all require the convenience of a hand-held digital camera. If the demands for the subsequent image are high, a conventional camera loaded with color transparency film should be used; otherwise, a digital camera may be used.

Scanning-back types of studio digital camera can match, or often exceed, the performance of film-based systems. Their use is restricted to still life subjects in a studio setting but, for many types of catalog photography, this is not a drawback. These cameras are also ideal for color-separating large reflective originals (e.g., fine art) that cannot be handled by scanners.

The initial goal of the color separation process is to capture a suitable-resolution. distortion-free image. These images may be produced by a photographer with a handheld digital camera or by a scanner operator with a drum scanner. Either one produces RGB color separation images for subsequent image processing purposes. In general, the final consumer is unaware of which workflow was chosen. The chosen method of image capture, therefore, will vary according to creative, economic, image transmission. storage, permanence, and quality requirements

RESOLUTION DISTORTION

The image resolution or detail recording quality is influenced by the frequency with which image signals are recorded. The segmentation of the image that occurs during electronic scanning or photography is a form of digitization that results, to some degree, in a loss of image detail. Conventional photography, by contrast, forms an image in analog form with no capture-related loss of resolution.

Digital cameras vary considerably in their image-resolving ability. The coarser-resolution hand-held, area-array systems may record as few as 640 pixels (picture elements) across the long dimension of an image while the finer-resolution systems may record over 3,000 pixels across the long dimension of an image. The linear-array studio camera systems may record around 8,000 pixels across the image in some systems.

The image sampling frequency also varies considerably within electronic scanning systems. The PMT-based rotary drum scanners are capable of the highest scanning frequency; up to *12,000* lines per inch in the scanning head direction may be achieved by some scanners". The CCD flatbed or slide scanners are generally limited to about 8,000 scan lines across the image. The scanning frequency for a CCD scanner, therefore, depends upon the size of the original. Small transparency originals may actually record with very high resolution.

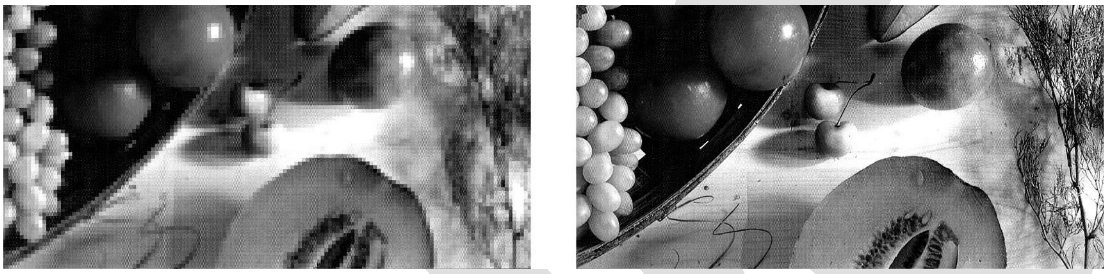

Figure: Image detail is lost (e.g., branches on the right-hand side) when the sampling frequency is too low for the reproduction scale: (top) low-frequency scan, (bottom) high-frequency scan.

In order to avoid confusion with halftone screen ruling, the input scan frequency is often designated in pixels per inch (ppi) rather than lines per inch.

The term "optical resolution" is used to describe the image capture performance of a scanning system. Interpolation techniques may be used to achieve higher reported resolution specifications, but such "improvements" are not based on actual image detail.

The key issues in scanning frequency are the required degree of enlargement, and the specified screen ruling. Images that undergo significant enlargement must be scanned at a higher frequency than those images that are reproduced at same size or reduced. Fine-screen halftone reproductions require higher input scan resolution than coarse-screen reproductions. A 300-lpi screen reproduction, for example, requires twice the scanning frequency of a 150-lpi screen reproduction, because 2.0 lines of input scan resolution are required for every row of halftone dots recorded at the output stage, assuming same-size reproduction.

Scanning frequency is increased in proportion to the degree of enlargement. If, for example, an original image is enlarged ten times, and the reproduction is printed with a 250-lpi halftone screen, then the required input scan frequency will be 5,000 ppi (10 times enlargement X 2.0 scan lines per row of dots X 250-lpi screen ruling = 5,000).

The size of the original, the size of the reproduction, and the required screen ruling will determine the suitability of the scanning system's resolving power. Modestenlargement, coarse-screen newspaper reproductions, for example, will reproduce satisfactorily on most scanning systems and also with most digital camera systems

MOIRE FRINGING

Moire fringing is an interference effect that can occur when a fine repetitive pattern is photographed with a digital camera. Such interference patterns are caused by the geometric clash between the spacing of CCD elements within the camera and fabrics, grids, fences, and other regular pattern elements within the original scene. The resulting localized image distortions may appear quite bizarre see the figure below.

The interference effect may be avoided by moving closer to or further away from the subject in question. Alternatively, a slight defocusing of the camera may eliminate interference, but only at the expense of sharpness. This is one instance when conventional silver halide emulsions have a clear edge over digital cameras.

The random grain distribution within the emulsions can never produce moire fringing effects, but the CCD sensor's regular structure will inevitably cause interference pattern problems with certain subjects.

SCANNER EVALUATION

The PMT -drum scanner has certain quality advantages over the CCD-flatbed scanner. The resolution of the scanning system will become critical when the job requires that small originals (35-mm or smaller transpareneies) with very large output requirements (e.g., posters) have to be screened at a fine screen ruling (150 lpi, or finer).Under such circumstances, the job will benefit from the higher-resolution capabilities of the PMT -drum scanner.Lower-resolution CCD scans not only will lack detail; they are also unsharp. The unsharpness is due to the "averaging" of edge regions by individual sensing elements within the CCDs, thus causing a gray band to be formed in black and white boundary regions. This is also true of PMT scanners, but these higher-resolution scans produce a much smaller "averaging" band in boundary regions.The boundary-softening action of much CCD scanning can be countered through the use of electronic edge enhancement techniques. There is a limit, however, to the degree of compensatory enhancement that may be used to offset low-resolution image capture. Other factors that influence the choice of scanning system are whether rigid originals are supplied, and the size of the original. Flatbed scanners are confined to smaller originals, and drum scanners are confined to flexible originals.

One of the major drawbacks associated with flatbed scanners has been the limitation that high resolution could not be achieved over the whole area of the platen surface, only the central band, so severely restricting the number of originals which could be scanned in a batch. The development of what is termed XY scanning has overcome this problem where the CCD array is able to move up and across the platen in both dimensions of the originals - i.e. - length and width (X and Y axes) so that every original can be scanned at the maximum resolution possible, regardless of its size or position on the platen with, finally, the process of stitching the scanned strips together into a single file or image if and when required.

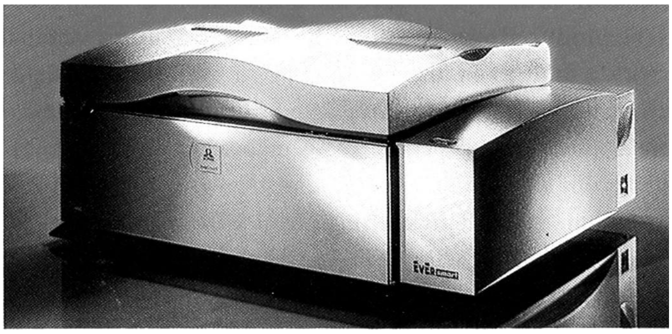

Figure: Example of a high-end flatbed scanner - i.e. - Scitex Eversmart

For many years large drum- or rotary-based colour scanners have been recognised as capable of far higher quality and productivity than flatbed types: this is now being seriously challenged by the new breed of desktop-type small drum and flatbed scanners, which are generally much less expensive than their larger counterpart, with an increasingly high level of quality and suitability to the modern desktop-based systems. Flatbed scanners also have the advantage of being able to reproduce relatively thick, rigid and in some cases three dimensional originals, which is not possible with drum-based scanners.

The PMT scanner will handle longer-density-range originals at a finer resolution than the CCD scanners. The PMT scanner because of its point-by-point (as opposed to line-by-line) method of analysis produces images that are free from the effects of image flare. The image rays in a PMT scanner are all on-axis of the optical system, unlike those in CCD scanners. Possible lighting unevenness and the influence of lens aberrations on the quality of the image will have a greater effect with CCD-scanned images than those produced on PMT scanners. In practice, however, the influence of optical and lighting effects will not be significant for most originals.

2.3. IMAGE EDITING AND MANIPULATION SOFTWARE PROGRAMS

This group of software programs have been developed to retouch, enhance, amend and manipulate graphic images. The main programs that fall into this category are ‘Photoshop’, ‘Live Picture’, ‘Artisan 6’ (part of Corel Draw) and ‘Color It!’ The range of features normally available, in at least some of the programs outlined above, include: converting RGB to CMYK; support for a wide range of file formats; painting tools; image transformation, including rotating, stretching, skewing and distort options; filters for image sharpening, softening, special effects; creation of duotones, tritones and quadtones; on-screen CMYK editing; monitoring and collaging of images; 3-D and 4-D (animation, video) links. Paint and image edit software are now virtually interchangeable.

SCANNING SOFTWARE AND IMAGE ENHANCEMENT

Most scanners come bundled with some type of software that is used to control the scanning process, adjust contrast, set resolution and ultimate image size, crop the image, etc., prior to making the actual scan. Many flatbed scanners come with either full-fledged or “limited edition” versions of popular photo manipulation programs such as Photoshop. Many scanning software programs can function as plugins to programs like Photoshop, which means that images can be scanned directly into those programs. Many programs now also are compatible with the TWAIN standard, which allows the use of different scanners without requiring a variety of different device drivers. A variety of third party scanning software utilities allow enhanced image calibration and color correction prior to scanning.

IMAGE CORRECTION AND ENHANCEMENT

There are a variety of ways of fixing and correcting scans. Depending on the scanner and the scanning software, it may be possible to do this prior to or during scanning. Often, however, especially with flatbed scanners, such processes can only be handled after scanning, in an image manipulation program such as Photoshop.

SHARPENING / EDGE ENHANCEMENT / UNSHARPMASKING

Some of the most common activities include sharpening, variously known as edge enhancement or unsharp masking. In the latter designation, abbreviated USM, the scanner includes a separate photomultiplier tube that captures a slightly out-of-focus signal. This somewhat blurry (or “unsharp”) signal is added to the sharp signal. The effect of this combination used for many years in photography is to sharpen the contrast at the edges of boundaries between separate portions of an image. (When USM is performed after scanning in a program such as Photoshop, it is effected by calculating the differences between the values of adjacent pixels and increasing the contrast between them.) Too much unsharp masking, however, can produce excessive noise and distortion in an image.

TONAL ADJUSTMENTS

Tonal adjustments can also be made in a scanned or to be-scanned image. This can take the form of adjusting the endpoints of an image (i.e., whitest white and blackest black, or highlight and shadow, respectively) or adjusting the midpoint of the image or the distribution of tones in the image. Similarly, color correction may be needed, depending on the quality of the scanner. Sometimes, a scanner will impart a color cast to an image, and at other times a few of the colors in the image will be off. **Global correction** is the correction of the color throughout the entirety of the image, which can consist of darkening all the reds, for example. **Local correction** is the changing of the color of one particular portion of an image, such as only the red of a fire hydrant present in the image.

Depending upon the nature of the image and the context in which it is ultimately to appear, further types of manipulations may be required, including forming collages, removing elements from the image, inserting elements in the image, etc.

There is no hard and fast rule to these adjustments, of course; most good software and scanning programs have “preview” functions that allow the user to see what the effects of a particular adjustment will be before they are actually made. The best judge of any image or color correction operation is the human eye.

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UNIT – II - DIGITAL REPRODUCTION TECHNIQUES

PART – A **2 Marks Questions**

1. What is digital camera?

A digital camera store photos as digital data.

By definition, a digital camera is an exceedingly practical and efficient electronic device that is used to store and capture photography by modes of an electronic or digital format.

2. State the advantages of digital photography.

- The elimination of the need for the intermediate step of scanning.
- Digitally photographed images can be imported directly into a processing or page makeup program.
- Also, the photographs taken can be "instant," or other words viewed almost immediately.

3. What is a scanner?

Scanner is a device used to analyze an original image.

- They generate color separations
- They digitize the image and store it in a computer for later manipulation and output.

4. What is CCD?

Charge-Coupled Device (CCD) are used as light sensors in digital cameras and scanners. A CCD is a solid-state device that consists of light-sensitive elements in linear or area-array form. Light that falls on the elements is converted into an electrical signal that is, in turn, converted from analog to digital form and stored on a RAM chip, card, or disk.

5. Expand CMOS.

Complementary metal-oxide semiconductor (CMOS) sensors work on the same general principle as CCDs and may be used in their place as light sensors.

6. Define scanning mode.

Scanning Mode

In scanning, a term referring to whether a scanner is set to digitize photographs, line art, color, grayscale, etc.

7. State the functions of PMT.

Photomultiplier Tubes (PMT) are used in drum scanners. Highly sensitive photomultiplier tubes are used to capture slight variations in tone, and they are capable of digitizing images at very high resolutions.

8. State the uses of OCR software.

Optical Character Recognition (OCR) software is used for scanning text copy.

OCR (Optical Character Recognition) is an electronic means of scanning (reading) copy, and converting the scanned image to an electronic equivalent. The ability to “read” printed text (characters) and convert it to digitized files that can be saved on disk and edited as a text file.

9. What the different types of digital camera?

i) Hand held digital camera using single area CCD.

ii) Hand held digital camera using three - CCD spilt beem system.

iii) Studio type digital camera using single CCD.

iv) Studio type digital camera using threeCCD’s.

10. What is the purpose of flatbed scanner?

Flatbed scanners are used for scanning originals in both DTP applications and professional prepress.

11. What is a PMT scanner?

Drum scanners uses photomultiplier tubes (PMT) to digitize images at very high resolutions. Hence drum scanner is an example for PMT scanner.

12. Define composite images.

The image that exist as an integrated (complete) one, i.e. includes text, graphics, illustrations, tints etc., is called composite image.

PART – B ***3 Marks Questions***

1. State some main parts of digital camera.

1. Viewfinder
2. Mode dial
3. Shutter button
4. Lens
5. Flash
6. Settings buttons
7. Menu button
8. LCD screen
9. Power and storage components
10. Internal electronics

2. What is Photo CD?

PHOTO CD (PRE-RECORDED IMAGES)

Pre-recorded images are those scanned from a conventional photographic image and recorded onto a CD-ROM. The Eastman Kodak PhotoCD system is a well-known example of this type of system. The consumer version of PhotoCD is used to record 35-mm color negative or transparency images. The resulting files have resolution sufficient for making magazine-page size reproductions at 133 or 150 lines per inch screen rulings. A professional version of PhotoCD accepts film input images up to 4X5 inches which may be used to generate fine screen reproductions up to about 16X20 inches.

3. List the different types of scanners.

Scanner Types

- drum scanners (horizontal, vertical, or inclined drum arrangement)
- flat-bed scanners (desktop scanners, XY scanners)
- color scanners
- slide and APS scanners (Advanced Photo System)
- OCR scanners (OCR - Optical Character Recognition)
- redigitizing scanners

4. State some modern digital input processes.

Modern digital input processes such as scanners, digital cameras, or photo CDs allow flexible editing and processing of images on a computer. In this respect digital data have the indisputable advantage of being able to be copied as often as required without loss of quality.

5. What is the principle of scanners?

The *scanning system* is used to scan in the original in the form of lines or dots. This involves converting the light energy reflected (or transmitted in the case of transparent originals) by the original into an electrical analog signal, corresponding to the tone and color value of the original. This electrical signal is corrected, amplified, and sent to the output unit/*recording system*, where it is either converted into light energy and exposes light sensitive materials. Scanners perform a computer - controlled digitization of single color and multi color images.

6. What are the cares need to be taken while placing originals in scanner?

The manual process of placing an original in or on a scanner for scanning has its own share of considerations. Needless to say, flatbed scanners should have their glass platens as free of dust, dirt, and other detritus as possible. Transparencies and prints should also be inspected for dust, scratches, or other visible problems that may be magnified by the scanning process. When attaching a transparency to a drum scanner, it is important that all parts of the image be flat against the drum; if any part of the image varies in distance from the scanner optics than the rest of the image, distortions in the scanned image will be evident. Sometimes, oil mounting is performed so as to eliminate an optical problem known as Newton's rings, or haloes of color caused by refraction of light passing through a transparency. Adhering the transparency to the drum by means of a clear oil can reduce this problem.

7. Write a note on unsharp masking.

Some of the most common activities include sharpening, variously known as edge enhancement or unsharp masking. In the latter designation, abbreviated USM, the scanner includes a separate photomultiplier tube that captures a slightly out-of-focus signal. This somewhat blurry (or “unsharp”) signal is added to the sharp signal. The effect of this combination used for many years in photography is to sharpen the contrast at the edges of boundaries between separate portions of an image. (When USM is performed after scanning in a program such as Photoshop, it is effected by calculating the differences between the values of adjacent pixels and increasing the contrast between them.) Too much unsharp masking, however, can produce excessive noise and distortion in an image.

8. State the advantages of drum scanners.

For many years large drum- or rotary-based colour scanners have been recognised as capable of far higher quality and productivity than flatbed types.

The Drum scanner will handle longer-density-range originals at a finer resolution than the CCD scanners. The DrumT scanner because of its point-by-point (as opposed to line-by-line) method of analysis produces images that are free from the effects of image flare. The image rays in a drumT scanner are all on-axis of the optical system, unlike those in CCD scanners.

9. What do you mean by tonal adjustments in scanner?

Tonal adjustments can also be made in a scanned or to be-scanned image. This can take the form of adjusting the endpoints of an image (i.e., whitest white and blackest black, or highlight and shadow, respectively) or adjusting the midpoint of the image or the distribution of tones in the image. Similarly, color correction may be needed, depending on the quality of the scanner.

10. State the advantages of vector images or Vector Format.

Exact representation is independent of single and resolution. Vector images take up less disk space and require less processing power and *RAM* to create and manipulate. As they are described mathematically, they can be output at as high a *resolution* as the output device is capable of generating, so long as the *file format* in which the file is saved is one that can handle vectors.

PART – C **10 Marks Questions**

1. Explain the various elements of digital camera.
2. Describe the digital image capturing techniques.
3. Explain the working principles of flatbed scanner with diagrams.
4. Describe the working principles of Drum scanner with necessary sketches.

5. Explain the various Image manipulation techniques that can be done on scanned images.

GLOSSARY

APR(Automatic Picture Replacement): the automatic replacement of a low resolution image by a high resolution image.

Camera, Digital: A photographic system using a charged-coupled device (CCD) to transform visual information into pixels that are assigned/binary codes so that they can be manipulated, compressed, stored, or transmitted as electronic files.

CCD Array: A group of light-sensitive recording elements often arranged in a line (linear array) and used as a scanner image-sensing device.

CEPS (Color Electronic Prepress System): In digital prepress, high-end, computer based system that is used to color correct scanner images and assemble image elements into final pages. They are device dependent systems.

Charge-Coupled Device: A component of an electronic scanner that digitizes images. A CCD consists of a set of image-sensing elements (photosites) arranged in a linear or area array. Images are digitized by an external light source that illuminates the source document, which reflects the light through optics onto the silicon light sensors in the array. This generates electrical signals in each photosite proportional to the intensity of the illumination.

Color Balance: (1) The correct combination of cyan, magenta, and yellow needed to reproduce a specific photograph without an unwanted color cast or color bias. (2) The specific combination of yellow, magenta, and cyan needed to produce a neutral gray in the color separation process. (3) The ability of a film to reproduce the colors in an original scene. Color films are balanced during manufacture to compensate for exposure to specific light sources.

Color Cast: Modifying a hue by adding a trace of another hue to create such combinations as yellowish green or pinkish blue. Colorcasts can be undesirable as in the contamination of the desired hue by the second hue.

Color Correction: A photographic, electronic, or manual procedure used to compensate for the deficiencies of the process inks and color separation. Any method such as masking, dot etching, re-etching, and scanning, used to improve color.

Color management: Is broadly defined as a system of hardware, software, and procedures that are calibrated to best ensure color accuracy and repeatability throughout the design and production process. See ICC.

Crop: To eliminate portions of the copy, usually on a photograph, indicated on the original by crop marks. Today, it is accomplished by positioning the image in a picture box.

Desktop Publishing: The process of designing and composing pages using a combination of standard computer, off-the-shelf software, device-independent page description language such as postscript, and then outputting final pages on a printer, image setter, plate setter, or digital printer.

Device-independent: The characteristics of a computer program or system that allows different output devices to image the same file more or less the same.

Digital photography: Uses a light-sensitive sensor in place of film to capture images electronically. Digital photography is used widely by photojournalists and is being applied increasingly by both professional photographers and consumers.

EDG (Electronic Dot Generation): In digital imaging, a method of producing halftones electronically on scanners and prepress systems.

Flatbed Scanner: A device that scans images in a manner similar to a photocopy machine; the original art is positioned face down on a glass plate.

Gray Balance: The values for yellow, magenta, and cyan that produce a neutral gray with no dominant hue when printed at a normal density.

Gray Component Replacement (GCR): An electronic color scanning capability in which the least dominant process color is replaced with an appropriate value of black in areas where yellow, magenta, and cyan overprint.

LED (Light Emitting Diodes): are used in place of lasers for some output systems.

Modem (Modulator, Demodulator): An interface device that allows a computer to talk to other computers through phone systems by converting computer signals (data) into high-frequency voice communications signals, and vice versa.

OCR (Optical Character Recognition): An electronic means of scanning (reading) copy, and converting the scanned image to an electronic equivalent. The ability to “read” printed text (characters) and convert it to digitized files that can be saved on disk and edited as a text file.

PMT (Photomultiplier Tube): A light sensitive sensor that can react to very low light levels by amplifying the signals applied to the sensor during the process. PMTs given drum scanners their superior color separation capabilities.

Resolution: Ability of an input device to record, or an output device to reproduce the fine detail of an image. There is a difference between resolution and addressability, or sampling rate. Resolution concerns how closely spots can be placed, and also whether gray levels can be distinguished. Resolution for output devices depends on addressability, bit-depth, and mark size.

SCSI (Small Computer System Interface): Pronounced “skuzzy”, SCSI was an industry-standard interface used to transmit digital data and to connect computers to peripherals. Replaced by USB (Universal System Bus) and firewall interfaces.

Sharpen: To decrease in color strength, as when halftone dots become smaller; opposite of dot spread or dot gain.

Silhouette halftone: A halftone of a subject with all of the background removed.

UCA (Under Color Addition): In process color printing, used with GCR, UCA is ink added in shadow areas to increase color saturation.

Under Color Removal (UCR): A technique used to reduce the yellow, magenta, and cyan dot percentages in neutral tones by replacing them with increased amounts of black ink.

WYSIWYG (What You See Is What You Get): Means that what you see on the computer monitor is generally the same as what appears on the hard copy. Pronounced “wizzywig” But you know that the color may not match.

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UNIT - III - LINE AND HALFTONE PHOTOGRAPHY

3.1 - LINE PHOTOGRAPHY OR LINE REPRODUCTION

REPRODUCING THE ORIGINAL FROM GRAPHIC ARTS CAMERAS

After inspecting the originals to ensure that they are suitable for reproduction, the next stage in conventional graphic reproduction is to produce negative or positive films, which are the intermediate step to produce the printing plates or other means of print surface preparation. Graphic arts cameras are now practically obsolete in most printers' workflows as they lock the printer into traditional film planning and reproduction.

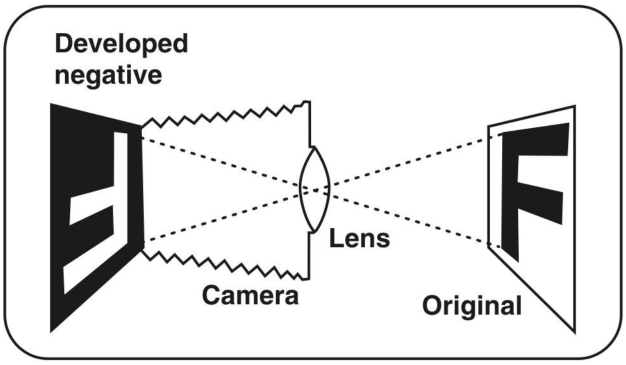

Figure: Production of a line negative using a traditional graphics arts camera

Generally graphic arts cameras are now only retained to handle the odd piece of flat artwork in conjunction with existing analogue film. When an original is exposed to light in front of a graphic arts camera, the light is absorbed in the black areas of the original, and reflected back by the white areas, through the lens onto the photosensitive material (photographic film) held in the camera. After development of the film material, a negative is obtained on which the white or clear areas of the original appear dense and the black areas transparent.

The negative is, in fact, the opposite form of the original, and normally must be contacted and re-exposed to another light-sensitive film to produce a positive: there are processes, however, which give positives from positives without an intermediary negative, with such processes using rapid access auto reversal duplicating film.

To avoid confusion, processed film for reproduction should always be described in terms of 'viewed from emulsion side-up' - for example, right reading or wrong reading emulsion side-up. Figure above illustrates the basic procedure of producing a line negative. Film produced on a graphic arts camera, scanner or imagesetter, for offset litho, needs to be in the form of wrong reading, emulsion side-up film, where printing from the plate is offset onto a rubber-covered blanket cylinder, before being transferred onto the substrate. For all the other major printing processes, which are forms of direct printing, the opposite is the case - i.e. - right-reading, emulsion side-up film is required.

Figures below illustrate the principle of 'offset' and 'direct printing, using a film-based route - the example representing emulsion side up film. The film type selected is a negative, although a positive could just as easily have been chosen to illustrate the process.

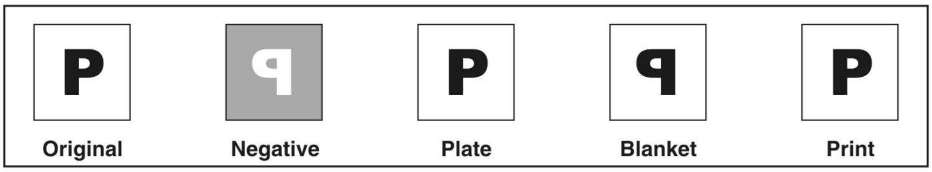

Figure: Reproduction reflecting 'offset' printing

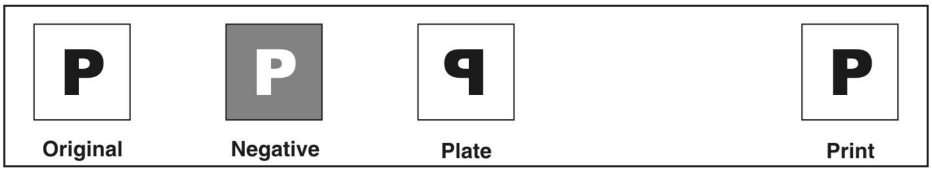

Figure: Reproduction reflecting 'direct' printing

STEPS IN LINE NEGATIVE REPRODUCTION

Line Reproduction is the most simple of all reproductions. Line reproduction is used for black-and-white copy that does not require tonal reproduction or the use of a halftone screen. This copy may be single-color or multi color, it may be of a job that is completely done in line, or it may be part of a line-and-halftone combination job.

Operational Steps

The operational steps of line negative reproduction using process camera are:

(1) Inspecting and scaling copy

(2) Placing copy on copyboard of camera

(3) Setting camera

(4) Loading film

(5) Exposing film

(6) Removing exposed film from camera

(7) Processing exposed film and

(8) Inspecting processed film.

All of these eight steps are discussed below:

1. INSPECTING AND SCALING COPY

In inspecting copy for reproduction, the camera operator usually divides the work into groups depending on (1) the quality of the copy received and (2) the reproduction size or scale required for the copy.

Both good and poor letterpress repro proofs, faded typewritten matter, copy with grayed or yellowed backgrounds, contrasty paste-ups of black ink or fine pencil drawings, Phototypeset matter, and laser printouts are just some of the various original copies that the camera operator receives. First, the cameraman will divide this wide assortment into groups of the same reproduction size for scaling. For this purpose, a proportion scale or similar device is used to obtain the desired percentage of enlargement or reduction. Then the cameraman will segregate copy into several groups depending on its quality. This arrangement is necessary, for it allows the cameraman to group the copy according to reproduction size and copy quality, thereby improving work efficiency.

Quality of Copy

The quality of copy is determined by considering color, background, and line quality. The color of the copy is an important consideration, as ortho film will not reproduce all colors as black and, consequently, certain types of colored copy will require the use of filters. The background of the copy is another factor that will determine the use of a filter. For example, in fine-line pencil drawings on paper or vellum, the contrast range of this type of copy may not be sufficient to produce good background density on the finished negative. In such a case, the use of contrast filters will greatly improve negative quality. The actual line work itself should be inspected; in particular, the fineness and blackness of letter characters.

Scaling Copy

The use of a proportion scale for calculating enlargement or reduction percentages is one of the most popular methods for scaling copy. The reproduction percentage can also be calculated by dividing the image size by the original size and multiplying by 100.

$$\text{Reproduction \%} = \frac{\text{Image Size}}{\text{Original size}} \times 100$$

2. PLACING COPY ON COPYBOARD

Most copyboards are marked in some manner to help the cameraman position copy. The three most common markings are as follows: rectangles (corresponding to the standard film sizes), diagonals, and centerlines markings. The diagonals and centerlines are usually subdivided into inch or half-inch increments. With such copyboards, it is a simple matter to center copy. Some copyboards are not marked for copy placement. If yours is not marked, *you* can make your own markings.

3. SETTING THE CAMERA

The lens aperture, use of filters, lighting angles, and camera setting for proper reproduction size are the main considerations involved in setting the camera.

For line work, the most common lens openings (f-stops) used at same size are f/16 and f/22 as process lenses have their best definition and resolution at these apertures. The aperture is varied according to the enlargement or reduction while the exposure time remains constant. In modern types of process cameras, the lens is equipped with a diaphragm chart mounted on the lens board. This diaphragm chart contains scales for all the f-stops and allows for selection of any desired aperture.

Filters

Filters used for black-and-white reproduction serve two purposes: to increase the contrast of the original and to reproduce certain colors monochromatic. Contrast filters are used extensively on poor copy, pencil drawings, and copy with a grayed or yellowed background. In line reproduction, it is also common to reproduce different colors in a monochromatic tone in relation to other colors;

Lighting Angle

The lighting angle of *45°* at a distance of 3 ft. from the copyboard is considered normal for process cameras. Reducing the angle gives much flatter lighting, resulting in a reduction of light intensity on the copy board. Increasing the light angle gives much greater intensity on the copy board but should be done with discretion, for it usually results in copyboard glare and also in undercutting of weak or poor type characters in the copy.

Setting for Reproduction Percentage

The setting of the camera for reproduction percentage varies greatly according to the camera manufacturers. In some of the cameras, the actual reproduction percentage is also the setting of the camera; in others there are arbitrary systems in use. These require the use of a percentage scale (to obtain the reproduction percentage size) and reference to the camera scale for proper setting numbers.

We might consider another step in the camera setting, namely the focusing of the image on the ground glass. Here the photographer will check the sharpness of the image and adjust for positioning. In some types of process cameras, the lensboard is equipped for vertical and horizontal movement; in such a case, exact positioning of the copy on the ground glass is simply made by use of the hand wheels for lens board movement. The higher priced precision-type cameras are equipped for electrically controlled movement of the copyboard, which greatly improves the ease of focusing and positioning on the ground glass.

4. LOADING FILM

After inspecting and setting the camera, the next step is the actual insertion of film in the camera. The film back of cameras can be one of several types.

The vacuum-type back is the simplest and most productive of these types and consists of an opaque metal or plastic back, with channels for vacuum, which is supplied by a motor pump. Vacuum backs are usually marked in some manner for easy placement of the film. The channels for vacuum are so designed that they are adjustable for various sizes of films.

5. EXPOSING FILM

During exposure, the photographic film receives the light reflected from the copy; the result of exposure is the formation of a latent image on the film. Exposure is actually equal to time multiplied by intensity. ($E = iT$, *where* E is exposure, i is intensity of light, and T is time.)

Mechanical timers for exposure control only take care of the actual time portion of the equation and make no measurement of light intensity values. Consequently, variations in line voltage may affect the exposure. The light integrator measures the predetermined amount of light by taking into consideration both intensity and time of exposure.

Exposure by Variation of Aperture. Exposure can actually be standardized by varying the aperture and maintaining the same exposure time or by using a fixed aperture and varying time according to the enlargement or reduction.

Exposure Variation with Light Distance and Angle. Another variation of exposure by varying the light distance and light angle can be computed by the following formula:

$$\text{New exposure} = \frac{(\text{new distance})^2}{(\text{old distance})^2} \times \text{old exposure} \times \frac{\text{sine of old angle}}{\text{sine of new angle}}$$

The use of this formula makes it easier to obtain a new exposure when making a radical change in lighting and/or light angle.

6. REMOVING EXPOSED FILM FROM CAMERA

After exposure, the film is removed from the camera for further processing. Many cameramen doing mass line production have some procedure of storing this film in a film cabinet and then developing it all together. The deterioration of the latent image on high-contrast films is small, but *prolonged storage* under varying temperatures and humidity conditions will affect the finished result.

7. PROCESSING EXPOSED FILM

During processing, the latent image is converted into a permanent visible image through the process of reduction in a solution called a developer. The developing agent reduces the exposed silver halides to black metallic silver, and the fixer dissolves those unexposed and underdeveloped areas of the film, thereby making the image permanent.

Factors of Development. In line photograhy, the two controlling factors of developing are agitation and temperature. The litho-type developer used for high-contrast film contains an alkali capable of extreme contrast; consequently, contrast can be greatly affected by agitation. Still development will reduce the development action and considerably reduce contrast, whereas increased agitation will greatly exaggerate contrast and may cause the printing areas to fill in. The temperature of the developer affects contrast in much the same manner; that is, a cold developer will reduce contrast and a warm developer will increase it.

Film manufacturers usually recommend a developing temperature of 68°F for tray processing. Developing time varies according to the make of the film, with 2 ¼ to 2 ¾ minutes being most common for tray processing. With automatic machine processing, the developing temperature is usually 80°F or more, and the developing time is usually less than 2 minutes.

Powder-Type Developers and Fixers. One way to prepare the developer or fixer is by using a powdered concentrate. These powders, which are packaged in a box, must be diluted to working strength using water. The typical mixing temperature is between 90 and 100°F. The major drawbacks in using powders is that they are hard to mix and they must be prepared in fixed amounts (an entire box at a time).

Liquid Concentrate Developers and Fixers. Liquid concentrate developers and fixers are quite popular because it is so easy to mix them. After dilution, the liquid concentrate developers exhibit working characteristics similar to those developers supplied in powder form. Before dilution for use, the concentrates should be stored at temperatures above 40°F to prevent the components from coming out of solution.

8. INSPECTING PROCESSED FILM

After development, the negative is inspected. Some measures can be taken after development for corrective action. A common corrective measure is the use of Farmer's reducer. By means of Farmer's reducer, silver is dissolved through a complicated chemical reaction, thereby improving an overexposed or overdeveloped negative. Intensifying is basically the addition of silver to an underexposed or underdeveloped negative. This is a rather detailed procedure. When inspection is completed, the negative is dried and passed on to the stripping or contact printing department

CONCLUSION

Line photography is considered by many cameramen as elementary and consequently not requiring much attention. But line work is, on the contrary, the basis of the photographic procedures and extremely important. With such products as auto reversal and prescreened films, the work and knowledge of the line photographer is broadened.

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3.1 STEPS IN LINE NEGATIVE REPRODUCTION (IN BRIEF)

Line photography is the most simplest of all photography methods. Line photography is used for processing of black and white line copy. This copy may be single or multicolor, it may be a part of the job that is completely done in line or it may be a part of the line and half tone combination job.

Inspecting and Scaling the copy

In inspecting the copy for reproduction the cameraman usually divides the work into groups depending on the quality of the copy received, the reproduction or scale required for the copy.

Scaling the copy:

The use of a proportionate scale for calculating the enlargement or reduction percentages is common to the modern types of process camera, although the old type galley camera require focusing on the ground glass to obtain the reduction scale. The reproduction percentage can also be calculated by dividing the image size by the original size and multiplying by 100 to obtain the percentages.

$$\text{Reproduction \%} = \frac{\text{Image Size}}{\text{Original size}} \times 100$$

Procedure for Line Negative Reproduction:

Before the camera is set-up for exposure, all the processing chemicals should be properly positioned. Temperature of the developer should be checked with a photographic thermometer. Most film manufacturers recommend 68^{o} F (20^{o}C) for tray processing. The following is the procedure involved in making a line negative.

1. Swing the copy board into horizontal position; clean the copy board glass with graphic arts glass cleaner.
2. Center the line copy face up on the copy board. Make sure the copy is free of dirt and finger marks; position a gray scale in the border area of the copy.
3. Close copy board glass cover, swing copy board into vertical position.
4. Un-lock copy board carriage; adjust copy board for the required reproduction size; re-lock carriage in place.
5. Un-Lock lens carriage; adjust bellow extension for the required percentage; re lock carriage in place.
6. Set the lens aperture to f/22, or the best f-stop of the lens, according to reproduction size.
7. Arrange and illuminate the copy board evenly.
8. Enter the dark room, switch on red safelights and turn off all white lights, and position the center of the film plane.
9. Position the ground glass panel in the focal plane.
10. Turn the illumination on; open the lens shutter.
11. Check the image position in relation to original rectangular guidelines of ground glass.
12. Using a 10 or 20 power magnifier, check the focus of the image on a position of the glass surface to examine the sharpness.
13. Turn off camera lights and close the shutter.
14. Swing ground glass out of the way to make room for the vacuum camera back to position in the focal plane.
15. Load the film emulsion facing the camera lens (orthochromatic) on the vacuum camera back using the rectangle as guide.
16. Apply vacuum to hold the film flat without movement during exposure.
17. Close the vacuum back into the exposure position.
18. Set the exposure control unit for the prescribed time, which is determined by standard exposure time.
19. Switch on unit to turn lights of camera and open the lens shutter.
20. After exposure, open the vacuum camera back and release the film.
21. Process the film finally.
22. Inspect the image quality for further use.

Inspection of Negatives:

The negatives can be examined on the viewer using a 10 or 20 power magnifier. Correct exposure and development will show that negative has clear transparent and dense opaque areas. Edges of type characters and lines should be sharp, and detail proportions true to original. Under exposure negative appear gray instead of black in the background areas and are unsatisfactory for plate making, as fine detail lines are blackened in and the edges of type characters are ragged. After development some measures can be taken for corrective action. A common corrective action is the use of reducer. By means of reducer, silver is dissolved through a complicated chemical reaction, thereby improving an over exposed or over developed negative. Intensifying is basically in the addition of silver to an under exposed or under developed negative. Following are the qualities of line negative.

a) Stencil like image the transparent areas must be perfectly transparent and the opaque areas perfectly opaque.

b) Uniform and high density throughout the image areas.

c) Open and clean thin type areas.

d) Enough and uniform contrast all over the image areas.

e) Dense black background.

f) Sharp uniform clear and correct width of lines.

g) High density extending to the edges of line.

3.2.1 - HALFTONE PHOTOGRPHY

DEVELOPMENT OF HALFTONE PROCESS

Two problems dominate the history of picture reproduction. One is the reproduction of tonal values, the other is the combination of reading matter and picture for printing in one and the same press run .The half tone process is the first effective solution of both problems. Fredrick Eu Guneives (1856-1937) of Philadelphia, solved the problem of tonal reproduction in 1886 by introduction of the glass cross-line screen. It was developed for letterpress printing and the reproduction of photographs and the tonal pictures together with reading matter was made possible.

HALFTONE PHOTOGRAPHY

Any image-such as a photograph-that exists as a series of small dots of varying size and color density, which serve to simulate the appearance of continuous gradations of tone is known as halftones. Halftones are necessary in the reproduction of photographic images; most printing presses cannot print *continuous tones,* so photographic images must first be converted to a series of dots in order to be effectively printed.

Lightness and darkness of portions of an image are effected by varying the size and density of the dots; small dots spaced far apart produce light areas *(highlights),* while large dots clustered more closely together produce dark areas *(shadows).*

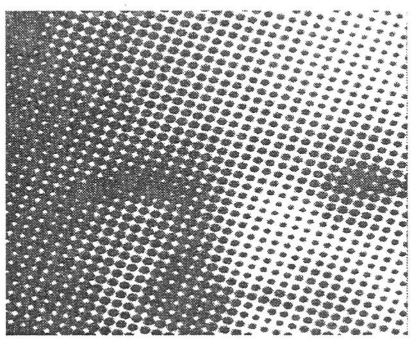
Halftones are produced either as film *positives* or *negatives* by photographing a continuous tone original through a *halftone screen* or fine grid. The screen pattern and frequency of the dots produced determine the ultimate quality of the reproduction. A 150-line screen, for example, will produce 150 rows and 150 columns of dots, or 22,500 dots per square inch. Halftones can also be produced electronically, using digital data.

3.2.1 HALF TONE PHOTOGRAPHY-BASIC PRINCIPLES OF TONE REPRODUCTION

Why Halftone Screen is Necessary?

The halftone screen is the basic tool of halftone photography. Now suppose for example, we want to print a black and white photograph. The original is composed of a wide range of shade of gray, from near white to dense black. The various shades or tones are “continuous” that is they blend smoothly one to the other.

As we have seen, it is not possible for a printing press to apply different shades or tones of an ink to paper. Thus the visual effect of the continuous and varying tones in the original is achieved in another way.



HIGHLY MAGNIFIED SECTION OF A HALF TONE IMAGE

The method by which continuous tone copy is transformed into a printable image is by photographing the original continuous tone picture through a half tone screen. The screen breaks up the continuous tone of the original into an almost countable number of tiny dots. These dots are equally spaced. However the size or diameter of the dots will vary according to the different amount of the light that was reflected from the different tones in the original.

When this half tone image is put on a press plate and printed, it prints tiny dots of ink. The ink printed by each dot, of course, has the same density. However what we see is the combination of the ink dots and the white paper that surrounds it. Wherever the dots are small and the area of the white paper is relatively great, the tone appears light. Wherever the dots are large and the areas of white paper around them are relatively small, the tone appears dark.

3.2.2 - AREAS OF CONTINUOUS-TONE PRINTS

There are three areas that both printers and photographers identify as the most significant measures of the quality of a continuous-tone print (figure):

- Highlight area
- Shadow area
- Middle tone area

The **highlight area** is that portion of a picture that contains detail but has the least amount of density. The darkest areas of the print are called the **shadow areas**. All the shades of gray between the highlights and the shadows are called **the middle-tone areas**. Middle tones contain the most pictorial detail or information.

A special kind of highlight, called a **spectral highlight**, has no detail or density. Examples include the gleam of the chrome on an automobile or the pinpoint iris of a model's eye. Spectral highlights contain no detail and should not carry a halftone dot.

It is possible to compare the density of these three areas of a print with the density of the steps on any graphic arts gray scale. We can also equate these densities to the size of halftone dots on the film negative and on the final printed sheet. For example, in figure:

1. The highlight detail begins in step 1, or with a density near 0.05. The highlight dots begin with the smallest reproducible dot (generally about 5 percent) and extend to about a 20 or 25 percent dot.
2. The shadow detail ends in step 10, or with a density of about 1.45. The shadow dots extend from about 75 or 80 percent to the largest reproducible dot (generally about 95 percent) before solid black is reached.
3. The middle-tone area for this photo is roughly from step 3 to step 7, but it is not a definite range. Middle-tone dots typically range from about 25 to 75 percent dot.

Several things need to be emphasized with respect to this comparison. Printers do not typically measure a particular highlight, middle tone, or shadow density. They are primarily concerned with density extremes (the density difference from the lightest highlight to the darkest shadow). This measure is called the copy density range (CDR) of the photograph. The CDR is the shadow density minus the highlight density. This is an important relationship to remember. The CDR of figure is 1.40 (1.45 -- 0.05). The typical continuous-tone photograph has a CDR of approximately 1.70.

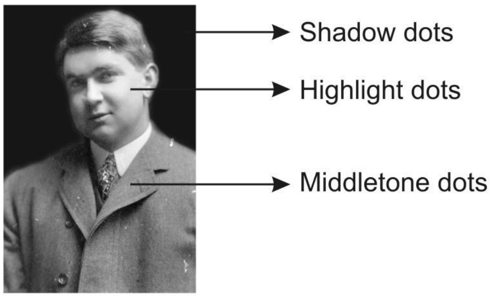


Figure - Areas of a continuous - tone print

In this continuous tone print, the high light areas correspond to step 1 and 2 on the gray scale. From the grayscale, we see that the middle range is from 3 to 7. The shadow area ranges from 8 to 11 on the gray scale.

Comparing the dot size and the gray scale tonal area should not be taken to mean that a certain dot size should be formed in any particular part of the gray scale for every halftone negative. Printers are concerned that the smallest dot appear in the highlight step and that the largest dot appear in the last shadow step. The placement of any dot sizes between these two extremes controls the contrast of the halftone and depends on the photograph being reproduced. There is no rule that states in which step any dot should be placed.

Understanding Halftone Dots

The density variations in a continuous-tone original are represented in a halftone reproduction as dots of various sizes. The size of these dots in any area of the halftone negative is determined by the amount of light reflected from the original to that area during the main and bump exposures, as well as by the amount of exposure produced by the flash. Halftone dots communicate information or detail from the original. Where there are no dots on a printed halftone, there are either completely open, inkless areas or completely filled in, inked areas.

The object of making a halftone is to produce a printed piece that reflects the tonal range of the original through variations in dot size and placement. The more closely the halftone approximates the tonal range of the original, the more closely it shows the detail of the original.

Printable Dots

It is impossible to observe all of the dot sizes on a halftone negative during film development to check for accurate dot size. Instead, printers use *aim points* that are typically at either extreme of the original's density range. They try to place the smallest dots or aim points that can be printed in the detail highlight areas of the original to show highlight detail in the print; the largest dots that can be printed are placed in the detail shadow areas. Thus, the positions of the smallest and largest printable dots on both the negative and the printed piece are important.

Remember that on the negative, the *smallest* printable dots appear as small, clear openings surrounded by black, exposed emulsion (density). During platemaking, these small openings expose only small dots on the printing plate. These small dots transfer small dots (highlight dots) to the printing paper and reproduce detail in the highlight area of the printed piece.

The *largest* printable dots appear on the negative as small areas of density surrounded by large, clear openings. During platemaking, these large openings expose large dots on the printing plate, which transfer large dots to the printing paper. These large dots (shadow dots) reproduce detail in the shadow area of the printed piece.

A press operator refers to a dot that is printable as a dot that the press can *hold,* or as a dot that can be *printed* on press. A 5 to 10 percent highlight dot can be printed in most offset presses. Dots that are smaller are too small to print accurately and consistently; some may not print at all.

Image Density

In imaging, *density* is a quantitative measure of the amount of light a particular surface absorbs. In a printed reproduction, density becomes a measure of how well the tone depth of an image has been reproduced. Density measurements can be made independent of hue, by using a densitometer and filters that can evaluate each color in a reproduction as a shade of gray.

Image Contrast

The term *contrast* refers to the distribution of tones in an image. For example, an image with a great deal of *shadow* and *highlight-but* little *middle tone* detail is considered to be high-contrast, while an image with a great deal of detail in the middle tone region would be said to be low-contrast.

3.2.3 HALFTONE SCREENS

Halftone Screening

All continuous-tone images whether they are color or black-and-white-need to be converted to *halftones* before they can be reproduced. Because few printing processes can lay down varying densities of ink, images must first be broken down into very small, discrete dots of varying size, density, and distribution in a process called *halftone screening.* This was originally accomplished by photographing the original image through a fine grid, or screen, of a set number of lines per inch. When the film is exposed, the image will consist of thousands of tiny dots: dark, tightly packed dots in the shadow areas, a moderate amount of dots in the middle tones, and few, light dots in the highlights. Each color separation negative is processed as a halftone. However, when successively colored dots are overprinted, if the angle of the lines of dots is the same for all four colors, the lines will interfere with each other and produce an undesirable *moire* pattern. Consequently, each screen needs to be placed at a different angle, experience generating certain specified *screen angles* that are the most effective for reducing moire.

On digital systems, halftoning is performed electronically. Computer output devices need to create images as a series of tiny dots (called *spots* to distinguish them from halftone dots). These spots are much smaller than the halftone dots, and in fact each halftone dot is composed of many of these printer spots. (Thus in digital output, halftone dots are referred to as *halftone cells.)*

TYPES OF SCREENS

There are two distinct types of screens used for the production of halftone images. These are the glass cross line screen and the contact screen. Each of these screens have certain advantage and disadvantage but end result from them is the same, the production of images made up of equally spaced dots of varying size.

The glass screen is, as the name implies, a screen made of glass. In use, it must be kept at a definitely predetermined distance from the surface of the sensitive emulsion on which the halftone image is projected. The contact screen however is a screen made on a film support and is used in direct contact with the sensitive emulsion.

What the Halftone Screen does?

On the process camera, light is either transmitted through a transparency or reflected from an opaque original copy. It then process through the lens of camera .It strikes the half tone screen before it falls on the light sensitive emulsion that will become the halftone positive or negative image. When the light coming through the lens strikes the halftone screen, the light either passes through the clear portion of the screen, or is absorbed by the opaque portion. The glass halftone screen act as a grating - allowing light to pass through the opening or blocking it in a previously determined pattern. The glass screen itself is a positive operation mechanism .It lets the lights through, or it does not. There are no compromises. The contact screen, however, acts differently. It allows the light to pass through the different areas in varying amounts.

The various tone of the continuous tone copy determine the amount of light that passes through the half tone screen. The smaller the amount of light that is reflected from or transmitted through a particular area of the copy, the smaller the amount of light that will pass through the halftone screen. These varying amounts of light are the main factor that determines the size of the dots that are formed on the film.

CONTACT SCREENS

Contact screens, used to create the illusion of continuous tone in film-based work with graphics arts cameras, has a pattern of gray or magenta dots separated by other dots of lesser density. In traditional film-based reproduction, the contact screen is held in close emulsion-side-to-emulsion-side contact with the light sensitive material being exposed to create the halftone pattern required. Manufacturers produce a variety of contact screens suitable for different purposes - coarse, medium or fine screens, special effects, gray or magenta, etc, to suit different circumstances. Contact screens are less used today due to the decline in traditional working practices.

HALFTONE DOT SHAPES

Many different dot patterns can be produced by halftone screens. They are round dot, square dot and elliptical and in numerous dot shapes. It is generally accepted that the round dot is best for high-speed presses and is used extensively for web-offset printing. The square dot results in sharper printing, and is used extensively in sheet-fed offset litho printing. The elliptical dot, since it allows more gradual transition and better detail on the midtones, is used extensively when printing flesh tones and very fine subtle colour blends or changes. For monochrome work, screen positions are such that the line of halftone dots falls at an angle of 45° across the processed image and the printed sheet. At this angle, the screen pattern is less apparent to the human eye than if it were vertical or horizontal.

HALFTONE DOT SHAPE

Halftone dot shapes (figure) may be varied across a considerable range that includes round, square, and elliptical. The dot gain for a given tonal value will vary according to the dot shape, but there is little reason to prefer *one* over another if the dot gain has been accurately characterized and if compensation is built into the tone curves of the color separations. Elliptical dot screens will tend to smoothen harsh, grainy middletone areas, but the same effect may be achieved with image retouching software. Of the conventional screen structures, square dots tend to be best for retaining image definition.

SCREEN RANGE:

The screen range is the copy density range that a screen, will produce (with half tone dot) into a single light white light exposure. Screen range differs from one screen to another. The screen range also changes according to ageing of screen. For eg: if the capacity of the screen to produce highlight is 0.4 and shadow is 1.6 the screen range is 1.6 - 0. 4= 1.2. The screen range decides the reproduction range but this can be compressed or expanded by adopting exposure techniques.

NEW SCREENING DEVELOPMENTS

Traditional screening methods used on scanners are based on the Amplitude Modulation (AM) approach, where the variation in signal (electrical) charge is used to create dots of different size. Some new screening methods are based on the Frequency Modulation (FM) approach, where the dots are all the same size (‘first order’ version), but more or less of them appear in each area as required see Figure. There are, however, developments in what has been termed ‘second order’ FM screening which results in variable dot sizes. FM screening is also often referred to as stochastic, or irrational screening.

New developments in screening technology such as stochastic, break down continuous tone originals into small ‘microdots’, resulting in much smaller file sizes and therefore faster processing; a further benefit is improved printing detail, often approaching the appearance of continuous tone/screen less printing from high quality originals on high quality coated substrates, plus the eradication of the screen clash pattern problem. The microdot sizes used in FM screening, vary from around 14 to 20 microns, going down to seven microns: a 20 micron FM dot equates to about the smallest highlight dot on a 150lpi screen.

To obtain the benefits offered by FM/ stochastic screening, several tightly monitored working practices should be put in place, including the use of high contrast film capable of holding a sharp hard dot, a tightly calibrated imagesetter, correct film and plate exposure in terms of time and processing, and a dust-free working environment as duct specks will show up more alongside the small microdots. Some suppliers, such as Scitex, have developed a screening system in this case Scitex Class Screening - which allows users to choose the best type of screening application appropriate to each particular job.

Figure A: illustrates the way ‘pixel squares’ build up the desired halftone dot shapes in lpi, through the use of an imagesetter

Figure B: illustrates the dot tonal range from small dot highlight areas through to large dot solid areas, created by conventional halftone screening techniques, such as use of the contact screen

FigureC: illustrates the scattered, irregular pattern of FM/stochastic dot distribution, where the clustering together of the microdots create the illusion of different tonal patterns

STOCHASTIC SCREENING

The tonal element distribution consideration mentioned earlier refers to stochastic or frequency modulation (FM) screening techniques. The difference between a conventional and a stochastic tone of the same density value is the distribution of the image recording spots within the dot formation grid. Consider a 50% halftone dot that is exposed within a 12 x 12 grid (144 recording dots): with conventional half toning exposure, 72 recording dots will form a single square halftone dot, whereas with stochastic halftoning, the 72 recording dots will be distributed throughout the grid. The exact distribution of the recording dots will vary according to a given manufacturer’s screening program. In some cases, the recording dots may vary in size.

There are two very significant advantages that stochastic screens hold over conventional screens: image resolution is higher and there are no moire (or rosette) pattems.Stochastic screens also eliminate subject moire problems; i.e., the interaction between the halftone screen and fabric patterns or other forms of periodic or regular image details. Misregister-induced color variation is less with stochastic screens, but image detail register is more critical.

A drawback of stochastic screens is the graininess that sometimes occurs in smooth even tones. This effect may be minimized through the use of certain screening algorithms and the use of 20-micron recording spot screening systems instead of those with 30-micron recording spots.

Stochastic screens make it possible to print more than four high-density colors to achieve high-fidelity results (the same requirement does not apply to light magenta and light cyan supplementary colors; they may be printed on the same angles as the regular magenta and cyan). Stochastic tones do exhibit greater dot gain than comparable conventional halftones, but compensation for this gain may be incorporated into the color separations.

3.2.4 SCREEN FREQUENCIES/RULINGS

Screen frequencies or rulings can be specified in lines per cm or lines per inch. Screens with 25, 34 and 40 rulings per cm are classed as coarse screens (Figure), and those screens with 48, 52 and 60 rulings per cm are classed as fine screens (Figure), other very fine screens such as 80 and 118 per cm are also available. With coarse screens, the size of the dot is larger and they are easier to print without, filling in and more detail is lost.

Several factors have to be considered when choosing the screen ruling but, generally, a coarse screen is more suited to rougher, uncoated papers. A fine screen is more suited to a smooth, coated surface. Ideally, originals should be reproduced to suit the method of reproduction.

In traditional reproduction, the screen reduces the original to a pattern of dots in the following manner: The light reflected by the original varies in intensity according to its tonal values, with the lighter tones reflecting more light than the darker tones. The rays of light of varying intensities pass through the screen and, where the light is strong, the area affected on the film is larger than where the light is weaker.

On development, the light-affected areas appear dense on the negative, varying in size according to the strength of light reflected by the various tones of the original. The transparent areas between the dense areas vary in size inversely, and it is these transparent areas which become the dots on a positive.

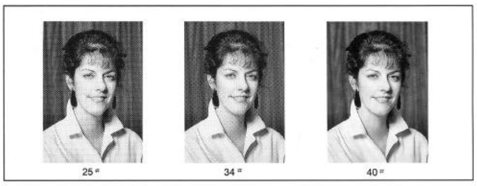


Figure: Examples of coarse screens measured in rulings per cm

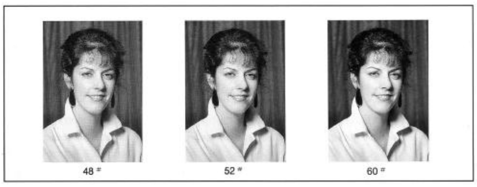


Figure: Examples of fine screens measured in rulings per cm

lines per inch	lines per.cm	lines per inch	lines per.cm
300	118	100	40
200	80	86	34
150	60	65	26
133	52	50	23

Table: Comparison of screen frequencies/rulings as number of lines per inch and per cm

It should be noted that due to the rounding up or down conversion between inches and centimeters, the actual figures shown below may differ slightly.

Printing Processes	Screen rulings (lines per cm)
Sheet-fed offset printing - e.g. - general commercial colour	40 - 60
Sheet-fed offset printing - e.g. - very fine screen/fine artwork	80 - 118
Cold-set web-offset printing - e.g. - newspapers	34 - 52
Heat-set web offset printing - e.g. – magazines	40 - 80
Screen printing	20 - 52
Flexography/letterpress printing	26 - 52
Gravure printing	34 - 60

Table: Average screen frequencies/rulings per cm used by the different printing processes

Screen ruling should be chosen to match the production constraints and final viewing conditions. The substrate and printing process are the factors that decide screen ruling. The viewing conditions are established by the nature of the printed product.

Billboard and similar kinds of poster displays are viewed at a considerable distance. A coarse screen ruling is ideal for such images because coarser screens are less susceptible to dot gain on press; hence, print variation will be minimized. This is an important requirement for billboard work that requires the pasting of several sheets on-site to assemble a single complete image. Finer-than-necessary screen rulings will not appear to have any more detail than coarser-screen images when viewed at the considerable distances that are typical of billboard poster display locations.

Fine screens are highly desirable for reading material. At normal reading distances of about 18 in. (0.5 m), the average visual system cannot detect improvements in image detail at screen rulings finer than about 250 lpi. Finer rulings may be justified for security printing or in those rare cases where the image is normally viewed under magnification. In practice, however, it is impossible to significantly exceed 300 lpi *and* retain about 150 tone steps. The printing system recording spot resolution is the limiting factor.

Choice of screen ruling:

The choice of screen ruling is also influenced by the paper surface texture and the grain. The finer the screen the better the paper must be. The most widely used screen ruling for various grades of paper are:

Screen ruling	Suitable for
45,55	low grades of newsprint
65,85	Best news print and machine finished paper
100	Super calendered paper, Imitating Art paper and cheapgrades of art paper
120	Normal art paper, Good imitation art paper, and finegradesuper calendered paper
133	Good Art paper
150	Finest quality art paper, Chromo and enamel papers.
300-400	Higher grades of plastic coated surface.

3.2.5 SCREEN ANGLES

The angle of the conventional halftone screen used in four-colour separations, must be different for each colour, to prevent the dots of successive colours becoming superimposed upon preceding ones, so forming an undesirable screen clash pattern or moiré effect when printed. Screen angles frequently used for sheet fed offset litho are: black 45°, magenta 75°, yellow 90° and cyan 105°. In web offset printing angles are often changed to black 15°, magenta 45°, cyan 75° and yellow 90°, although other permutations of screen angles are used. The objective is to achieve a 30° angle of separation between the colours where possible.

The standard screen angles are yellow on 90°, magenta on 75°, cyan on 105° (15°), and black on 45°.

The extra colors used in high-fidelity printing may pose some problems from the moire avoidance point of view. Screen angle choice is guided by the nature of the extra colors.

If red, green, and blue inks are chosen as supplementary colors, they should be placed on the same angles as those inks that have the opposite hue. Green, for example, is opposite magenta so both of these colors should be screened at 75°. The logic behind this recommendation is that opposite colors would never print together in any region of the image; therefore, their screen angles do not interact with each other. They could, of course, still cause unacceptable interactions with other process colors.

Screen Angle Guidelines

Three-Color Printing	Four- Color Printing	Six-Color Printing	Seven-Color Printing
Cyan …………. 45°	Cyan ………..105°	Cyan…………….105°	Cyan…………105°
Magenta ……….75°	Magenta …… 75°	Lt. Cyan…………105°	Red…………..105°
Yellow ………. 105°	Yellow ……….90°	Magenta…………75°	Magenta………75°
	Black…………45°	Lt. Magenta………75°	Green…………75°
		Yellow…………….90°	Yellow………..90°
		Black……………..45°	Blue…………..90°
			Black…………45°

Table: Typical screen angle recommendations for process color printing. The black printer angle (45°) may be switched with either the magenta printer (75°) or the cyan printer (105°) inorder to eliminate moire problems between the yellow and either the magenta or cyan. In some cases, when using the six-color guidelines, the screen angles for the cyans and black are switched.

The use of stochastic screens will eliminate moire concerns when high-strength chromatic inks are used as extra image-area colors. Hybrid systems that use stochastic screens for some colors and regular screens for the others can similarly reduce moire while retaining some conventional screen advantages.

Rosette Patterns

When the colors are correctly angled, a rosette pattern will be visible in highlight and middletone areas where all colors are present. The frequency of the rosette pattern is such that it occurs at one half that of the screen ruling; i.e., the rosettes appear at a frequency of 75 per inch for a 150-lpi process color halftone.

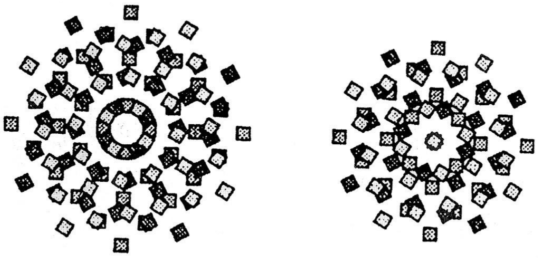
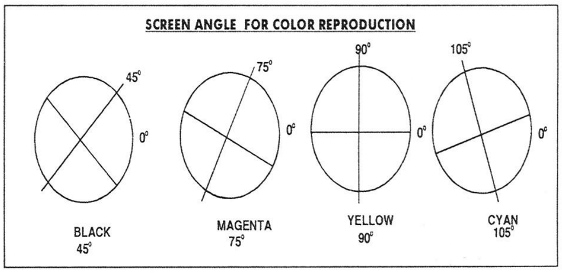


Figure: Example structures of (A) clearcentered and (B) dotcentered rosette patterns.

There are two types of rosette pattern: those with a clear center and those with a dot center (figure). Dot-centered rosettes are less noticeable but must be printed to tighter register tolerances in order to minimize color variations in certain tonal values (this is the reason why dot-on-dot same angle printing has generally been unsuccessful, despite its superior resolution when compared to multi-angle printing)



3.2.6 SCREEN (IMAGE) RESOLUTION

The resolution of a photo mechanical reproduction system is of importance for at least two reasons. The most obvious reason is the retention of fine image detail. Higher-resolution systems are more capable of reproducing such fine detail as fabric patterns and facial detail than lower-resolution systems. The other reason to prefer highresolution systems is related to the number of distinct tonal values that may be rendered by a given halftone screening system. This latter reason has become a matter of some concern since digital image recording technologies were introduced during the early 1970s.

Resolution limits are established by the smallest spot size that may be consistently reproduced by a printing process. Offset Printing, with around an 8-micron minimum spot size, is probably the highest-resolution process. The physical engraving requirements for gravure and relief process image carriers probably dictate a coarser resolution for those processes, while the supporting mesh required for screen printing certainly restricts the resolution of that process. Direct digital processes reportedly have a considerably coarser resolution than lithography.

Process and/or Substrate	Ruling (lpi)	Process and/or Substrate	Ruling (lpi)
i. Screen printing-textiles	50	vi. Offset machine finished paper	120-133
ii. Letterpress-newsprint Paper	65-85	vii. Letterpress-coated Paper	133-150
iii. Screen printing-smooth substrates	85-100	viii. Gravure-all substrates	150-200

iv. Flexography	85-133	ix. Offset coated	150-250
v. Letterpress-machine finished Paper	100		

Table: Screen rulings generally used for printing processes and substrates.

The smoothness of the substrate generally influences resolution; coarser screen rulings are normally preferred for rougher papers. The ink rheological properties will also influence resolution. Inks for gravure, flexography, and (less so) screen printing processes have lower viscosity than the paste-type inks used in lithography and letterpress, and are therefore more likely to cause reduced resolution. In fact, the gravure process relies upon the diffusion of the ink around the printed cell perimeter to produce text and solid images without the cell wall structure pattern that is part of the cylinder image.

Resolution may be restricted in offset by whether plates are made directly or indirectly. Plates that are imaged directly from the data files sometimes produce higher-resolution images than in the indirect case (record to film and then contact to plate). Direct-recording proofing systems and indirect proofing systems sometimes have less resolution than lithographic printing systems. Indeed, some of the difficulties associated with stochastic screens were due to the fact that some proofing systems could not resolve the fine image elements that are part of stochastic halftone structures.

Digital halftone dots are formed by selective laser exposures within a 12 X 12 (or higher) grid structure. The overall 12 x 12 grid represents one halftone dot at a particular screen ruling. If finer screen rulings are required, the laser spot must be made finer to retain the same 12 X 12 grid. If the spot size has reached a limiting value, it may not be possible to expose a halftone grid finer than (say) 8X8. An 8X8 grid allows 64 tone steps whereas a 12X 12 grid produces 144 steps. The trade-off between fineness of halftone screen ruling and number of tonal steps is a well known one that is dictated by the system's minimum addressable spot size. If there are too few tonal steps, then "banding" effects occur in vignettes, and tonal fidelity is limited.

Printing Process	Recording Resolution	Smallest Recordable Value	Tonal Steps*
Conventional Offset	3386 dpi	8 microns	~256
Direct-Imaging Offset (Heidelberg Quickmaster DI)	1270 dpi	20 microns	~100
Indigo	812 dpi	31 microns	~64
Printing Process	**Recording Resolution**	**Smallest Recordable Value**	**Tonal Steps***
Xeikon, Chromapress, IBM, DocuColor 70	600 dpi	42 microns	~49
CLC, Gce and DocuColor 40	400 dpi	64 microns	~36
* Assuming 120-lpi halftone screen ruling; calculated from recording resolution data.			

Table: *Resolution and tonal step capabilities of some common digitally-driven imaging systems.*

3.2.7 COLOR SEPARATION

Color separation can be made by two methods: the direct and the indirect method of color separation.

Direct Method Color Separations

In this method, the color-separation exposures are made through the halftone screen onto high-contrast films or plates so that halftone separation negatives are obtained in the first step. A glass crossline screen or a gray contact screen should be used in this method, but not the magenta contact screen. Printing plates for photo engraving or surface photolithography are made directly from these screen negatives after any necessary handwork has been accomplished. For deep-etch photolithography, screen positives are made by contact printing from the screen negatives.

Indirect Method Color Separations

In the indirect method the halftone negatives or positives are not made directly from the original copy, but from intermediate continuous-tone separations. The use of the continuous-tone negatives makes possible the broader use of masking procedures for tone control and color correction, and eliminates the very long exposures which are sometimes needed for direct halftone work.

Retouching for color correction can be done on the continuous-tone images either by using retouching pencils or by staining with a neutral dye or neococcine. When anyone of several masking methods is used, much of the handwork can be eliminated. .

The indirect method is capable of improving the general reproduction of detail and color separation in separation negatives. It also makes possible an improvement in the dot structure of photoengraving plates because less handwork is necessary. Most masking techniques are more practical when used with the indirect method.

COLOR SEPARATION

Color printing, in its most basic expression, involves the overprinting of colored dots at various densities to produce a wide range of secondary colors. Since each individual process color needs to be printed separately, each color needs its own plate. To make a plate, therefore, each color needs its own *negative.* The conversion of a full-color *continuous-tone* photograph (or other image) to a series of (typically four) individual color negatives or *positives* is called *color separation.*

Traditional Color Separation

Until the early 20th century, “full-color printing” typically involved printing an image in black and white and hand-coloring it. Color printing as such was limited for the most part to what we now refer to as “spot color,” or single localized portions of solid color that can be laid down exactly as black ink is.

Traditional color separations were performed either manually or, more often, photographically. Essentially, a full-color image (either *reflection* copy-such as a print-or *transmission* copy-such as a *transparency)* was photographed three times, through a red filter (which produced the cyan film), a blue filter (which produced the yellow film), and a green filter (which produced the magenta film). An additional film-black was also needed to add shading and contrast. These four films-called *printers or process color separated films could* then be used to make plates. Often additional manual *color correction* (such as *dot etching)* was required to adjust any *hue errors* generated by the color separation process. (The shorthand term for these four process colors-CMYK-is the acronym of the three subtractive color primaries plus “K” for black. The “K” stands for *key,* as it was the *black printer* that was printed first and used as a guide for the subsequent *registration* of the other colors.)

Digital Color Separation

In the late 1970s and early 1980s, Scitex and other vendors began introducing *color electronic pre press systems* (CEPS), which quickly rendered photographic color separation processes virtually obsolete. In addition, the prevalence of the *PostScript* device-independent *page description language* has made digital color separations of higher quality and greater ease. Desktop systems-personal computers, either *IBM-compatible computers* or Apple Macintoshes-using off-the shelf *page makeup software* such as QuarkXPress or PageMaker are now able to generate high-quality color film or paper output. Where once high-quality color pre press was strictly the purview of high-end color electronic publishing systems, relatively inexpensive desktop systems can easily rival that quality.

Digital color separation typically functions by means of converting from one *color space* (such as CIE, RGB, or *YCC)* to the CMYK color space. (Actually, the initial conversion is to just the CMY color space; black is added later.)

An additional process required in color separation is *the generation* of the black *printer. Although* most of the colors produced in process color printing are produced by combinations of CMY, black is added to increase the density range of the reproduction and to reduce the amount of the more expensive process inks that need to be used.

3.2.7 COLOR SEPARATION

The color separation step is the pivotal control point in a color reproduction system. This is the only stage where individual halftone values may be independently adjusted to achieve optimal color reproduction objectives within the constraints of a given set of printing conditions.

Quite apart from the optimal color reproduction requirements of a particular original, and the influence of the printing process, the color separator must also assess the characteristics of the color separation system itself when preparing to make a set of color separations. The separation system factors that influence the nature and quality of the color separations include optical-mechanical-electronic design of the image capture system, image recording distortions, image processing compromises, and output recording choices.

The color separation challenge, therefore, includes the equipment selection process as well as the knowledge and skills of the operator. The nature of the original is also of importance to the color separator because of the sometimes unpredictable interaction between the colorants in the original and the sensitivity response of the image recording system.

3.3 SCANNER

Scanner is a device used to analyze an original image and either generate color separations and/or digitize the image and store it in a computer for later manipulation and output. Essentially, a scanner records one row of the image at a time, and converts the original into an electronic matrix of pixels (or a bitmap). Each pixel is recorded as some level of gray for each of the red, green, and blue components of an image, and the scanner then collates them back into the appropriate (or closely approximating the appropriate) color for each pixel.

One basic distinction between scanners is whether it is an image scanner or a text scanner. An image scanner images all originals as a bitmap, regardless of whether it is text or a photograph. A text scanner-utilizing optical character recognition (OCR) software-can scan text material and convert it to ASCII text. Some desktop scanners can function as both, depending on which software is used, while dedicated image or text scanners can only function as one or the other.

Another important distinction in prepress is drum scanner versus flatbed scanner. A drum scanner is a high-end machine that utilizes a highly sensitive photomultiplier tube to capture subtle variations in tone, and it is capable of digitizing images at very high resolutions.

Flatbed scanners are much less expensive, but their use of charge-coupled devices (CCDs) makes them less sensitive to subtle color variations. Drum scanners are beginning to come down in price, and flatbed scanners are beginning to improve in quality, so at some point the twain shall meet. Some flatbed scanners are also sheet fed scanners and have automatic stacking and/or document-feeding functions. Some flatbed and most drum scanners can scan transparencies rather than simply reflective copy.

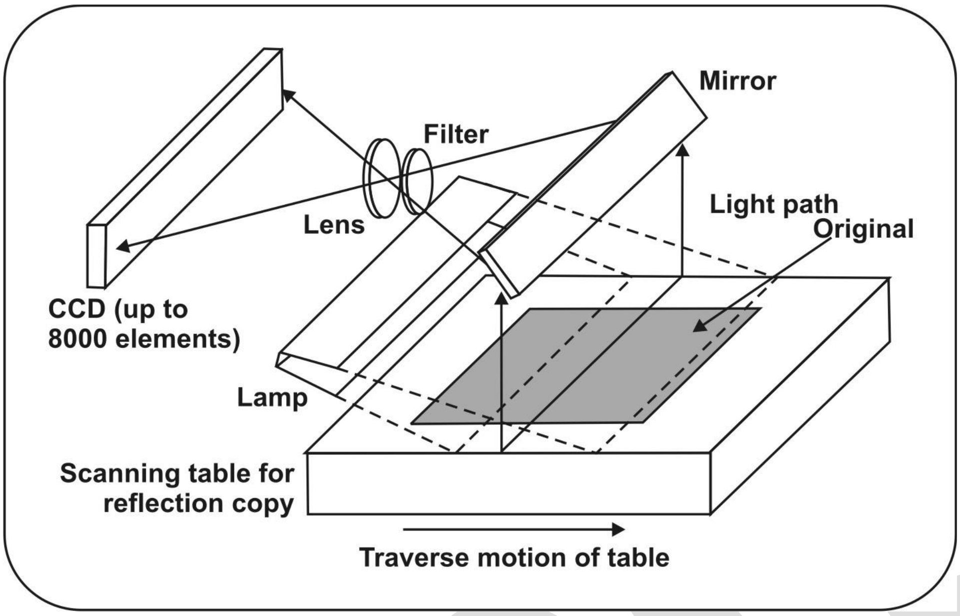


Figure: The line-by-line scanning principle of the flatbed CCD scanner.

Many scanners have the ability-through software to display previews and allow color modifications prior to scanning, enabling the operator to optimize the contrast and color attributes prior to image capture. Post-scanning image manipulation using programs such as Photoshop can be used to further refine and manipulate a scanned image.

Not all scanners feature user-selectable resolution, and thus offer only a handful of fixed resolutions (i.e., 100, 200, 300 . . . dpi), while some allow any resolution to be specified (i.e., 331 dpi). Other functions common to most scanners and scanning software include the ability to scan only a selected portion of an image and the ability to scale an image (either enlarging or reducing it) prior to scanning.

Scanning Originals

The manual process of placing an original in or on a scanner for scanning has its own share of considerations. Needless to say, flatbed scanners should have their glass platens as free of dust, dirt, and other detritus as possible. Transparencies and prints should also be inspected for dust, scratches, or other visible problems that may be magnified by the scanning process. When attaching a transparency to a drum scanner, it is important that all parts of the image be flat against the drum; if any part of the image varies in distance from the scanner optics than the rest of the image, distortions in the scanned image will be evident. Sometimes, oil mounting is performed so as to eliminate an optical problem known as Newton's rings, or haloes of color caused by refraction of light passing through a transparency. Adhering the transparency to the drum by means of a clear oil can reduce this problem.

Beyond Scanning

It has been suggested that scanning may ultimately be replaced by other forms of imaging, especially digital cameras, which capture images directly in digital form. There is widespread popularity and enthusiasm for these devices, but so far quality and price issues have impeded their widespread use. But they are gaining ground. The popularity of the Photo CD, which many perceive to be a transitional medium, is an indicator that pre press departments and other users of digital images would like to eliminate the scanning phase as much as possible.

SCANNER TYPES

- drum scanners (horizontal, vertical, or inclined drum arrangement)
- flat-bed scanners (desktop scanners, XY scanners)
- color scanners
- slide and APS scanners (Advanced Photo System)
- OCR scanners (OCR - Optical Character Recognition)
- redigitizing scanners

3.4 STEPS IN HALFTONE REPRODUCTION USING SCANNER

Electronic Color Separation

Electronic color separation, otherwise known as color scanning, has been used in the graphic arts for many years.

Scanners are primarily machines that separate color copy into its components so that it can be reproduced on a printing press. Although the scanners of different manufacturers vary, all of them utilize the three-color principle of color separation; that is, they separate colored originals using the three additive primary colors of light in the form of blue, green, and red filters. In addition, scanners are usually programmed to produce a black printer correctly balanced with the color separations.

The end products of the scanner are either continuous-tone intermediates or screened (halftone) films. Continuous-tone intermediates can be used directly for conventional gravure or, with letterpress and lithography can be converted into screened films on a standard graphic arts camera or in a contact printing frame. If the scanning is done properly, these intermediates or films will be completely color-corrected and properly masked and will have the proper amount of undercolor removal.

One big advantage of electronic color scanning is the consistency of reproduction. Scanned separations of matched originals will always match, provided the same information is given to the scanner for each original. They will match in optical density range, in the degree of color correction, and in sharpness, which means that separations can be made on the scanner uniformly from day to day.

SCANNER PRINCIPLES

The term “scanner” describes the manner in which copy is viewed (analyzed) and the way in which the light-sensitive material is exposed.

In the operation of a rotating-cylinder scanner, original transparency or reflection copy is mounted on a transparent analyzing cylinder, or drum, while one or more sheets of unexposed film are mounted, either manually or automatically, on another cylinder. With scanners that feature one cylinder for scanning and another for exposure, both cylinders rotate at the same speed.

A very small spot of intense light is projected through or reflected from the original copy. As the analyzing drum rotates, the original copy is scanned by the light spot, which travels in the direction of the axis of the drum. With each revolution, the light spot advances the width of a scan line. Although this light beam is extremely narrow, the mechanical design provides for slightly overlapping or adjoining scans. These scans are spaced close enough and the exposing beam is wide enough to give the effect of a continuous exposure.

Generally, the number of lines to the inch (or millimeter) is varied to reproduce as much image detail as is desired. Obviously, the more scans per inch or millimeter, the more detail that can be recorded from the original copy. These scanning rates determine the resolution, or amount of detail, that can be picked up from the original and reproduced on the unexposed film.

Each spot on the copy is analyzed as light passes from the copy through a small aperture to the scanner’s optical system. The optical system usually consists of some array of lenses, prisms, mirrors, and interference filters. The net effect of this system is to split the light into four optical signals, each of which passes through either a red, green, or blue separation filter or an aperture for unsharp masking. Each optical signal that passes through a color separation filter is focused on a photomultiplier tube that converts the optical signal into an electronic signal that is proportional to the amount of each color of light present in the scanned spot on the copy.

These three electronic signals, which correspond to the magenta, yellow, and cyan printing inks, are directed into the color computer where the signals are modified to suit specific inks and are corrected for unwanted colors. Next, the signals go to the tone and undercolor-removal computer, which introduces the desired range compression, tone reproduction, and neutral gray balance and, at the same time, computes a signal for the black printer (which can be programmed to be either a full-tone black or a skeleton black).

Subsequently, the electronically generated and computer modified signals are sent to a digital scale computer that controls reproduction size.

With the signals electronically modified, the next step exposure is performed. The method of exposure varies somewhat depending upon the sophistication of the scanner. Unlike a separation made on the camera, where the entire light-sensitive material is exposed simultaneously, a separation made on a scanner is exposed in one minute area at a time as the electronic signals are converted into light signals. This exposure occurs as quickly as the corresponding point of the original is scanned and analyzed.

If the output is a continuous-tone or contact-screened separation, the exposure intensity varies according to the relative image density of the scanned original. The dots of the screened separation are soft, with a fringe area. Some scanners do not require contact screens for making screened separations; rather, they use laser optics to generate an electronic dot pattern. The nature of the dot varies, depending upon the scanner.

Types of Copy

Most of the scanners on the market accept either color transparencies or flexible reflection copy. Transparencies are far more popular and usually easier to handle. Flexibility is necessary because the copy for practically all scanners is attached to a rotary cylinder, which automatically eliminates reflection copy that is too stiff. In some cases, special holders or drums are used for small transparencies, such as 35-mm transparencies, which are otherwise difficult to hold in position. Positive transparencies are more common, but negative transparencies can also be used on some scanners.

Originals are usually mounted with clear transparent tape. To eliminate or minimize Newton's rings, a special powder or oil is applied to the back of the transparency. Many scanners are equipped with a pin register system to hold both the original and the light-sensitive material. Such a pin register system ensures that all separations are in register with each other and that they can be remade from the original, if necessary.

SCANNER PROGRAMMING

In reality, a scanner is fairly simple to operate and not much more complicated than a modern graphic arts camera. When a scanner is installed, it is programmed to accommodate the kind of work done in a plant. The program includes the following:

- Range compression
- Gray balance
- Tone reproduction
- Black printer characteristics
- Ink and paper densities
- Platemaking losses
- Screen and photographic emulsion characteristics.

Once the programs have been established and recorded, operation becomes standard for the majority of copy. As with any computer, however, these instruments can work only with the information that has been programmed into them. This constraint demands a high level of operator competence. The operator has to know how to evaluate the original and what the computer can do with the information. The operator has many controls at his or her disposal but must know how to handle them in order to produce excellent results.

Size Reproduction

Copy can be reproduced same-size on all scanners and, on most, can be enlarged or reduced. Reproduction size capabilities of different scanners vary greatly. A digital computer is used for enlarging or reducing the output. This is done not by changing the speed of the exposure drum, but by purely electronic means. In other words, the analog signals normally produced by the scanning head are converted into digital data using core memory and then played out at a faster or slower speed. Thus, enlargement or reduction in the drum's circumferential direction is controlled electronically, not mechanically.

SCANNER OPERATION

Once the scanner has been programmed and tested, a color separation can be made. First, the original is mounted on the scanning drum. With a scanner that has a removable scanning drum, one original can be scanned while another is being mounted. Next, the required enlargement or reduction percentage is set on the scanner.

Before a separation is made, the copy is first evaluated by using densitometer measurements. Highlight and shadow densities are analyzed on an optical viewer and entered into the machine. Required densities or dot percentages are dialed into the scanner. Density values are typically 0.3 and 1.6, while dot percentages are typically 5 and 95. Normally they are not changed from one original to another, unless the type of original changes.

The computer takes over the calculation of range compression, cast removal, setting of correct middle tone, end densities, gray balance, and color values. The scanner operator decides how much color correction is needed, which colors to boost, whether shadow expansion is necessary, the amount of undercolor removal, and the amount of unsharp masking to use to emphasize details.

The operator has many controls available if special corrections or deviations from copy are necessary. Again, ability and experience dictate the course of action. It is possible to increase or decrease unwanted colors in each separation. Overprint colors of red, green, and blue can be adjusted separately, and flesh tones can also be treated specially-to name only a few of the possible adjustments. If necessary, the tone reproduction curve can be altered to favor detail reproduction in any part of the scale. Undercolor removal and the black printer can also be varied. Many of these corrections cannot be made by process camera color separation methods.

At this stage, the machine is ready to run, except for the loading of the unexposed film. Once the film is loaded, the scanner can be started. Depending upon the capabilities of the scanner and the reproduction size, one, two, or all four separations can be made simultaneously. At this point, since the scanner is already programmed, it is simply a matter of flipping the right switches or depressing the right pushbutton.

Film and Film Processing.

Typically, the separation film is loaded into cassettes in the darkroom, or the scanner is located entirely within a darkroom. In the former case, a light tight cassette is locked into position on the scanner. Its contents are then automatically attached to the exposure drum. After exposure, the contents are unloaded and removed to the darkroom for processing. To ensure the greatest consistency, all four separations should be processed at the same time. Automatic film processing is the most desirable, practically a necessity.

Before the film can be exposed, however, the scanner must be calibrated to the film and film processing method. The calibration procedure is fairly simple. Four gray scales, each one corresponding to a particular separation color, are scanned or electronically generated and exposed to the film. After processing, the exposed steps are measured on a densitometer, and the resulting densities or dot percentages are fed back into the scanner. For normal daily calibration, it is only necessary to reset the highlight, mid tone, and shadow density steps of the gray scale.

Even if the separations are exposed properly and uniformly, how the film is processed can drastically affect the final results. Therefore, uniformity in developing the film is essential. A properly operating processor ensures that all separations are developed equally and are balanced with each other.

Scanner Output

Halftone separations are also feasible with most scanners. These are made either by using contact screens and high contrast films or by electronic dot generation. Special film holders, exposing methods, and electronic circuitry are needed for this purpose. One of the disadvantages of this system is that if the separation requires further enlargement, it cannot be used. However, most scanners have a more-than-adequate enlargement range. In many cases in commercial four-color printing, the same copy has to be reproduced to several different sizes. Obviously, it would be more practical to prepare continuous tone separations and then enlarge or reduce them as required for the final screened printers. Scanners produce either one, two, or four separations at a time, depending upon the particular machine and the size of the intermediate needed. Producing four separations simultaneously is obviously a great timesaver.

Many types of light sources are used to expose film, from glow lamps to lasers. It should be noted that the laser is used only to expose the separation (using fiber optics), not to scan or analyze the original.

Newer scanners incorporate digital computers. All kinds of benefits result from capturing information in digital form. It is possible to record and store digital data on magnetic tape or disk for later use; to transmit it from one device or location to another.

Scanners that can generate their own halftones without requiring a contact screen are the result of linking the laser with digital technology. A scanner is able to electronically generate a halftone pattern, because a separate digital computer stores information about the halftone screen, its rulings, and screen angles. Various screen rulings are available, all of which are switch-selected.

EVALUATION OF SEPARATIONS

After development and drying, scanned separations can be treated in much the same way as separations made in a process camera or enlarger are. Chemical etching on the continuous-tone separations or dot etching on soft-dot halftones can be performed as usual. One of the objectives of using scanners, however, is to minimize or even eliminate the need for handwork on the separations. If handwork is excessive, then the operator techniques should be modified; either the original evaluation of the color copy is incorrect, or the machine settings are not as ideal as possible. Both should be reassessed, and experiments should be conducted until a higher degree of perfection is attained. The scanner should practically eliminate hand corrections and dot etching, and the scanner operator should make a great effort to attain this degree of perfection.

UNIT – III - LINE AND HALFTONE PHOTOGRAPHY

PART – A ***2 Marks Questions***

1. State the different areas of a continuous tone photograph.

- Highlight area
- Shadow area
- Middle tone area

2. Define highlight and shadow areas in a photograph.

The **highlight area** is that portion of a picture that contains detail but has the least amount of density.

The highlight detail begins in step 1, or with a density near 0.05. The highlight dots begin with the smallest reproducible dot (generally about 5 percent) and extend to about a 20 or 25 percent dot.

The darkest areas of the print are called the **shadow areas**.

The shadow detail ends in step 10, or with a density of about 1.45. The shadow dots extend from about 75 or 80 percent to the largest reproducible dot (generally about 95 percent) before solid black is reached.

3. How will you specify a screen ruling?

Screen frequencies or rulings can be specified in lines per cm or lines per inch.

4. Define screen ruling.

The screen ruling describes the fineness of screen in the rendering of the picture information. Screen frequencies or rulings can be specified in lines per cm or lines per inch. Screens with 25, 34 and 40 rulings per cm are classed as coarse screens (Figure), and those screens with 48, 52 and 60 rulings per cm are classed as fine screens (Figure), other very fine screens such as 80 and 118 per cm are also available. The choice of screen ruling depends on the printing process and the surface of the printing material.

5. What are screen angles?

In four color printing the individual color screening must be angled in order to avoid moire pattern. Screen angles frequently used for sheet fed offset printing are: black 45°, magenta 75°, yellow 90° and cyan 105°.

6. What are the different exposures used in film reproduction?

i) Main exposure
ii) Flash exposure, and
iii) Bump exposure.

7. What you mean by screen resolution?

The screen ruling describes the fineness of screen in the rendering of the picture information. Screen frequencies or rulings can be specified in lines per cm or lines per inch.

Screens with 25, 34 and 40 rulings per cm are classed as coarse screens (Figure), and those screens with 48, 52 and 60 rulings per cm are classed as fine screens (Figure), other very fine screens such as 80 and 118 per cm are also available. The choice of screen ruling depends on the printing process and the surface of the printing material.

8. Define halftone printing.

All continuous-tone images whether they are color or black-and-white-need to be converted to *halftones* before they can be reproduced. Printing done with halftone dots is halftone printing.

PART – B **3 Marks Questions**

1. Different between line and halftone reproduction.

Line Reproduction is the most simple of all reproductions. Line reproduction is used for black-and-white copy that does not require tonal reproduction or the use of a halftone screen. This copy may be single-color or multi color, it may be of a job that is completely done in line.

Halftone reproduction is the method by which continuous tone copy is transformed into a printable image is by photographing the original continuous tone picture through a half tone screen. The screen breaks up the continuous tone of the original into an almost countable number of tiny dots. These dots are equally spaced. However the size or diameter of the dots will vary according to the different amount of the light that was reflected from the different tones in the original.

2. What do you mean by line reproduction?

Line Reproduction is the most simple of all reproductions. Line reproduction is used for black-and-white copy that does not require tonal reproduction or the use of a halftone screen. This copy may be single-color or multi color, it may be of a job that is completely done in line, or it may be part of a line-and-halftone combination job.

Operational Steps

The operational steps of line negative reproduction using process camera are:

1) Inspecting and scaling copy
2) Placing copy on copyboard of camera
3) Setting camera
4) Loading film
5) Exposing film
6) Removing exposed film from camera
7) Processing exposed film and
8) Inspecting processed film.

3. What is halftone reproduction?

Halftone reproduction is the method by which continuous tone copy is transformed into a printable image is by photographing the original continuous tone picture through a half tone screen. The screen breaks up the continuous tone of the original into an almost countable number of tiny dots. These dots are equally spaced. However the size or diameter of the dots will vary according to the different amount of the light that was reflected from the different tones in the original.

4. Write a note on contact screens.

Contact screens, used to create the illusion of continuous tone in film-based work with graphics arts cameras, has a pattern of gray or magenta dots separated by other dots of lesser density. In traditional film-based reproduction, the contact screen is held in close emulsion-side-to-emulsion-side contact with the light sensitive material being exposed to create the halftone pattern required. Manufacturers produce a variety of contact screens suitable for different purposes - coarse, medium or fine screens, special effects, gray or magenta, etc, to suit different circumstances. Contact screens are less used today due to the decline in traditional working practices.

5. State the necessity for using different screen angles in process colour reproduction.

The angle of the conventional halftone screen used in four-colour separations, must be different for each colour, to prevent the dots of successive colours becoming superimposed upon preceding ones, so forming an undesirable screen clash pattern or moiré effect when printed. Screen angles frequently used for sheet fed offset litho are: black 45°, magenta 75°, yellow 90° and cyan 105°. In web offset printing angles are often changed to black 15°, magenta 45°, cyan 75° and yellow 90°, although other permutations of screen angles are used.

6. What are the different screen angles used for process color separations?

Cyan - 105°
Magenta - 75°
Yellow - 90°
Black - 45°

This is the typical screen angle recommendations for process color printing. The black printer angle (45°) may be switched with either the magenta printer (75°) or the cyan printer (105°) inorder to eliminate moire problems between the yellow and either the magenta or cyan.

7. State the different types of contact screens.

- Gray contact screens
- Magenta contact screens
- Special effects contact screens

PART – C 10 Marks Questions

1. Explain the procedures involved in line negative reproduction.
2. Write notes on (i) High light areas (ii) Middle tone areas, (iii) Shadow areas.
3. Discuss the steps involved in halftone reproduction using scanner.
4. Write notes on (i) Halftone screens (ii) Screen ruling (iii) Screen angles.
5. Explain halftone reproduction. Describe the different areas of continuous tone photograph.
6. How the screen resolution influences print quality?

GLOSSARY

AM(Amplitude Modulation)Screening: Traditional halftone screening, as apposed to FM (Frequency Modulated) screening, has dots of variable size with equal spacing between dot centers. Hybrid screen combines AM and FM screening.

CALIBRATION A process by which a scanner, monitor, or output device is adjusted to provide a more accurate display and reproduction of image.

COLOR SCANNER A device incorporating a digital or analog computer that separates colored originals electronically by using the three additive primary colors of light in the form of blue, green, and red filters, plus a pre-programmed black printer correctly balanced with the color separations. A light beam moves over the image point by point, generating a separate, color-corrected, continuous tone intermediate or screened halftone film negative or positive representing each of the process colors and black.

Contact print: A photographic print made from a negative or positive in contact with photosensitized paper, film, or printing plate.

Contact screen: A halftone screen on film having a dot structure of graduated density, used in vacuum contact with a photographic film to produce halftones.

CONTINUOUS-TONE GRAYSCALE A scale of uniform tones, from white to black or transparent to opaque, without a visible texture or dot formation.

CONTINUOUS-TONE NEGATIVE An inverse impression of tones from the original reproduced on sensitized film without using a visible texture or dot formation.

COPYDOT TECHNIQUE Photographing halftone illustrations and associated line copy without rescreening the illustration. The halftone dots of the original are copied as line material.

Contrast: A tonal gradation between the highlights, middle tones, and shadows in an original or reproduction.

DARKROOM The light-tight chamber in which photographic materials are handled and processed.

Densitometer: In photography, a photoelectric instrument that measures the density of photographic images, or have colors. In printing, a reflection Densitometer is used to measure and control the density of color inks on the substrate. Densitometry may be built into reproduction devices.

DENSITOMETER An instrument for measuring the optical density of a negative or positive transparency, or of a print.

DENSITY (1) The light-stopping ability of an image or base material, sometimes referred to as optical density. (2) A photographic term used to describe the tonal value of an area. (3) The specific gravity or weight per unit volume of paper.

Density: the degree of darkness (light absorption or opacity) of a photographic image.

Direct screen halftone: In color separation, a halftone negative made by direct exposure from the original on an enlarger or by contact through a halftone screen.

Drum scanner: uses photo multiplier tubes (PMT) and produces color separation with higher resolution and dynamic range than CCD (change coupled device) scanners. Color separation equipment on which the original transparency is wrapped around a hollow, plastic rotary cylinder.

Dynamic Range: Density difference between highlights and shadows of scanned subjects.

Elliptical dot: In halftone photography, elongated dots that give improved gradation of tones particularly in middle tones and vignettes-also called chain dots.

Emulsion side: In photography, the side of the film coated with silver halide emulsion.

EXPOSURE The period of time during which a light-sensitive surface is subjected to the action of actinic light.

FM (Frequency Modulation) Screening: A computerized method for digital screening.

FILM Sheets of flexible translucent or transparent acetate, vinyl, or other plastic base materials that are coated with a photographic emulsion.

FOG A photographic defect in which the image is either locally or entirely veiled by a deposit of silver. Caused by stray light or improperly compounded chemical solutions.

Gamma: A measure of contrast in photographic images.

Gray Balance: The dot values or densities of cyan, magenta, and yellow that produce a neutral gray.

GRAYSCALE A reflection or transmission filmstrip showing neutral tones in a range of graduated steps from black to white. Exposed along with originals during photography, it is used to standardize exposure time, development, determine color balance, or measure density range, tone reproduction, and print contrast.

HALFTONE Tone values represented by a series of evenly spaced dots of varying size and shape, the dot areas varying in direct proportion to the intensity of the tones they represent.

High Contrast: In photography, a reproduction with high gamma in which the difference in darkness (density) between neighboring areas is greater than in the original.

Highlight: The lightest or whitest parts in a photograph or digital image represented in a halftone reproduction by the smallest dots or the absence of dots.

LIGHT SENSITIVE A material that is chemically altered after it is exposed to light.

LPI (lines per inch): Acronym for lines per inch. Used as a measurement of resolution or halftone screening.

Magenta screen: A dyed contact screen that is used for making halftones.

Mask: In color separation photography, an intermediate photographic negative or positive used in color correction. In offset lithography, opaque material used to protect open or selected areas of a printing plate during exposure.

Middle tones: The tonal range between highlights and shadows of a photograph or reproduction.

MIDTONE DOT A point in a middle-gray area of a halftone. Its area equals or approaches the average of the nearby background areas.

MIDTONES The range of tonal values between halftone highlight and shadow areas.

Moire: In color process printing, the undesirable screen pattern caused by incorrect screen angles for printed colors of overprinting halftones.

MOIRE An undesirable, unintended interference pattern caused by the out of-register overlap of two or more regular patterns such as dots or lines.

Negative: In photography, film containing an image in which the values of the original are reversed so that the dark areas in the subject appear light on the film, and vice versa.

OPI (Open Prepress Interface): An extension to postscript that automatically replaces low-resolution placeholder images with high-resolution images.

Orthochromatic: Photographic surfaces insensitive to red but sensitive to ultraviolet, blue, green, and yellow rays.

OVEREXPOSURE A condition in which too much actinic light reaches the film, producing a dense negative or a washed-out print or slide.

Panchromatic: Photographic film sensitive to all visible colors.

PHOTOGRAPHIC PROOFS Blue, brown, or silver prints made from negatives or positives and used to check layout and imposition before plates are produced.

PHOTOMECHANICAL All processes in which printing surfaces are produced with the aid of photography.

Positive: In photography, film containing an image in which the dark and light values are the same as the original. The reverse of a negative. Negatives and positives are visual opposites.

REPRODUCTION Duplicating an original by any photographic or photomechanical process.

Scanner: An electronic device used to convert reflection and transparent materials into digital files that are used in the making of halftones and color and tone-corrected separations of images. Flatbed electronic devices that are used in conjunction with desktop publishing systems to scan line art, logos, photographs, and typewritten or printed text supplied by the client.

SCREENING The process of converting a continuous-tone photograph to a matrix of dots in sizes proportional to the highlights and shadows of the continuous tone image.

Screen angles: In color reproduction, angles at which the halftone screen are placed in relation to one another, to avoid undesirable moiré pattern. A set of angles often used is: black 45^{o}, magenta 75^{o}, yellow 90^{o}, cyan 105 ^{o}.

Screen ruling: The number of line or dots per inch on a halftone screen.

Shadow: The darkest parts in a photograph, represented in a halftone by the largest dots.

Soft dot: Halftone dot with considerable fringe that causes dot gain or sharpening in printing or photography.

Stochastic screening: A digital screening process that converts images into very small dots (14-40 microns) of equal size and variable spacing. Second order-screened images have variable size dots and variable spacing. Also called Frequency Modulated (FM) Screening.

Surprint: In photomechanics, exposure from a second negative or flat super imposed on an exposed image of a previous negative or flat.

Tints: Various even tone areas (strengths) of a solid color.

Tone reproduction: The tonal relationship between all the elements of a reproduction.

UNDEREXPOSURE A condition in which too little actinic light reaches a photosensitive paper, plate, or film, producing a thin negative, a dark slide, or a muddy looking print that lacks detail.

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UNIT - IV - FILM PROCESSING

4.1 PHOTOGRAPHIC FILMS

Lith film is a high contrast, high quality film,. usually with orthochromatic dyed emulsion. It is one of the oldest of the current film technologies and its use is declining due to the complex bath processing required in the process, especially in controlling the correct strength of the developer.

Most traditional photographic material is based on chemical compounds of **silver-producing light-sensitive materials in two main types - paper-based, known as bromide, and film-based, as negative or positive.** When film is processed, it becomes transparent in the unexposed areas, whereas paper remains opaque, or translucent, at least.

Almost all traditional photography depends on silver-based emulsion, which requires the unexposed areas to be developed away, leaving the exposed silver salt areas to turn to opaque silver, with the process of development halted by stabilization or fixing, depending on the emulsion type.

Films are made up of light-sensitive emulsion, consisting of silver halide salts and gelatin coated on a stable base. Silver-based film emulsions are colour-sensitive, reacting normally to the ultra-violet, blue-violet and blue regions of the spectrum. In order to extend this colour sensitivity, colour dyes are added. The two most common films of this type are orthochromatic and panchromatic.

Orthochromatic film has an extended colour spectrum, going from blue-violet, blue, green, yellow through to orange, but not including red. As it is insensitive to red, it can be operated under ‘red’ safelights in the darkroom. Orthochromatic film is used extensively for black-and-white reproduction, and with electronic colour scanners.

Panchromatic film is sensitive to the whole visible spectrum, from blue-violet through to red. It, therefore, can only be operated in total darkness until the exposed material is fixed, when a dark-green safelight can be used.

The newer generation of colour scanners and laser imagesetters use **red sensitive film**, which require a cyan safelight. Unlike the film used in conventional cameras, which reproduce the whole tonal range, lith and rapid access films deliberately offer a steep transition between clear film and solid image.

Rapid access film has become much more popular than lith, due to the fact that keeping the chemicals in balance is less critical in rapid access than in lith processing. It is also a single chemistry system but does not produce as high quality results as lith.

New film technology has seen the introduction of **third-generation film** and **daylight-operated film**. Third-generation film is an attempt to combine the processing speed of rapid access with the quality of lith, if not improve on it. Daylight films are normally insensitive to all areas of the colour spectrum other than blue. It can, therefore, be safely handled with red, orange or yellow safelights which offer nearly as good operating conditions as normal daylight.

Fourth-generation film has been developed to improve on its predecessors, to the extent that higher and more consistent results are obtained through a more stable developing process, along with sharper and higher intensity dots and a reduced consumption of chemicals. It is available as a conventional camera-based option or for imagesetters and scanners depending on the exposure source used - e.g. - HeNe, IR laser, etc.

TYPES OF GRAPHIC ARTS FILMS / PHOTOGRAPHIC FILMS

Graphic arts films can be categorized by four criteria:

(1) **Color sensitivity** - Orthochromatic, Panchromatic and blue-sensitive films.

(2) **Contrast gradient** - high contrast (lith) films, low contrast (continuous tone) films.

(3) **effect of light on silver emulsion** - More darkness (conventional emulsion) or less density (direct-positive emulsion)

(4) **base material and thickness**.

1. COLOR SENSITIVITY

Daylight (white light) is an equal combination of the three primary colors: red, blue, and green. Artificial “white” light contains a mixture of all the spectrum colors, but the proportions of the colors vary, producing white light that may appear somewhat yellow, or blue, or red.

The color emitted by the lights on most process cameras is quite close to the theoretical “true” daylight. Film emulsions are formulated to be sensitive to all the colors in light or only to certain colors. There are good reasons for the availability of films with these special color sensitivities.

Silver-based emulsions have colour sensitivity, meaning that they are sensitive to specific colour or colours of light. Normally, the sensitivity of silver halide emulsions is limited to the ultraviolet, blue violet, and blue regions of the spectrum. To extend the colour sensitivity of the emulsion, dyes must be added. The resulting differences in colour sensitivity become three emulsion types: blue-sensitive, orthochromatic, and panchromatic.

i. Blue-sensitive film

This film is sensitive to only the blue portion of the spectrum in white light. It does not “see” red or green so does not record red or green.

Blue-sensitive film, sometimes referred to as “color-blind” film, is best used for making film contacts for two principal reasons. (1) The nature of the emulsion and its processing chemistry offers considerable exposure and processing latitude; and (2) because the film is sensitive only to blue light, it can be handled under either a red, orange or a yellow safe light. This characteristic is quite useful because the contacting procedure frequently involves producing a composite film for plate making that may be a complex combination of film pieces each requiring a separate exposure. Blue sensitive film is suitable for making both halftone and line images from black-and-white copy, gravure positives, contacts from line positives or negatives or any job that does not require colour separation.

ii. Orthochromatic film

Because of its insensitivity to the red wavelengths, it is safe to use a red light in the darkroom when handling on orthochromatic emulsion.

Since the emulsion lacks sensitivity to the red wavelengths, it is seldom used to colour separate blues, greens, oranges, etc., from blacks, as in line copy.

The emulsion side of blue-sensitive and orthochromatic film has a rather dull finish as compared to the high gloss of the base. These differences are easily distinguished under the prescribed darkroom safelights.

Orthochromatic, commonly called ortho, film is used to make halftone and line for images from black-and-white reflection copy, or black-and-white contionuous-tone film, and contacting using a transparent or translucent imaged material. It can be used for any purpose other than making colour separations from full-colour copy. Ortho is the most common film, by colour sensitivity, used in black-and-white reproduction photography.

Ortho film is the most widely used photomechanical film, for both line and halftone work. Since ortho film is sensitive to both blue and green light, exposure times are considerably shorter than blue-sensitive film.

iii. *Panchromatic film*

Panchromatic film emulsions are dye-treated to be sensitive to all visible wavelengths of light, including red. For that reason, it can be handled safely only in total darkness before the material is fixed. For limited visibility during handling, panchromatic film can be used under a dark-green safelight toward the end of the processing cycle. The shapes of film also aid in identifying the type.

Panchromatic film is used for making both continuous tone and direct screened colour separations from the color copy such as colr transparencies, color prints. ‘Pan’ film, as it is often called, is also used for separating coloured originals.

2. CONTRAST

The tonal differences between highlight and shadow areas of an image represent its contrast. The way in which a film emulsion records the tones of a gray scale, graphically represented, is referred to as the characteristic curve of the emulsion. The gray scale, used to measure contrast, is a strip of photographic film or paper of graduated tones. A film gray scale will have tones ranging from a dense solid black to transparent. Film gray scales are used when reproducing transparent copy or making contacts. On a paper gray scale, from which light is reflected rather than transmitted (as it is with film), the tone gradation will range from a solid black to a pure white. Paper gray scales are used when reproducing reflection line work or half toning reflection copy.

The gray scale is placed at the side of original copy and reproduced along with the copy. In line work, the gray scale will check the negative or positive film for proper exposure and development. It will also measure the tonal range and fidelity obtained in halftone work. For color separation negatives, it will help determine color balance and proper tonal range of the separation negatives.

For film contacts the gray scale is placed on the film in the contact frame and is used to check the film contact for proper exposure and development

High-contrast graphic arts film is referred to as lith-type film. Depending on exposure and development times, this film will record the graduated tones of a gray scale as either black or white. It will not record shades of gray. High-contrast film is the most commonly used graphic arts film. It is used extensively for reproducing line work and halftones using a process camera, and for making contacts in a contact frame.

Continuous - tone graphic arts film will record all the graduated tones of the gray scale and the original copy. This kind of film is of lower contrast than the lith-type film and is used primarily in the color separation process.

4. FILM BASES

Photographic emulsions are coated onto transparent film bases that are characterized by their thickness and the material from which they are made. The stability or degree of resistance to dimensional distortion caused by variations in temperature, humidity, and handling is dependent on both of these characteristics. The thickest and most stable base material is 0.007-in. polyester. A 0.004-in. polyester base is slightly less stable, and acetate-base film or polystyrene-base film even less. Film bases and thicknesses are selected according to the requirements of the job.

Work that calls for critical register requires a thick polyester base. Line work, or work that does not demand critical register, can be reproduced on a thin acetate-base film.

4.2 PHOTOGRAPHIC FILM STRUCTURE

The structure of a light sensitive film when viewed as a cross section will be similar to the diagram drawn below:

Anti stress layer:

This thin top coating or super coat reinforce the emulsion layer helping to minimize scratches, abrasions and Newton’s rings formed during rough film handling.

Emulsion layer:

This is the gelatin layer holding the light sensitive layer of silver halide grains. In some cases – color films, tone correcting films, x- ray films – the base is multicoated with two, three or more differing emulsions. There is a basic relationship between the grain- size and the sensitometric properties of the particular emulsion.

a) An emulsion containing large grains will react faster and more easily with light rays. Because of the large surface areas (more sensitive centers) of the light sensitive grains, this emulsion will have a high sensitivity but accompanied by a coarse grain effect throughout the recorded image.

b) An emulsion capable of recording an original which has a long range of tonal gradations must possess grain of different sizes, resulting in an image of relatively lower contrast. This is because of the fact that some grains both large and small will become completely black and represent tones of high, medium, and low density. Conversely an emulsion consisting of virtually equal size will not record many tonal gradation. The grains will become either completely blackened or remain unexposed. This type of emulsion is used when an image of extreme contrast is required.

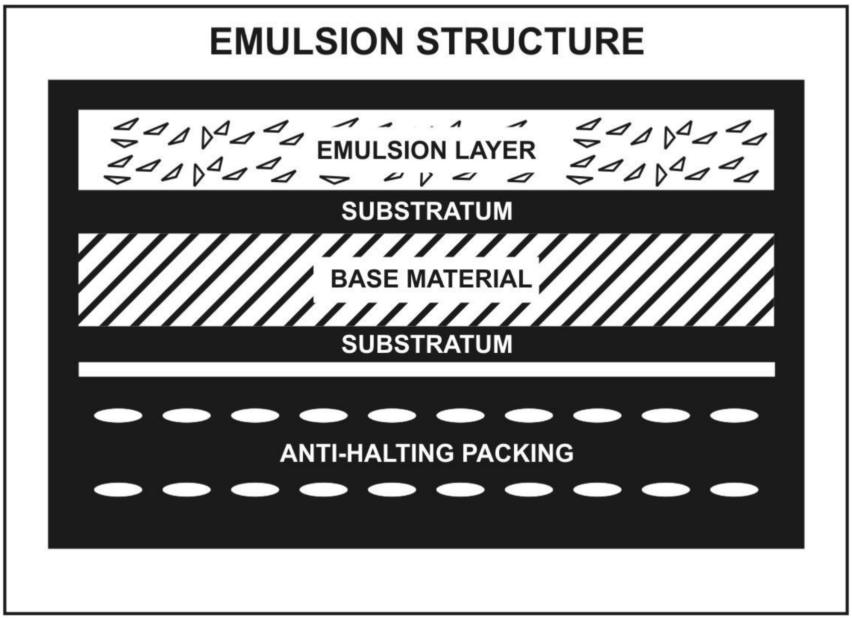


Fig: The structure of photographic film

Base material:

There are many materials used in each category, but generally speaking paperand plastic layers are few materials used as base. The base supports the light-sensitive emulsion and, therfore must have uniform thickness without surface irregularities.

Substratum layer:

Substratum is generally a weak mixture of gelatin and base material solvent. This substance is employed wherever adhesion is required.

Anti- halation backing:

Selected dyes are dissolved in gelatin and coated onto the back of the base material. These dyes absorb any light that has passed through the emulsion, arresting the reflection of these rays which would result in a second exposure being recorded on the emulsion. This backing layer also stops the film curling and is doing so ensures that the emulsion lies flat during exposure. In some cases the absorption of the unwanted light is increased by tinting the base material with gray color.

FILM SPEED :

Film speed is a term describing the film's time response to exposures. A film may be fast or slow, depending on the amount of light required to expose it purposely. A film that requires intense or long exposure is considered to be a slow film. The films used in graphic arts are in this category.

Emulsions vary in the amount of light they need to record an image. Of the silver halides, silver chloride requires the most light to cause a reaction . In addition to the silver halide used, the size of the grain also affect the speed of the film. A larger grain size means a faster films speed.

Two additional factors influence a film's speed: *the film's colour sensitivities and the light source used for exposure.* Blue-sensitive film will be slower when a tungsten light source is used than if exposed with a pulsed xenon lamp because tungsten light contains far less blue light than the pulsed-xenon. Two films of different colour sensitivity will also differ in speed exposed by the same light source. Thus, panchromatic film is faster than blue-sensitive film when exposed to a tungsten light because the pan film is also affected by the green, yellow, and red light present in the light source.

4.3 - PROCESSING CHEMICALS / THE CHEMISTRY OF PHOTOGRAPHY

The chemistry of photography is a vast subject; we can merely present some of its fundamental aspects. Our presentation is divided into the following:

(1) The photographic emulsion
(2) Developer solutions
(3) Stop bath solutions
(4) Fixer solutions
(5) Reducers
(6) Intensifiers
(7) Washing solutions

1. THE PHOTOGRAPHIC EMULSION

The silver emulsion used on sensitized materials consists of a colloid such as gelatin, silver halides, and additives for producing certain effects.

Gelatin

Gelatin is a protein obtained from the tissues, hides, cartilage, and bones of animals. Since it is of animal origin, its composition is extremely varied and consequently complicated the process of standardization. The important specifications for photographic use of gelatin are jelly strength, pH, moisture content, and metal contents of iron, lead, copper, and alumina, together with limits of ash and sulfur dioxide.

Silver Halides

The important salts of silver chloride, silver bromide, and silver iodide, which are formed by precipation in the emulsion, are extensively used in emulsion manufacture. Silver fluoride is not used to any extent because of its fog action in combination with other silver halides.

Silver bromide (AgBr) is the most widely used of the silver salts for paper and film products. It is usually the major portion of the halide salts in film and is characterized by the effect of its high speed and low fog action on the emulsion.

Silver iodide (AgI) is used generally in combination with other halides. In speed, it is approximately one-third that of silver bromide

Silver chloride (AgCl) is a pure white powder, which is used primarily on paper-type emulsions for amateur use. Its speed is approximately one-eighth that of silver bromide.

Although the halides of silver are widely used, the oxalates, nitrates, tartrates, and citrates of silver have been used to a lesser degree for sensitization.

Additives to Emulsions

The silver salts are color sensitive inherently to the blue portions of the spectrum only. To increase this sensitivity to red and green, color-sensitizing dyes are added to the photographic emulsion. These sensitizing dyes are absorbed by the silver halide, and the increase in color sensitivity by this process is referred to as optical sensitization

To obtain special effects such as an increase in speed, prevention of fog, and control of gamma, all emulsions contain certain additives to achieve these desired effects. The specific chemical reactions and functions of these additives are complex.

Preparation of the Photographic Emulsion

The technique of manufacture for photographic emulsions has long been considered a “trade secret,” but the basic procedure is well-known and consists essentially of the following:

1. Soaking and dissolving a portion of the gelatin.
2. Addition of bromides and iodides used in precipitation of the silver halide
3. Addition of silver salts, causing the precipitation of the silver halide. (This process is called emulsification.)
4. Recrystallization of emulsion by heating. (This is commonly referred to as the “first ripening”.)
5. Addition of the remaining gelatin, and chilling.
6. Formation of “noodles” by forcing the chilled gelatin through a wire screen
7. Washing, to remove the emulsion of unwanted salts.
8. Reheating, which is referred to as after-ripening or second-ripening, to recrystallize the silver salts.
9. Addition of special chemicals, such as sensitizing dyes, preservatives, antifoggants, stabilizers, etc.

Although the preceding list of operations is considered a basic procedure, there are endless variations that will affect the finished product. Purity of gelatin, agitation, salt concentration, degree of heat, and procedure of addition of silver salts are just a very few of the factors that make emulsion manufacture a complex procedure.

2. DEVELOPER SOLUTIONS

Developer:

The latent or invisible image in the exposed film emulsion is made visible by a process which is termed development. Chemical development is the reduction of the exposed silver halides in the emulsion to blackened metallic silver. The process is performed in solutions that contains various mixtures of chemicals which has the property of reducing the exposed silver salt to metallic silver. This solution is called a Developer. Developers are sold either in ready mixed powder forms or in made up stock solutions which have only to be dissolved in water for use.

During exposure, light affects the photographic emulsion by forming a latent image. The purpose of developer is to convert the latent image into visible image. This is accomplished by reduction of the silver halide to black metallic silver with the use of a solution referred to as a developer.

The developing solution consists of:

i. A solvent, such as water.

ii. A developing or reducing agent, such as metol or hydroquinone.

iii. A preservative, such as sodium sulfite.

iv. A restrainer, such as potassium bromide.

v. An accelerator or alkali, such as sodium hydroxide.

vi. Miscellaneous additives.

Chemicals in a developer function according to the above constituents; The difference among developers is caused by the different types or proportions of these chemicals to achieve the desired developing action.

CONSTITUENTS OF A DEVELOPER

i. Solvents

Almost all developers use water as their solvent, although some color-coupling developers use other solvents in combination with water. The water used for developers should be of fairly high purity and should not contain large amounts of calcium or chloride salts.

ii. The Developing Agent

Organic chemicals are widely used as developing agents and are characterized as strong reducing agents containing the hydroxyl (OH) and amino (-NH2) groups in varying proportions. The most important of this group is paradihydroxybenzene (hydroquinone*)* and monomethyl paraminophenol *(Metol).* Hydroquinone is a slow but powerful developer, taking longer time to show a visible image on the film but gaining density much more rapidly over a prolonged period of time. Metol is a much more energetic agent, showing an image rapidly but building density slowly. The combination of Metol and hydroquinone in developers is excellent, for each chemical helps to correct the shortcomings of the other. Varying combinations of these two agents are used in the most popular types of paper and film developers.

iii. The Preservative

Due to the high reducing action of the developing agent, a preservative (or antioxidant) is necessary to prevent or control developer oxidation. Sodium sulfite is the most common chemical in this group. The sulfite, in addition to acting as an antioxidant, also prevents the formation of staining developer products, acts as a silver solvent, and in some cases serves as a weak alkali, which increases the rate of development.

iv. Restrainer

Potassium bromide is used as a restrainer in the developer. The action of potassium bromide in a developing solution is such that it reduces the ionization of the silver salt, thereby controlling (restraining) development. This action, however, is greater on the fog image than on the denser image. Restrainer is used to control the fog image.

v. Accelerator

In order to increase the pH of the developing solutions, thereby increasing the ionization of the developing agent, the addition of an alkali, or accelerator is important in developing formulas. The alkali also has the dual function of absorbing the bromine ions formed by the action of the developing agent of the silver salts. The more important types of alkalis include the carbonates and hydroxides of sodium and potassium. Paraformaldehyde is the common type of alkali control used in “lith” type developers due to its ability to produce extreme contrast.

vi. Miscellaneous Additives

There are a number of additives to developing solutions each designed to achieve some desired effect. The most common in use are the following:

1. Wetting agent, to permit the rapid penetration of developer into the gelatin.
2. Desensitizer, to reduce the color sensitiviry of the emulsion without affecting its speed. Phenosafranine and the pina kryptols belong in this group of chemicals.
3. Silver solvent, for reduction of grain size, include sodium thiocyanate and ammonium chloride.
4. Other chemicals, used to increase gamma, control water impurities, and permit the use of developers environments characterized by extremes of temperature.

Action of Development

The action of the developer on the photographic emulsion has been the subject of debate for sometime, and to date, there is not a complete understanding of this complex reaction. However, in the case of a hydroquinone developer, the reactions proceed as follows:

1. The alkali dissociates the hydroquinone, with the liberation of ions of the developing agent in solution.
2. The hydroquinone ion reacts with the silver bromide yielding quinone and ions of silver and bromine.
3. The quinone then reacts with sodium sulfite to form sodium hydroquinone monosulfonate and sodium hydroxide.
4. The sodium hydroquinone monosulfonate is oxidized to quinone monosulfonate, which in turn reacts with sulfite to form sodium hydroquinone disulfonate. The latter chemical is practically inert as a developer.
5. As the development proceeds, hydroquinone ionizes. Ar the same time, hydrogen ions are formed; and bromine ions are released into the solution, which is equivalent to adding potassium bromide to the developer.

Basically this reaction may be simplified by saying that the developing agent is gradually used up and during this process forms complex developing agent salts, which act on the image to a lesser degree. The solution then reaches a point when the developing agent is completely exhausted and the bromine ions formed by the silver bromide restrain development and will not produce sufficient density in the negative or positive.

3. STOP BATH SOLUTIONS

After a negative or print has been developed, it is usual to rinse it in clean water for a minute or so to halt development before transferring it to the fixing bath. A solution of 2-5% acid or citric acid, or potassium meta-bisulphite is commonly used for this purpose. It immediately neutralizes the alkalinity and thus the activity of the developer.

It is classified into three types of rinse baths they are

1. Water rinse bath:

It helps to slow down the action of the reducing agents and remove the excess developer from the emulsion.

2. Hardening rinse bath:

It is used to harden the emulsion when processing at high temperature (for tropical processing).

3. Acid rinse bath:

It always be used after a high speed developer (for weather processing).

The acid stop bath also:

1. Minimizes the formation of dichloric fog,
2. Removes calcium scum,

3. Preserves the acidity and hardening characteristics,
4. Prevents excessive swelling of the gelatine.

4. FIXER SOLUTIONS

When development is completed, those areas not affected by exposure or development have to be removed to make the image on the film permanent. These unexposed and undeveloped areas are removed from the film by use of a fixing bath.

In addition to its reaction of dissolving the unexposed and undeveloped silver salts, the fixing bath also serves two other basic purposes: it neutralizes developer alkali, thereby stopping developer action and eliminating oxidation staining, and it sufficiently hardens the emulsion, preventing scratches and washing away of the gelatin image.

Composition and Reactions of the Fixing Bath

The fixing bath contains a number of chemicals each acting on the silver image in some manner. The formulation of a typical bath used for general purposes on lith films would consist of the following:

1. A solvent, such as water.
2. A silver halide solvent, such as sodium thiosulfate (hypo), which is used to dissolve the silver halides. Generally emulsions with large grain size will clear much faster if ammonium thiosulfate is used. This chemical is the common ingredient of the liquid-type fixers.
3. A stabilizer, such as sodium sulfite. In this reaction, the sodium sulfite combines with the ionized sulfur of the sodium thiosulfate to form a complex sulfite salt, thereby stabilizing the bath and preventing formation of a sulfur precipitate.
4. An acid, such as acetic acid, to bring the bath to the pH necessary to neutralize alkalinity caused during development.
5. A buffer, such as boric acid, to limit the change of pH of the fixing bath solution, thereby preventing formation of aluminum precipitates.
6. A hardener, such as potassium alum. In this reaction, the hardener toughens the emulsion so that the resulting physical hardness is such that it will not be affected by washing or normal handling when the film is dry. The hardening action of chrome alum is greater than that of the potassium salt, but since it has a tendency to form a sludge more rapidly, it is not used too widely.

5. REDUCERS

The action of a reducer is essentially that of an oxidizing agent: oxidizing the metallic silver to form a soluble silver salt. In some cases, the silver salt is insoluble in water, and the solution must contain another chemical that can convert the silver salt into soluble silver compound.

A common reducer is Farmer's reducer, which is a mixture of potassium ferricyanide and sodium thiosulfate. The silver reacts with the potassium salt to form silver ferrocyanide.

At the same time, the iron in the ferricyanide ion is reduced to form ferrocyanide ions. Then the sodium thiosulfate reacts with the insoluble silver ferrocyanide, converting it into soluble complex Ions.

Another reducer is a mixture of iodine and sodium or potassium cyanide. Potassium iodide reacts with the iodine to form potassium iodate. The latter substance oxidizes the silver. Silver iodide is very insoluble in water but is soluble in a potassium cyanide solution. The silver iodide is thus converted into a silver cyanide complex ion, which is soluble in water. This type of reducer is sometimes used for flat etching of halftone positives.

REDUCTION

Basically three types of reduction are used. They are un-proportional, proportional and super proportional reduction.

Un-proportional reduction:

This is carried out in farmers reducer, a two stock solution reducer made from mixing one part of the potassium ferricyanide solution with two parts of the sodium thiosulphate in three parts of water. The highlight tones or the thinnest lines are reduced first. The effect of this reducer is increased or decreased by changing the amount of potassium ferricyanide and sodium thiosulphate in relation to one another. Excess amount of ferricyanide will lead to more violent reducing action.

Proportional reduction:

This takes place when the solutions action is in proportion to the amount of silver. Shadow areas (densely populated areas of black silver) are reduced faster than the high light areas. A most useful proportional reducer is old Tri-mask or multi mask bleach fixing solution which may be diluted to achieve the desired degree of proportional reduction.

Super proportional reduction:

These rely on a catalytic reaction which is increased in proportion to the amount of silver present. A very effective of this type can be prepared in a two stock solution form by mixing ammonium persulphate in water. This is the reducing solution while the second solution of sodium sulphite is used as a stop bath arresting the reducing agent.

6. INTENSIFIERS

There are numerous intensification methods - lead, copper, silver and mercury compounds are used as intensification compounds to reinforce the image areas which appears too weak for subsequent printing down operation. The most popular compound seems to be mercuric chloride. The emulsion have to be thoroughly washed in warm water. The emulsion is now immersed in the mercuric chloride potassium bromide solution where it will be seen to bleach out producing a white appearance throughout the depth of the image areas. Once this has been achieved the emulsion is washed and finally reblackened in a 10% solution of ammonia.

6. WASHING SOLUTIONS

This is really the third stage of fixing, the removal of water soluble salts now present in the unexposed areas of the emulsion. A required supply of clean running water is needed to wash the processed emulsion. We have to completely change the water every 5 minutes ensuring that unwanted salts are being continuously removed. Washing should be continued for a period of 30 minutes ending with the addition of few drops of wetting agents to facilitate even drainage. The washed emulsion can be squeezed or wiped carefully with a chamois leather.

DRYING

To retain dimensional stability in the base material, drying should take place by the circulation of cool air. Rapid drying may be achieved in a drying cabinet with a maximum internal temperature 40° c (104° F) and relative humidity of 55%.

4.4 - PROCESSING ACCESSORIES

Processing Trays

A processing tray is an open-top container that holds one of the solutions used to process photographic materials. One tray is used for each processing solution. Processing trays are sized slightly larger than a specific, standard film size. Keep developing trays in all the standard film size to be used. Generally, two trays for each film size, in addition to the stop bath and fixing bath trays are needed in every dark room.

Processing trays are made of many materials including stainless steel, enamel, hard rubber, plastic and glass. Because glass trays are easily broken, their use is limited. Stainless steel is the best material. Trays are either transparent or opaque. A transparent tray has a major advantage over an opaque tray. By being transparent, it can easily be illuminated by a correctly positioned safelight. This aids in the visual inspection of the material while it is being processed in the tray.

Processing Tanks

Processing tanks process several sheets of exposed photographic material at one time. Processing tanks used in graphic arts darkrooms are made of stainless steel. They have close fitting covers and a floating lid that prevents the processing solution from becoming oxidized. Normally, they are used in sets, one tank for the developer, and the other tank for the fixer. A processing tank contains an acid stop bath and a water rinse tank is often used between the developing and fixing tanks. Special stainless steel hangers support the photographic material in the solution, spring loading clips hold the film tightly stretched. The temperature of the processing solution must be at the optimum temperature.

4.4.1 - MANUAL FILM PROCESSING

Manual film processing involves the following steps:

i) Developing

ii) Stop Bathing

iii) Fixing

iv) Washing

v) Drying

1. Developing

The latent or invisible image in the exposed film emulsion is made visible by the Developer solution. Developers are sold either in ready mixed powder forms or in made up stock solutions which have to be dissolved in water for use.

2. Stop Bathing

After a negative or print has been developed, it is usual to rinse it in clean water for a minute to stop the development action before transferring it to the fixing bath. A solution of 2-5% acid or citric acid, or potassium meta-bisulphite is commonly used for this purpose.

3. Fixing

After the development is stopped, the image on the film is made visible, but they are not permanent. The fixing bath is used to remove any remaining unexposed salts and to make the image permanent.

The main compound in the fixing bath is sodium thiosulphate, or hypo as it is commonly known. The fixing bath also serves two other basic purposes:

i) it neutralizes developer alkali, thereby stopping developer action and eliminating oxidation staining, and

ii) it sufficiently hardens the emulsion, preventing scratches and washing away of the gelatin image.

4. Washing

This is really the third stage of fixing, done to remove the water soluble salts now present in the unexposed areas of the emulsion. A required supply of clean running water is needed to wash the processed emulsion. We have to completely change the water every 5 minutes ensuring that unwanted salts are being continuously removed. The washed emulsion can be squeezed or wiped carefully with a chamois leather.

5. Drying

To retain dimensional stability in the film base material, the processed film must be dried.

4.4.2 - Automatic Film Processing

Traditionally, film processing was done in shallow trays and controlled manually. Today automatic processors are used.

In automatic film processing a continuous belt or roller system passes the film through a developer, a stop-fixer combination bath, a washing tank, and a dryer. With deep-tank chemical storage, there is little problem with oxidation because there is little surface area of the liquid exposed to air.

Long periods of disuse will cause some activity change. Chemical exhaustion as a result of film processing is controlled by adding a small quantity of replenisher after each piece of film enters the machine. The amount of replenisher that is generally added is a function of the area, of the sheet of film being processed. When replenishers are used, the chemical solutions generally need to be removed from the tanks only several times a year for machine maintenance.

Automatic film processing is an attractive alternative to shallow-tray processing. Most automatic film processing units are designed for dry-to-dry (operator touches no liquids) delivery in four to five minutes. In addition, automatic processing provides accurate time, temperature, and agitation control and reduces production costs through faster processing.

4.5 - COMPUTER TO FILM TECHNOLOGY - FILM IMAGESETTERS

Through the development of digital generation and storage, imagesetters have been developed which, free from the restrictions of photographic masters, can create images not only of type, but also of a wide range of graphics including line, tints and photographs, by reproducing in a predetermined dot or other shaped pattem. The development of imagesetters, and laser printers, has allowed full DTP and WYSIWYG (What you see is what you get) - ie - full make-up on screen, to flourish, as all elements on the computer screen can be reproduced in the desired finished form. Previously, with phototypesetters, 'windows' or gaps needed to be left into which the screened pictures or other graphics would be stripped.

Imagesetters are driven from application programs which can output their information in a page description language called PostScript, which is a deviceindependent programming language. This means that the Postscript file can be output on any device, regardless of its resolution. As a programming language, PostScript can support any level of graphic complexity: it is a page-dependent description language - ie - the entire file needs to be interpreted prior to imaging a single page.

The **process of imagesetting** essentially **consists of two parts** - **a Raster Image Processor (RIP)** and **a film imagesetter** i.e., a high resolution printer or output unit normally using laser exposure.

RIP (RASTER IMAGE PROCESSOR)

A RIP operates by transforming the front-end instructions from the host DTP / EPC system, which are stored in PostScript language, into a 'digestible' bitmap form of managed data the output device can understand and utilise.

A RIP has to perform three functions:

- Interpret the page description language from the application program, such as Quark XPress or PageMaker.
- Create a list of all the objects on a page, known as a 'display list'.
- Create a page bitmap for the output device, which tells it where to place the 'dots' that form the page image - to draw the objects on a page.

There are **two types of RIP - hardware RIP**, which exists as a separate piece of physical hardware or box, coming between the computer-driven front-end unit and the output unit - ie - the imagesetter; alternatively there is **software RIP**, which resides in the computer front-end. Traditionally, hardware RIPs have been used, but there has been a major swing to software RIPs in recent years as computers and processing power have increased and improved so dramatically during the mid to late 1990s. The software option tends to be the cheaper one, with upgrading a simple job of increasing the processing power of the host computer, or in fact changing the computer, whereas the hardware upgrade path can mean a start-again cycle.

Each RIP has a limit on the overall size of each single graphic it can handle at anyone time - with just below A3, for example, being the maximum some RIPs can handle. Adobe, the originator and developer of PostScript, has issued licenses for RIP designs which continue to improve to take account of developments such as PostScript levels 2 and 3.

Most forms of powerful output device are controlled by a RIP from, for example, colour copiers transformed into colour printers, to imagesetters and CTP systems. RIPs are designed to run AppleMac, PC or UNIX platforms, some as dedicated/proprietary units, and others as relatively general purpose RIPs driving a wide range of output devices. The MGI 'Jetstream' RIP, for example, has the facility to support colour copiers, electrostatic and inkjet printers, as well as image setters on the AppleMac, PC or UNIX platform.

Major prepress companies such as Linotype-Hell (now Heidelberg Prepress) and Agfa have developed RIPs to drive their specific range of image setters with built-in upgrade path. Linotype-Hell developed the 'Delta' RIP (which is in the form of a modular software RIP developed from their previous hardware RIP experience) to drive some of their imagesetters: it consists of three parts, DeltaSoftware, Delta Workstation and DeltaTower. The Delta Software drives the A3+ Quasar, B2 Herkules and DrySetter imagesetters; the Delta Workstation is based on a PC running Windows NT; and the Delta Tower looks after the screening requirements.

Agfa has developed the 'Cobra' software RIP, a powerful, upgradable product run on a UNIX platform SPARC workstation which is capable of driving image setters and other input and output devices simultaneously. Electronics for Imaging (EFI) are well known in the industry for their Fiery RIPs converting colour copiers into colour printers: the range has now been extended to cover large format digital printing.

Apart from the relatively proprietary/dedicated RIPs developed by major prepress companies, 'open' systems have been developed by companies such as Harlequin which has, for instance, produced its own PostScript interpreters, rather than licensing them from Adobe, producing powerful, feature-rich RIPs which are very popular in high-end workflows driving imagesetters, platesetters, digital proofing systems and digital presses.

Imagesetters

Imagesetters generate and expose dots onto photosensitive material- such as film, bromide paper and in some cases polyester and film plate material. The material is mainly supplied in light-tight removable cassettes in roll form to different widths depending on job requirements and the capabilities of the machine; photosensitive material is also supplied in sheet form in some applications. Often two sizes of film can be held in the image setter for ease of switching work.

There are two main types of imagesetter - capstan and drum type imagesetters.

Capstan imagesetters use a flatbed system, utilizing a drive mechanism which moves the photosensitive material, such as film, up to and past the imaging head in the form of a platen. Due to the mechanical nature of the capstan system, which relies on the correct amount of tension being present at all times, it has generally been regarded as an inferior product to the drum option and one which is often not considered appropriate for fine and accurate colour registration work. It must be acknowledged, however, that the latest capstan imagesetters are far more accurate, and create work to far higher tolerances than their predecessors. Many are capable of producing four-colour separations for printing - with resolutions to 200+ line screen.

Drum imagesetters come in two main types - internal drum imagesetters and external drum imagesetters. With the drum-type imagesetters, the material to be exposed is held or attached internally or externally around a drum or cylinder. With internal machines, the light source/imaging head moves along the inside of the rotating drum, imaging as it traverses; conversely, with the external machine, the drum not only spins but also traverses while the imaging head remains stationary. One advantage of the external drum machine is that the laser light path to the film is very short compared to the internal drum, helping to achieve very accurate imaging.

Imagesetters are continuously improving in terms of quality of result, such as screen frequency and precise positioning, but also in speed by use of multiple laser beams for imaging.

The wide range of exposure technologies on modern imagesetters includes argon-ion, infra-red, laser diode, HeNe, YAG, and visible red lasers. Holographic technology is now being applied to some imagesetters, resulting in double the imaging speed of other systems, along with improved screen quality and reduced banding problems.

Laser light is highly intensive, but cannot be easily switched on and off, while retaining high speeds and stability. To overcome this problem, the laser light is passed through a crystal-based prism which deflects the light differentially, simulating switching on and off.

A further necessary component is a spinning mirror which delivers the imaging dots onto exactly the required positions: alternatively a deflecting mirror mechanism without a prism system can be used to introduce the 'on - off' imaging cycle to create the micron image dots.

The higher the resolution used, the greater the range of tones that can be reproduced in halftone form - eg - to reproduce a 150lpi screen frequency with up to 256 grey levels requires an imagesetter which can generate an output resolution of at least

2400dpi. For text, line and relatively coarse halftone work, 1200 dpi is generally considered adequate.

Modern imagesetters come with a range of output resolutions, which allow each job to have the resolution best suited to its own specific requlrements and characteristics, alongside the most efficient use of ‘RIPing’ and imaging/ outputting times. The resolution range offered by image setters now covers from around 900dpi to over 16000 dpi in some cases. In recent years there has been a considerable trend towards printers installing image setters to match the size of their biggest press - eg - B3, B2, B1 or above. The drive towards electronic imposition has accelerated this move to output one-piece composite punched pin register film, ready for platemaking. Imagesetters are, in fact, available in a wide range of format/film output sizes through A4+, A3+, A2+, A1+ to 2 BO and above.

B2 imagesetters can output a four-page A4, imposed flat in under five minutes; with BO imagesetters capable of generating a 16-page A4, imposed flat in under 15 minutes at 2540dpi. It should be noted that the more complex and fine the data to be output, for example, a halftone image as against typematter, or 300lpi rather than 150lpi, the slower will be speed of the output device.

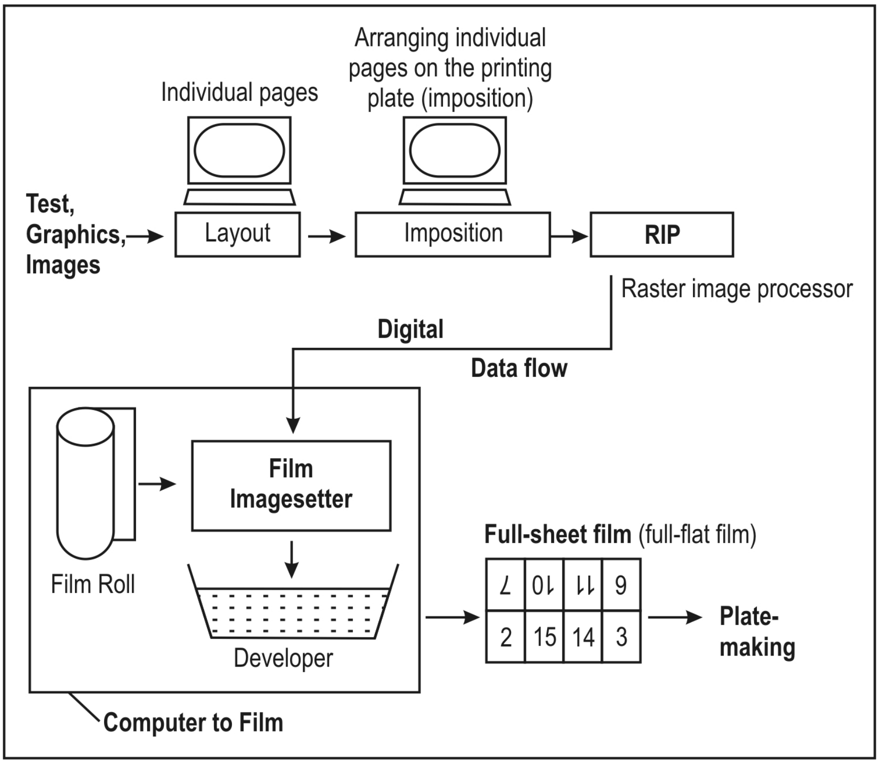
B3 imagesetters give the small-size sheet printer a very cost-effective, flexible system, producing film output for high-end process colour work and polyester plates for general commercial work. Some devices offer film and polyester processing on the one machine, and developments are being worked on to include CTP with metal plates, which will result in a truly multipurpose output device.

COMPUTER TO FILM TECHNOLOGY

Principles of Computer to Film Technology

“Computer to film” describes the *complete* imaging of films based on digital data and is controlled by the computer. However, if a full-flat (full-sheet) film is exposed, the term “computer to film” is used. The special feature of the full-flat film is that manual assembly is no longer necessary. The full-flat film already includes all the pages as well as all the print control elements and marks for finishing.

Figure shows the characteristic workflow of computer to film. After the layout of the individual pages is complete, digital “imposition” takes place in the computer. This imposition is the central prerequisite of computer to film and the decisive factor for cutting down on costs and time, to the raster image processor (RIP), which converts it for output on film. The full-flat film is created in the film exposure device, together with series connected developing equipment, the full-flat film can then be copied in the copying frame onto the printing plate material without need for any further manual assembly operations.



Workflow with Computer to Film

Advantages of Computer to Film Technology

Compared with conventional manual sheet assembly, computer to film – and therefore the output of a full-flat film – offers the following *advantages*:

- As compared to manual assembly of numerous individual elements (films), *work time* can be reduced considerably, depending on the complexity of the elements.
- *Productivity* in the prepress area is thereby increased; during the same time, more films can be produced than previously. On average, it can be assumed that productivity is increased by a factor of three.
- There is a *saving in materials* (base material, copy and print control strips, adhesive strips, intermediate film).
- Drawing the *layout sheet* is no longer necessary.
- With repeating imposition patterns, in particular with *repeat jobs*, the imposition data is available and can be called up at the touch of one button.
- *Operators learn* to handle digital data and digital methods of production in general, and gather experience for use later with computer to plate. With computer to film, flexibility is maintained, even for (analog) films supplied by the customer, which can then be integrated. Digitization of these analog films is, of course, also possible and advantageous, but with this hybrid method of working, as described, it is not necessary.

- If needed, *proofs* can be produced using analog equipment.
- The *plate copy* requires less time. Cut edges for positive plate imaging systems, which would have to be removed, are no longer present on the plate (cut edges can occur when film pieces are stuck on top of one another while using analog plate exposure).
- There are even advantages in time and quality at the *printing press*. Register accuracy of the individual full-flat films is better than it could be with manual assembly. In this way, the time needed for ink register setting at the press is reduced for multicolour jobs.

Numerous film exposure devices (imagesetters) contain an *integrated punch* to ensure that the register accuracy of the films for copying to the printing plate is as great as possible and that no additional manual operation is necessary.

Text Output for the Production of Film/Plate

During word processing the text is continuously output/displayed on the screen in front of the operator. Paper prints are also produced for proofreading purposes.

Should the further processing of the text into a master (film for platemaking) be done conventionally, that is manual assembly, exposed films are required. These may be produced either as columns or a page of text with blank spaces for the manual importing of pictures or as a complete full-page including pictures. The columns contain only text justified to the column or page width. This involves the largest amount of effort in the manual assembly of the page, the *page make-up*. It is better to pre-edit the page of text with a layout program that creates the blank spaces into which the images already present as film may be imported. The production of whole pages electronically, the displaying of text and image together, and outputting them at the same time on film requires that all of the images are stored in digital form in the computer and may be processed together with the text in the layout program.

Output to film is normally carried out in small-format imagesetters (also called “recorders”) in approximately a 25cm\35cm format, that is, approximately an A4 format. This section only deals with these small format imagesetters, which are used for the production of films to be assembled with conventional assembly systems – that is not “totally digital” prepress. Large-format imagesetters, computer to film and computer to plate units are described in sections 4.2 and 4.3.

Designs of Output Devices

Output devices used for the exposure of films are called “film imagesetters”. There are imagesetters of the flatbed design, capstan imagesetters, and internal and external drum imagesetters. In all of them exposure takes place spot by spot in lines across the whole area being exposed. In continuous exposure the pixels form straight lines in the direction of the lines of text and solid areas in conjunction with the pixels of the following lines. Letters and symbols are constructed using this process. The process assumes that each line of text is represented as a number of “micro lines.”

If text and images are output together, the images, which are also divided into micro lines, are exposed in one pass along with the text. The separation of text and image into micro lines takes place in the RIP (Raster Image Processor).

To be able to produce letters with the smoothest possible contours and high resolution pictures, the exposure dot within a line, also called a spot, must have a very small diameter. The spot size limits the *resolution of the output device* (7 μm corresponds to approximately 5000 dpi and 30 μm approximately 1200 dpi; dpi: dots per inch). The individual dots must be located on the film so closely together that they can form a solid tone area. This determines the distance between the spots and from one line of spots to another.

Imagesetters on the market have a *spot size* from 7 to 45μm; this corresponds to a resolution of between approximately 5080 dpi and 800 dpi or approximately 2000 cm–1 and 315 cm–1 (315 points per cm). High performance devices offer a resolution of 8000 dpi, that is 3150cm–1.This assumes that the spot size equals √2 x the pixel distance (the minimum required to achieve solid tone coverage by building up with individual pixels).

This leads to a considerably sharper rendering of the shape, but at the same time the number of pixels is increased by a factor of 4 and thus requires much more storage capacity. Doubling the resolution is associated with a four fold increase in the number of pixels, which therefore means a correspondingly greater memory requirement.

The large number and small diameter of pixels that must be exposed one after the other demand beams of light that may be very rapidly modulated; it also includes high energy light sources. Laser diodes or gas lasers in the visible range of wavelengths (e.g., laser diodes of 670nm, helium neon lasers of 633nm, argon lasers of 488nm) adapted to the sensitivity of the film are used.

Flat-bed Imagesetter

In flat-bed imagesetters the material lies flat in the machine during exposure. This allows a simply constructed exposure table and substrate holder. As the format of the total area to be exposed increases, the optical system required becomes more complex in order to guarantee the exact placing of the pixels at constant spot diameter on each part of the exposure area. Flat-bed imagesetters are renowned for their robust construction, high reliability and throughput for small to medium formats, which makes them particularly suitable for the newspaper sector.

Capstan Imagesetter

It processes media in a roll that is transported by rollers and wraps itself around a capstan roller that moves the media during exposure. Optical elements guide the laser beam along a surface line on the capstan roller across the total width of the film. The laser beam and movement of the film are synchronized such that exposure takes place line by line to build up a complete page/image. The capstan imagesetter is therefore similar to the flatbed imagesetter as exposure takes place line by line and the lines are straight. The use of material in a roll and the special transport mechanism mean that in principle there is no limit to the length of the film format to be exposed, giving this type of imagesetter a wide range of formats, which distinguishes it from other imagesetters.

The quality achieved depends on the precise synchronization between the film advance and the deflection of the laser beam and has a direct effect on the distance between the lines and pixels. Lack of synchronization leads to banding, shapes not forming part of the image, and register difficulties with process colors. Such faults in synchronization are particularly prone to occur when the operator interrupts the exposure in the middle of the text or image.

In general, imaging occurs only in the scan direction (not in reverse) and with the film transported via step motors. Sophisticated devices are able to reproduce colors absolutely accurately even in a stop-and-go mode (i.e., the film exposure for multicolor, screened images of the individual color separations meet the required register quality). A further criterion for quality is the precise reproduction of the exposure spot at the film edges; this is achieved by optical means (beam correction using special lenses).

External Drum Imagesetter

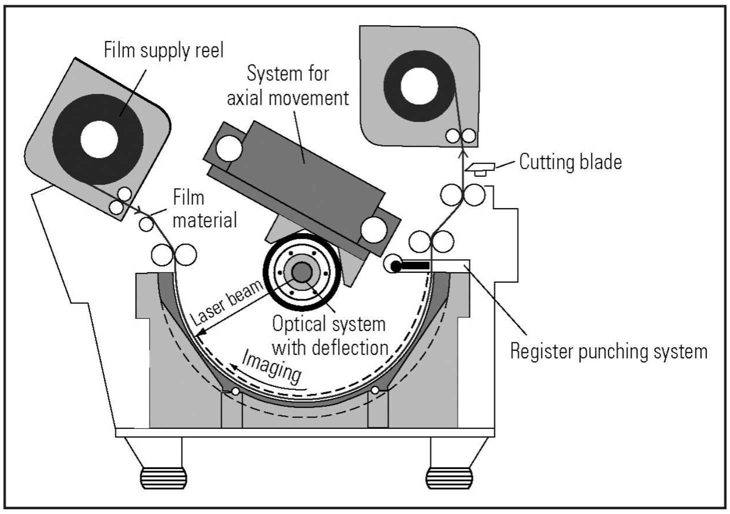
The carrier for the material to be exposed is a drum. During the exposure process this rotates at high speed. The laser beam is guided slowly along the axis of the drum so that the exposure trace covers the drum surface in a uniform way similar to the thread of a screw. For this principle, too, the quality depends on the precise synchronization of the two motions together with the exposure frequency.

Particularly good scanning quality is achieved if the laser beam is directed across the drum step-wise so that it is advanced along the axis by one pixel distance after each rotation of the drum and then stops during one complete rotation (this is, therefore, a ring-like and not screw-like exposure).

Simple function and the short, constant optical path of the laser beam render the best exposure quality compared to the other types of imagesetters.

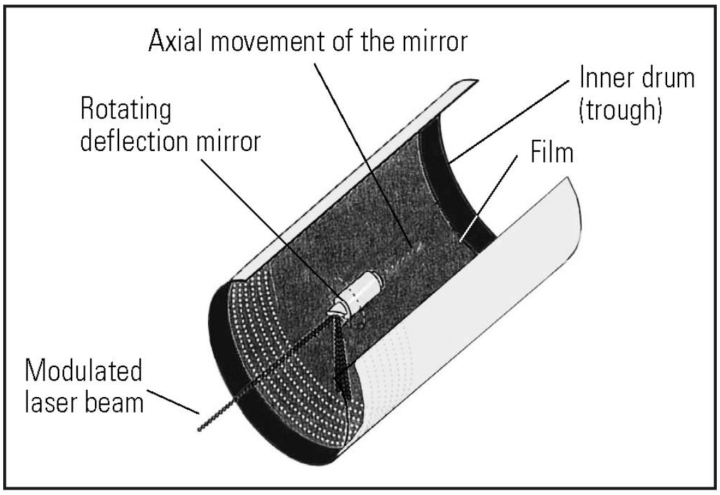
Working Principles of Internal Drum Film Imagesetter

Internal drum imagesetters also work mostly with material in a roll that is inserted and held in a trough in the shape of a segment of a hollow cylinder for exposure. The material does not move during the exposure process. Depending on the design of the imagesetter the trough consists of an internal drum segment of approximately 180° to 270°. The laser beam is directed precisely along the axis of the hollow cylinder and is deflected at right angles by a mirror or prism rotating at high speed around the axis projecting from within onto the surface of the cylinder casing. The deflector rotates at up to 30000 rpm so that the whole surface of the film can be exposed in a short time if there is synchronization of movement along the axis.



Structure of the Internal Drum Film Imagesetter (Quasar, Heidelberg)

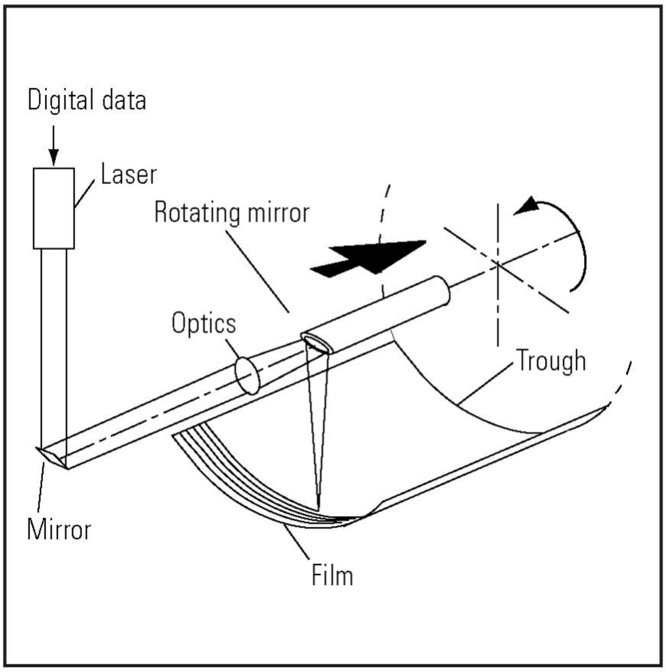
In general laser light sources are moved along the trough axis together with the optical system.



Internal Drum Film Imagesetter (AGFA)

The advantage of an internal drum is that the moving parts of the optical system have a relatively small mass and can therefore rotate at a very high speed and be moved quickly along the axis.

Internal drum imagesetters work mostly with one laser beam, while external drum imagesetters generally image using several beams simultaneously.

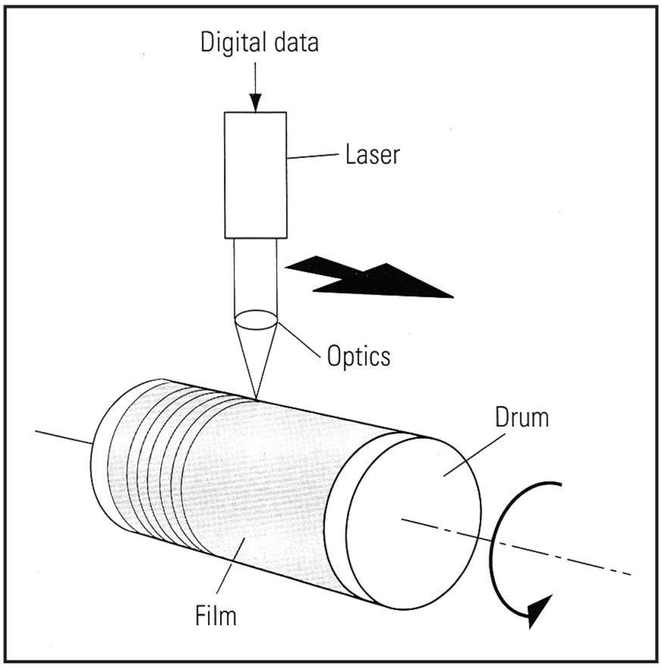


Internal drum imagesetter; the film is held in a cylindrical trough

Working Principles of External Drum Film Imagesetters

The construction principles are shown in figure.

The underlying concept of *external drum imagesetters* is based on the fundamental technologies of scanners/imagesetters that were already being used earlier for color separations. In a drum imagesetter the material is placed around (external drum) or inside a concave curved surface (internal drum, trough).



External drum imagesetter; the film is fastened over the drum

The optical system of an *internal drum* imagesetter is located inside the drum.As with the external drum principle the reflected laser beam is at a constant distance to the film throughout the entire exposure process. In a typical construction the laser beam is directed onto a mirror rotating about the central axis of the drum. This means the optical system moves along the axis and records one line after another.

In the *external drum* system the optical system is located on the outside of the rotating drum. The drum with the film revolves past the optical system, which records one line after another and is itself guided along the axis.

Drum imagesetters are able to transport the recording material in two ways: either with a feeder device from a roll of film or by placing cut film manually. The photographic material must be placed accurately in position and held in exactly the right place over its total area. It is particularly important that the material is evenly attached and fits the contour of the drum exactly, usually via a vacuum system.

There are large differences in quality and precision between the devices that are currently available on the market and the choice should be based on the application. In general, drum imagesetters are used in production intensive environments where predominantly color separations have to be produced.

The productivity of imagesetters (imaged area per minute) depends not only on their individual mechanical optical features but also on the specifications of the preceding RIP.

Capstan Film Imagesetters

Capstan imagesetters were developed from photosetting units. The first PostScript imagesetters were basically photosetting devices combined with PostScript RIPs. This resulted in the early models having tolerances that were sufficient for black-and-white photosetting but not for color work.

In a capstan imagesetter a film is pulled from the supply roll along a fixed rail, around the capstan roller, and past the optical system of the imagesetter. A critical factor is the precision with which the film is transported from scan line to scan line in order to be imaged line by line by the laser beam. Contrary to the way the material is transported by drum imagesetters, the capstan transport system is continuous.Factors such as the tension of the material are critical because they may cause extremely small variations in the positioning of the material and thereby losses in quality.

The transport system is the most critical component of a capstan imagesetter. In the early imagesetters stepper motors were used to transport the material from one imaging line to the next. A stepper motor normally works on a start/stop principle. The stepper motor transports the recording material to the next imaging line, stops until the imaging line has been recorded, and then continues moving the web to the next imaging line. This starting and stopping causes variations in torque that can lead to vibrations that reduce quality. In addition, each stepwise switching limits the speed at which the recording material can be transported.

There are systems with continuous film transport in use today that have highly precise synchronization between the laser beam and movement of the film. Even though drum imagesetters still offer advantages with respect to greater resolution (finer halftone screening) and productivity, capstan imagesetters are today capable of producing colored pages with high resolution that satisfy the quality demands of many applications.

Expansion of Film Imagesetter Equipment

The differences between individual models of imagesetters on the market concern mainly the range of resolution available, the recordable formats, speed, type of light source, and so on. It is only the areas of application that should still determine whether a film imagesetter works according to the capstan, or the internal or external drum principle. All three designs are fully developed. Capstan imagesetters, with which the spread of PostScript began, are renowned for their interesting price-performance ratio but are still only supplied by a few large companies. The market is clearly dominated by internal drum systems, which make up far in excess of half the products and installations available. External drum devices (with multi-beam imaging systems) are used predominantly for imaging large format films at high production speeds.

Computer to Plate Systems

Computer to plate systems also work according to the internal and external drum construction principles described above as well as the flatbed principle (similar to capstan recording). The vast majority of computer to plate units use external drum systems. The state of the art is the use of thermally imageable plates (laser wavelength around 830 nm), which can be handled in daylight and do not require a special UV protected room as is the case with conventional plates. Capstan imagesetters are only used for computer to plate applications in combination with polyester-based printing films (the recording material must be processable from a roll). A detailed explanation of computer to plate systems technology. The following section will therefore look more closely at workflow when using digital imaging systems.

Computer to Film and Computer to Plate in the Prepress Workflow

If CtF or CtP systems can be directly compared due to their technical specifications, the workflow concepts of the individual manufacturers are considerably more difficult to compare. The workflows should therefore be very closely analyzed and the larger the imagesetter format, the more carefully they should be scrutinized, since the more pages there are on the sheet the larger the quantity of data to be transferred, processed, and archived. This all increases the need to organize an efficient and secure flow of data.

The use of computer to film and especially computer to plate is something for the future. It is virtually beyond a doubt that computer to plate is superior to the conventional production method, but there are still a number of technical and organizational problems to be overcome before film can be discarded on a large scale for producing printing plates.

When considering the possibilities of rationalization, large format film imagesetters and CtP systems offer the possibility of offsetting the large cost factor, namely manual sheet make-up. The difference is that a film imagesetter means considerably less expenditure, allows flexibility with respect to the plate material, and can easily process originals that are not fully digital. Besides this, it is still easier to carry out a final check and last minute corrections as well as postexposure of individual printing plates, and it is also possible to manage the induction of employees in to computer to film without a great deal of retraining as the first step towards digitization of the production process. A benefit of CtP is that another processing step, namely photographic platemaking (plate exposing via the film), becomes obsolete and direct imaging of the plate leads to an obvious increase in quality.

Therefore it is often recommended that printing houses that are about to set up their own digital prepress start with a large format film imagesetter so that they can more easily move to CtP recording after they have gained experience with digital production. Benefits of this way of working are not only the lower entry and running costs but also the advantage of being able to work with familiar plate materials.

Since computers work more accurately than humans, digitally imaged films and particularly imaged plates have a more accurate registration, which allows a reduction in print wastage as well as machine setup times.

4.3.3 - AUTOMATIC FILM PROCESSORS:

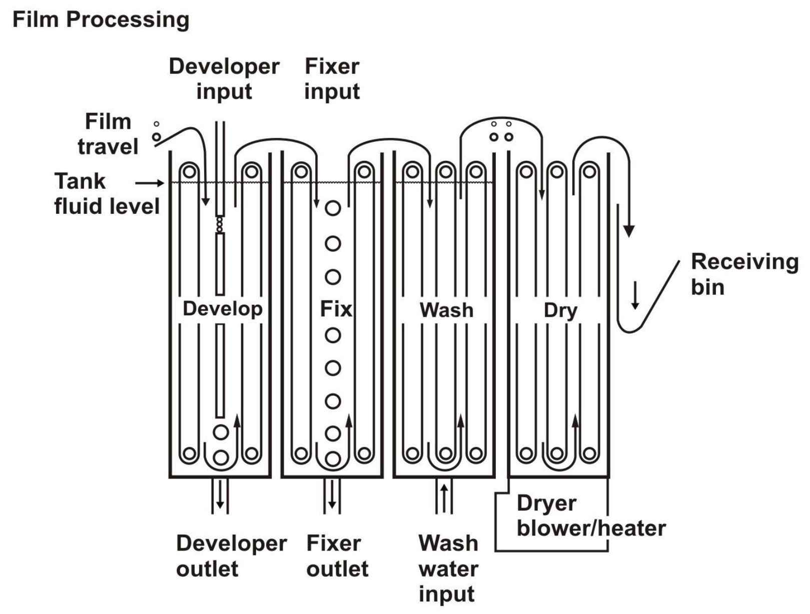


Figure: Side view diagram of a typical automatic film processor. Rollers move the film from tank to tank.

An automatic processor automatically develops, fixes, washes and dries large volumes of exposed photographic material with very little operator time required. Automatic processor reduce the man power, improves reproduction quality and standardizes processing procedures. These machines contain the photographic processing and washing solutions. Exposed films are transported through the developing, fixing and washing solutions and delivered after being dried by warm air. Total processing time varies depending on the photographic material, processing solution and processor used. The developing time and the temperature and amount of developer agitation are controlled.

In most automatic processors, the photographic material is carried by rollers through the processing solutions. Rollers transport sheet or roll film through the machine. The photographic material is carried through the processing solutions by rollers that contact both sides of the material. The rollers are arranged in racks for easy removal and cleaning. Advantages and limitations of rollers-transport processors are:

(i) Any length of roll material can be handled.
(ii) Less space required for the feed table of the processor in the darkroom.
(iii) Exposed film directly sent to processor.
(iv) Time reduction- processors can complete a sheet of film in four to six minutes.
(v) Cost reduction – avoids exhaustion of developer, since air contact is less.
(vi) Negative of consistent quality can be produced.
(vii) Special resin coated films are used for automatic processing to withstand rollers and high temperature.
(viii) Grain size must be greater than usual.
(ix) Racks are heavy and require special system for removal.
(x) Cross-over of material may cause the processing solution to become contaminated.
(xi) Daily machine check-ups and routine maintenance helps good photographic reproduction.

<u>Types of Automatic Film Processor:</u>

There are three basic types of processors: Lithtype, contact, and rapid access processors. These types are similar physically and mechanically, but vary according to length of processing time, processing solution, and photographic material processed.

- The Lithtype processor is designed to automatically develop, fix wash and dry, high-contrast material. The speed of a litho-type processor varies from about 4 to 6 minutes.
- Contact processor is designed to process high-contrast film used in contact printing. A contact processor delivers processed contact film in less than 2 minutes.
- A rapid-access processor is used for line and contact negatives and positives. This processor reproduce less density and deliver processed material in 90 seconds. An advantage of rapid-access processing is the high stability of the chemicals used. The disadvantages of rapid-access processors are less exposure latitude, lower maximum film density because of very short developing time (less than 90 seconds) and higher chemicals.

UNIT – IV - FILM PROCESSING

PART – A ***2 Mark Questions***

1. State the types of films based on light sensitivity.

Types of films based on **Color sensitivity** - Orthochromatic, Panchromatic and blue-sensitive films.

2. What do you mean by film contrast?

The tonal differences between highlight and shadow areas of an image represent its contrast.

High-contrast graphic arts film is referred to as lith-type film.

Continuous - tone graphic arts film is of lower contrast than the lith-type film.

3. What is film speed?

Film speed is a term describing the film's time response to exposures. A film may be fast or slow, depending on the amount of light required to expose it purposely. A film that requires intense or long exposure is considered to be a slow film. The films used in graphic arts are in this category.

4. Define film contrast.

The tonal differences between highlight and shadow areas of an image represent its contrast.

High-contrast graphic arts film is referred to as lith-type film.

Continuous - tone graphic arts film is of lower contrast than the lith-type film.

5. State the purpose of stop bath in film processing.

After a negative or print has been developed, it is usual to rinse it in clean water for a minute to stop the development action before transferring it to the fixing bath. A solution of 2-5% acid or citric acid, or potassium meta-bisulphite is commonly used for this purpose.

6. What is the necessity of fixing stage in the film processing?

After the development is stopped, the image on the film is made visible, but they are not permanent. The fixing bath is used to remove any remaining unexposed salts and to make the image permanent.

7. What is CTF technology?

Computer to film technology (CTF) is the direct imaging of films from the digital image data. CTF Technology uses Film Imagesetter and Raster Image Processor (RIP) for film imaging.

8. State the purpose of RIP in Computer to Film technology.

A RIP operates by transforming the front-end instructions from the host DTP / EPC system, which are stored in PostScript language, into a 'digestible' bitmap form of managed data the output device can understand and utilise.

9. What are the different types of CTF technology?

Types of CTF Technology

i) Capstan (Flatbed) CTF Technology

ii) Drum CTF Technology

a) Internal Drum CTF Technology

b) External Drum CTF Technology

10. Expand CTPP.

CTPP - Computer to Polyester Plate.

PART – B ***3 Mark Questions***

1. State the different layers of photographic film.

- Antistress layer
- Emulsion layer
- Base material
- Substratum layer
- Antihalation backing layer

2. Explain Film sensitivity.

Silver-based emulsions have colour sensitivity, meaning that they are sensitive to specific colour or colours of light. Normally, the sensitivity of silver halide emulsions is limited to the ultraviolet, blue violet, and blue regions of the spectrum. To extend the colour sensitivity of the emulsion, dyes must be added. The resulting differences in colour sensitivity become three emulsion types: blue-sensitive, orthochromatic, and panchromatic.

3. Define film speed. State the factors which influence film speed.

Film speed is a term describing the film's time response to exposures. A film may be fast or slow, depending on the amount of light required to expose it purposely. A film that requires intense or long exposure is considered to be a slow film. The films used in graphic arts are in this category.

Two additional factors influence a film's speed: *the film's colour sensitivities and the light source used for exposure.* Blue-sensitive film will be slower when a tungsten light source is used than if exposed with a pulsed xenon lamp because tungsten light contains far less blue light than the pulsed-xenon. Two films of different colour sensitivity will also differ in speed exposed by the same light source. Thus, panchromatic film is faster than blue-sensitive film when exposed to a tungsten light because the pan film is also affected by the green, yellow, and red light present in the light source.

4. What are the ingredients of a developer solution?

The developing solution consists of:

1. A solvent, such as water.
2. A developing or reducing agent, such as metol or hydroquinone.

3. A preservative, such as sodium sulfite.
4. A restrainer, such as potassium bromide.
5. An accelerator or alkali, such as sodium hydroxide.
6. Miscellaneous additives.

5. State the different stages in film processing.

Manual film processing involves the following steps:

1) Developing
2) Stop Bathing
3) Fixing
4) Washing
5) Drying

6. Write notes on film processing trays.

<u>Processing Trays</u>

A processing tray is an open-top container that holds one of the solutions used to process photographic materials. One tray is used for each processing solution. Processing trays are sized slightly larger than a specific, standard film size. Keep developing trays in all the standard film size to be used. Generally, two trays for each film size, in addition to the stop bath and fixing bath trays are needed in every dark room.

Processing trays are made of many materials including stainless steel, enamel, hard rubber, plastic and glass. Because glass trays are easily broken, their use is limited. Stainless steel is the best material. Trays are either transparent or opaque. A transparent tray has a major advantage over an opaque tray. By being transparent, it can easily be illuminated by a correctly positioned safelight. This aids in the visual inspection of the material while it is being processed in the tray.

7. State the advantages of Automatic film processing.

An automatic processor automatically develops, fixes, washes and dries large volumes of exposed photographic material with very little operator time required. Automatic processor reduce the man power, improves reproduction quality and standardizes processing procedures.

1) Any length of roll material can be handled.
2) Less space required for the feed table of the processor in the darkroom.
3) Exposed film directly sent to processor.
4) Time reduction- processors can complete a sheet of film in four to six minutes.
5) Cost reduction – avoids exhaustion of developer, since air contact is less.
6) Negative of consistent quality can be produced.

8. What are the components of CTF workflow?

1. Computer system for pagination & designing & Imposition
2. RIP (Raster Image Processor)
3. Film Imagesetter
4. Automatic Film Processor.

9. State the different types of film imagesetters.

i) Capston (Flatbed) Imagesetter.

ii) Drum Imagesetter.

a) Internal Drum Imagesetter.

b) External Drum Imagesetter.

10. Write notes on flat bed film imagesetters.

Flat-bed Imagesetter In flat-bed imagesetters the material lies flat in the machine during exposure. This allows a simply constructed exposure table and substrate holder. As the format of the total area to be exposed increases, the optical system required becomes more complex in order to guarantee the exact placing of the pixels at constant spot diameter on each part of the exposure area. Flat-bed imagesetters are renowned for their robust construction, high reliability and throughput for small to medium formats, which makes them particularly suitable for the newspaper sector.

PART – C ***10 Marks***
Questions

1. Explain the structure of photographic film with necessary sketches. Define film speed.
2. Describe the different types of films and their characteristics.
3. Explain the automatic film processor with necessary diagrams.
4. Describe the Computer to Film Workflow.
5. Explain the working principles of internal drum film imagesetter with necessary sketches.
6. Describe the working principles of external drum film imagesetter with the diagrams.
7. Write notes on (i) Film processing chemicals, (ii) Advantages of CTF technology.
8. Describe briefly the various stages in film processing.
9. Describe the Computer to Film Workflow and describe the working principles of external drum film imagesetter with the diagrams.
10. Write the different photographic chemicals used for developing. Explain their characteristics.

GLOSSARY

Color proofs: Simulations of eventual output of a reproduction device. Because it is costly to proof in a press, a number of methods are used to proof offline. In digital printing, a proof is a run of one.

Developer: In photography, the chemical agent and process used to render photographic images visible after exposure to light. In lithographic plate making, the material used to remove the unexposed coating.

Digital color proof: A color proof produced from digital data without the need for separation films.

Imagesetters: In digital imaging, a generic term that applies to film – output devices for type and graphics. A device used to output fully paginated text and graphic images at a high resolution onto photographic film, paper, or plates.

Imposition: In image assembly, the positioning of pages on a signature so that after printing, folding, and cutting, all pages will appear in the proper sequence.

INTERFACE The electronic device that enables one kind of equipment to communicate with or control another.

Laser: (Light Amplification by Stimulated Emission of Radiation) - The laser is a high energy, intense light beam with very narrow bandwidth used in digital-imaging devices to produce images by electronic impulses from computer to facsimile transmission.

Page makeup: In stripping, assembly of all elements to make up a page, In digital imaging, the electronic assembly of all page elements to compose a complete page with type, graphics, images and color in place on a display screen for output to plate or printer.

PAGE LAYOUT A dummy indicating page size; trimmed job size; top, outside, and foot trims; untrimmed page size; and head, foot, outside, and bind margins.

Pagination: In computerized typesetting, the process of performing page makeup automatically.

PROCESSOR An automatic device that feeds exposed photosensitive paper or film over rollers through baths to develop and dry them before they reach the delivery area.

RASTER An image composed of a set of horizontal scan lines that are formed sequentially by writing each line following the previous line, particularly on a television screen or computer monitor.

RASTER IMAGE PROCESSOR (RIP) The device that interprets all of the page layout information for the marking engine of the image setter. PostScript or another page description language serves as an interface between the page layout workstation and the RIP.

RESOLUTION The precision with which an optical, photographic, or photomechanical system can render visual image detail. Resolution is a measure of image sharpness or the performance of an optical system.

Server: A file server provides file data interchange between compatible peripheral devices on a local area network. Servers are identified by the type of resource they provide (e.g., disk server, file server, file server, printer server, communications server).

SILVER HALIDE A silver salt suspended in gelatin to prepare the emulsion of photographic film.

Stripping: In image assembly, the positioning of film negatives (or positives) on a flat to compose a page or imposed layout for plate making.

UNIT - V - PLATES PROCESSING

INTRODUCTION

Platemaking demonstrates that oil and water, generally, do not mix. A lithographic plate must consist of two kinds of areas: the printing areas, which accept ink and repel water; and the nonprinting areas, which accept water and, thus, repel ink. The wider the difference between the ink-receptivity of the image areas and the water-receptivity of the nonimage areas, the better the plate will print and the easier it will run on the press.

5.1 MAIN TYPES OF LITHOGRAPHIC PLATES

There are various ways of putting an ink-receptive image onto a lithographic plate. Plates are generally classified according to the method used.

i. Original plates

Original plates are plates on which the artist has drawn an image with a greasy crayon or a special ink called tusche. The artist may also apply a mechanical dot pattern, or benday, with a greasy ink. This technique provides a method for creating various tone values. Most original plates were on stone. The modern “direct-image” plates are, strickly speaking, original plates. Direct-image plates are seldom used today. The remaining direct-image plates are paper plates used mostly on duplicators.

ii. Hand Transfer Plates

When two or more identical images were to be printed from the same plate, the artist did not draw the same image two or more times. Instead, a single design was drawn from which the required number of ink impressions were duplicated on hand-transfer paper. Hand-transfer paper is coated on one side with a gummy or gelatinous layer. The duplicate transfers were then laid face down in the proper positions on a new plate, and their ink images were pressed against the plate. After soaking in water, the transfer paper was then removed, leaving the inked images on the plate. This procedure was used for the first metal lithographic plates.

iii. Contemporary Lithographic Plates

Original and hand-transfer plates are practically obsolete today. They have been replaced by photomechanical plates imaged from negative or positive lith film. Direct-image plates are in current use, but only for special uses as in duplicating.

THE PHOTOMECHANICAL PRINCIPLE

A photolithographic plate is a metal, paper, or plastic plate that is cleaned, treated, and coated with a thin film of light-sensitive, ink-receptive material, and then dried. Lithographic plates are classified as: ***presensitized plates***, which are coated by the manufacturer, and ***wipe-on plates***, which are coated by the printer. A photolithographic plate may be exposed through negative (negative-working plate) or positive (positive-working plate) lith film.

For a ***negative-working plate***, the coating is soluble in some solvent, such as water, but becomes insoluble after it is exposed to light. A negative of the image is placed in close contact over the coated plate, usually under vacuum, and exposed to a controlled light source. Light goes through transparent areas of the negative and polymerizes (hardens) the plate coating, making it insoluble. Where the coating is covered by the opaque parts of the negative, light is blocked and the unexposed coating remains soluble. After being exposed with light, the plate is developed by rubbing developer over it. Developer removes the unexposed coating from the water-receptive nonimage areas. The exposed coating is ink receptive and provides the printing image.

For ***positive-working presensitized plates***, the nonimage areas are solubilized, or depolymerized, by light. Exposed areas are thus soluble; unexposed areas remain insoluble in the developer and become the printing image.

THE MAIN TYPES OF CONTEMPORARY PLATES

Lithographic plates are mainly divided into four groups: **surface plates** (both presensitized and wipe-on, or consumer-coated); **deep-etch plates ; bimetal plates; and direct-image, photo-direct, and electrostatic plates**. Deep-etch plate is now obsolete. Made from positives, deep-etch plates used a light-sensitive coating as a stencil to protect nonimage areas while the printing image was etched into the metal plate. After the image was produced, the stencil was removed.

i. Surface plates

On all surface plates, the light-sensitive coating becomes the printing image.

Presensitized plates provide the ultimate in simplicity for platemaking. Presensitized plates are named as such because they are sensitized by the manufacturer. They generally remain sensitive for one year or more. Presensitized plates consist of a thin film of light-sensitive material, usually a diazo compound or photopolymer, that is coated on a specially treated aluminum, plastic, or paper base material. Photopolymer coatings consist of polymers and photo-sensitizers that react (cross-link) during exposure to light to produce a tough, long-wearing image area. Diazo coatings also react with light to produce a tough, long-wearing image area. The exposed coatings require special organic or aqueous solvents for processing. Both negative and positive plates are available with diazo or photopolymer coatings.

Wipe-on plates are chemically similar to presensitized plates, but are coated with aqueous diazo coatings in the plateroom in a simple roller coater. A specially treated aluminum or anodized aluminum plate is used. Wipe-on coatings are thin and lack durability on press; special developers are required that contain lacquer or plastic that builds up on the image to greatly increase durability.

ii. Bimetal plates

Bimetal plates are excellent for exceptionally long runs and for printing with abrasive inks, papers, boards, or metal. All of the plates described previously were single-metal plates. Bimetal plates consist of two different metals, one for the image areas and the other for nonimage areas. The metals of bimetal plates are chosen so that the image metal is ink-receptive under the same conditions that render the nonimage metal water-receptive. All bimetal plates, in present use, have copper or brass as the image metal. The usual nonimage metals are aluminum, chromium, or stainless steel. When copper and chromium are used together, they are usually electroplated as layers on a third metal, such as aluminum, mild steel, or stainless steel. Such plates are often called trimetal or multimetal plates, even though the third or base plate metal takes no part in the formation of the printing image.

Most bimetal plates have the image metal electroplated over the nonimage metal, such as copper on stainless steel or copper on aluminum. These plates today are presensitized as either positive- or negative-working plates. It may seem that bimetal plates are actually relief plates since one metal is above the other. The top layer of metal is so thin that its thickness is usually measured in millionths of an inch. Thus, metal plates are true lithographic plates.

There may still be some bimetal plates on which the image metal is under the nonimage metal. Examples of image metals under nonimage metals include copper under chromium or brass under chromium. Bimetal plates are usually made from positives.

Bimetal plates are coated and developed much like surface plates. After development, the remaining coating is a resist protects he top metal when unwanted areas are etched to expose the lower image or nonimage metal.

iii. Plates for Duplicating machines

Offset duplicators are used to a limited extent in commercial printing for special jobs.

For their principal purposes, offset duplicators use a variety of plate types. These include paper, plastic, paper laminated to plastic, paper laminated to aluminum, and aluminum. Some are direct image plates on which the image can be produced by drawing, typewriting or printing. Most of the others are presensitized and are prepared by photographic means.

Commercial Printing Plates

Commercial printing plates are defined as plates for press sizes of 17" x 22" and larger. Such plates are mostly metal, usually aluminum, ranging in thickness from 0.012" to 0.025", depending on their size. For some of the older presses, the required thickness may be 0.030".

Besides metal, laminated plates are used to some extent in the smaller sizes where close colour register is not involved. Paper plates, in general, are not sufficiently stable dimensionally for multicolor work.

SELECTION OF THE PRINTING PLATE

The type of plate to be used for a particular job depends on the type of job, its quality requirements, and length of the run. For long runs, the cost of platemaking is not an important factor. But in shops that specialize in producing many small jobs and require many plate changes per day, platemaking expense is an important item. There is no point in making long-run plates for short runs if less expensive short-run plates will produce the required printing quality.

Surface plates of the bichromated albumin casein and types have been greatly improved in recent years. With modern platemaking techniques they give excellent results in runs of 150,000 or more. They can be regrained and used several times. For short runs with no halftones, a simplified and less expensive technique can be used.

Presensitized plates print with exceptionally high quality and have the advantage of convenience. They come already coated and ready for exposure, thus doing away with need for plate whirler. They are also unaffected by variations in relative humidity which sometimes complicate the making of albumin and casein plates. Presensitized plates are somewhat delicate, but with proper press adjustments are good for runs of 50,000 or more.

Wipe-on plates are somewhat less expensive than presensitized plates, but have to be coated by the platemaker prior to exposure. Coating is not a problem, however, and can be done by hand or with a roller. Once coated, wipe-on plates have all the advantages of presensitized plates and, because of their thicker coating, are somewhat more durable. With proper handling, they are usually good for runs of 100,000.

Deep-etch plates, especially the copperized aluminum type, are preferred for runs up to 2,50,000 or more. They are more expensive to make than surface plates and require more knowledge and experience. They are capable of high quality printing in long runs.

Bimetal and trimetal plates, being electroplated with copper or copper and chromium, are the most expensive. But they produce high-quality printing and are usually good for a million or more impressions.

Direct-image, photo-direct, and electrostatic plates. These plates are generally used for offset duplicating or on small offset presses for short runs. Metal electrostatic plates are being used on larger presses for relatively long runs.

Direct-image plates are made of a specially coated paper that permits direct use of the plate in a typewriter with a special ribbon for applying the greasy printed image. Despite declining popularity, direct-image plates are still used in systems printing and in encoding cheques for magnetic Ink Character Recognition (MICR) sorting.

Photo-direct plates can be produced directly in either camera or projection types of equipment. Projection plates are an easy way of making printing plates directly from a good copy in about one minute. Projection plates eliminate the intermediate step of making a photographic negative. The printing image can be an enlargement or reduction of the original.

Electrostatic plates are made with the Xerographic and Electrofax processes. Most electrostatic plates are on zinc-oxide coated paper for duplicator work up to 10,000 impressions. Metal plates are usually made by the Xerographic or transfer process using organic photoconductors and are used for newspaper-qualityjobs with run lengths in excess of 1,00,000 impressions.

5.2 FACILITIES, EQUIPMENTS & MATERIALS USED IN PLATEMAKING DEPARTMENT

I. FACILITIES IN PLATEMAKING DEPARTMENT

The platemaking room should be air-conditioned and wellventilated to remove fumes from chemicals and evaporation of lacquer, alcohol, and other solvents. The room should be large enough to provide space for all equipment.

Hot and cold water supply

The plate room should be situated so that ample supplies of hot and cold running water are readily available. Water temperature as high as 120oF (50oC) is occasionally needed. Some plate problems (even plate failures with some processes) have been found out due to the an insufficient supply of hot water.

Illumination

Room lighting is also important. Plate coatings are sensitive to ultraviolet and blue light. When coated plates are being handled, they should not be exposed to any stray blue, white, or ultraviolet light. Direct daylight or sunlight should be blocked, or filtered, by fastening yellow or orange plastic sheets over the windows. Yellow bulbs or fluorescent tubes serve as suitable safelights for most plate rooms without sacrificing viewing conditions. Regular white lights should be wired to a separate switch.

Air Conditioning

An air conditioning system should have provisions for controlling both temperature and relative humidity. Good conditions are $75^{o} \pm 3^{o}$F ($24^{o} \pm 2^{o}$C) and 45% ± 5% RH in the United States and Canada. Air conditioning is preferred because both plates and films can change size with temperature changes before and during exposure. Dimensional stability of film is extremely important for color separation in the camera, scanning, stripping, and platemaking operations. Therefore, all four areas should be at the same atmospheric conditions for optimum register or fit of images on the plates.

Platemaking Sinks

Sinks for platemaking are generally made of stainless steel, plastic, or plastic-covered wood or steel. If stainless-steel sinks are used, the steel should be a good grade of 18-8 stainless steel with a high-gloss finish. Polished surfaces resist corrosion much better than rough surfaces. Wood, plywood, or steel sinks that are covered with fiberglass or polyvinyl chloride materials are also satisfactory.

The sink should be approximately 1 ft. (305 mm) larger in each dimension than the largest plate used. A flat platform to support the plate should cover most of the area inside the sink. The platform should be about 3 in. (76 mm) below the rim of the sink, and should slope toward the sink drain.

II. EQUIPMENTS IN PLATEMAKING DEPARTMENT

i. Whirlers

Plate whirlers are gradually going into disuse as a result of the increasing use of presensitized, wipe-on, and precoated plates. But whirlers are still needed for conventional deep-etch and bimetal plates, but the toxic bichromated coatings used in whirler coatings have been outlawed in many areas.

The plate whirler is designed to coat lithographic plates. The whirler is actually an oversized turntable. The plate is fastened or mounted on the turntable and the sensitized coating is poured on and centrifugally distributed over the plate while it is turning. The whirler usually has a positive variable-speed drive and accurate controls for setting and measuring whirler speed. The coating is dried by heat and/or forced air as the plate revolves.

There are two types of whirlers in general use-horizontal and vertical. The horizontal whirler distributes the coatig solely by the centrifugal force. The vertical whirler, which has the turntable placed at an angle of 15o to the perpendicular, distributes the coating by a combination of centrifugal force and gravity. The vertical whirler has the advantage of taking up less space. The horizontal whirler is better suited for coating frasile materials such as plastics and glass. Whirler should be equipped with thermostats to control inside temperatures.

ii. Roll Coaters

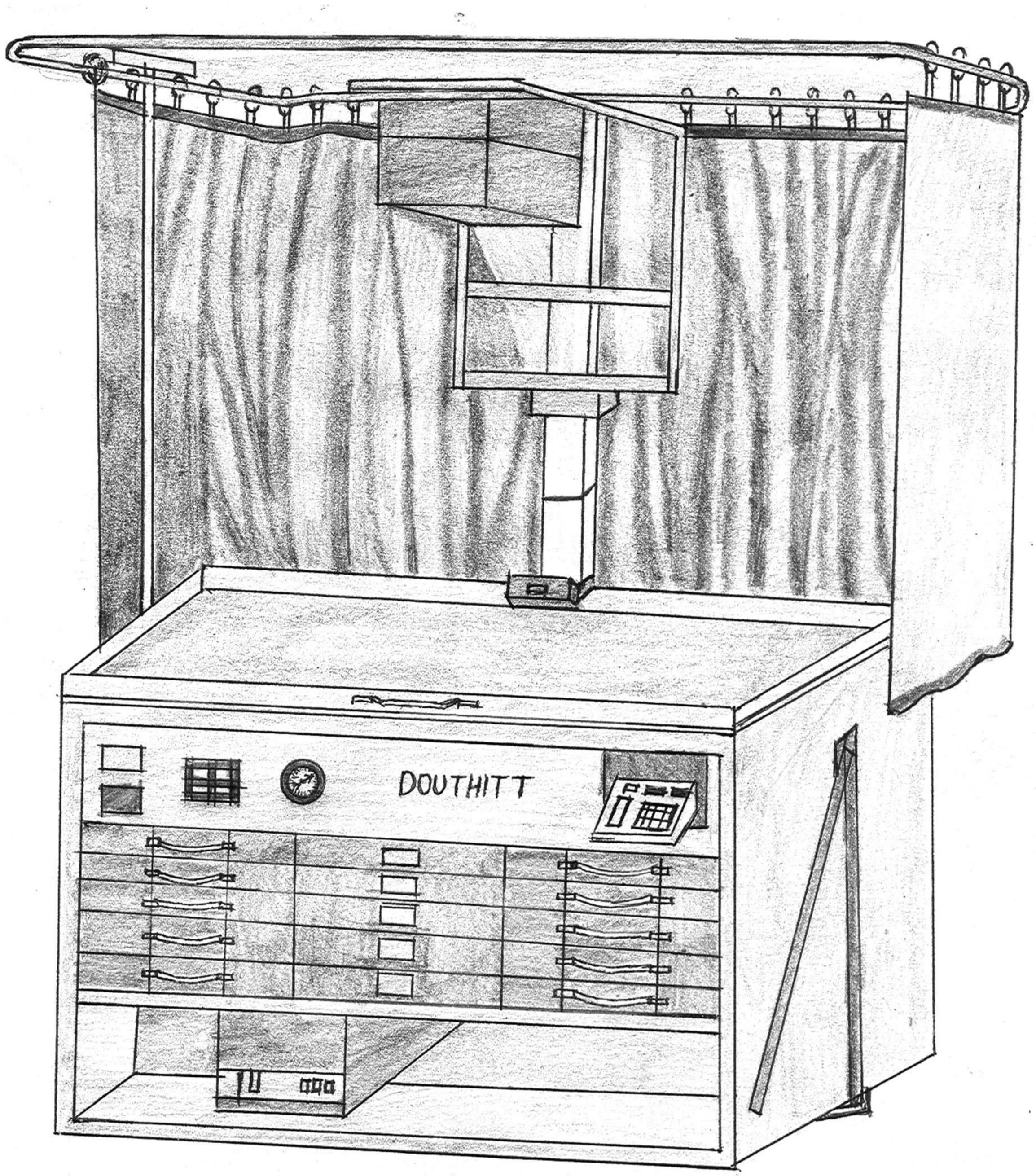
Simple two-roll coaters, with the coating pan under the lower roller, are used for coating wipe-on plates. The machine consists of two soft synthetic-rubber rollers mounted one over the other. The lower roller rotates partly submerged in a trough or pan containing the coating solution. The plate is passed face down between the rollers, and coating is transferred to the face of the plate. Most of the coating is squeezed off between the rollers. The upper roller is adjusted to maintain just enough pressure between rollers to uniformly squeeze off most of the coating. The coating air-dries very rapidly, but some coaters use heat or circulating air to dry plates. Coaters are effective, productive, and economical if a large number of plates need coating. However, it is not economical to roll-coat single plates.

iii. Vacuum Printing Frames

The vacuum printing frame holds the negative and plate in close contact during exposure. The frame consists of two metal frames; the bottom frame holds a corrugated or channeled rubber blanket with a rubber bead or gasket around its edges; the top frame contains a sheet of flawless plate glass. Smaller vacuum frames are usually hinged together on one side. The rubber blanket is connected to a vacuum pump by a flexible rubber tube. Special frames are used with glass on both sides, so plates and films can be put into the top side while exposing plates on the bottom side of the frame.

Operating the Vacuum Frame

When the printing frame is open, the blanket is horizontal and the glass is raised up out of the way. The sensitized plates laid on the blanket with the coated side up. the positive or negative, or a stripped-up flat, is laid on the plate in exact position, emulsion side down. The glass frame is lowered and the two frames are locked together. The vacuum pump is then turned on. The pump sucks the air from between the blanket and glass, thus forcing the sensitized plate and the negative or positive together. When this has been done give the necessary exposure. On a flip-top frame the glass is inverted through 180 Degree, since the exposing light is underneath.



Printing Down Frame

Making good contact

Good contact between the negative or positive and the plate is absolutely essential; otherwise undercutting or spreading of the light during exposure will occur. This is a serious problem with aluminum plates especially with the thin presensitized plates. To ensure good contact the frame must be checked periodically for air leaks. The reading on the vacuum gauge does not necessarily correspond to the actual vacuum in the frame, and a high reading on the gauge could still not indicate an air leak between the gasket and the glass.

The gaskets must be kept smooth and clean and replaced immediately if they dry out, crack, or chip.

Another way to insure good contact between the flat and the plate is to cover the flat and plate with a thin sheet of clear flexible plastic such as polythene. The plastic should be large enough to cover the gasket areas of the frame. When the frame is closed, the glass is above the plastic. The air is exhausted between the plastic flat and plate. Because the plastic is flexible it conforms to the irregularities in the thickness of the flat resulting in much better contact between the flat and the plate than is possible with glass alone.

Testing contact

An easy way to test the contact between the plate and the negative or positive in a vacuum frame or on a photocomposing machine is to illuminate the area to be checked with a pen flashlight. The light is held at a 45 Degree angle to the glass and the area examined with a magnifying glass. If there is enough vacuum for good contact, there will only by one image. If a sharp shadow appears along the side of each dot or line, the contact is poor and the exposure should not be started until the shadow disappears.

iv. Photocomposing machines

The photocomposing machine, sometimes called the step-and-repeat machine, is used for exposing lithographic plates or films. The machine produces a series of exposures in register on the same plate or on successive plates. The same precautions as described for conventional vacuum frames hold true for the photocomposing machine. The machines and operating procedures are described in Chapter 9, “Film Image Assembly.”

v. Exposure (LIGHT) Sources

A number of light systems are available for exposing litho-graphic plates. The following factors govern the choice of a good light source:

Spectral distribution: Most light-sensitive coatings are only sensitive to blue-violet and ultraviolet light. Diazo coatings are sensitive to blue-violet light of about 420 nm while most photopolymers are sensitive to UV light of about 350-370 nm. The light source used for exposure should have appreciable energy in the near-ultraviolet to blue (350-450 nm) part of the spectrum. Special *water-white glass* should be used on printing frames as this glass transmits more ultra-violet light than ordinary plate glass.

Light intensity: The stronger the light is the shorter the exposure time will be.

Point source versus diffuse source: A point source of light produces sharp shadows and reduces risks of undercutting. Diffuse light, or light from a broad source, can cause under-cutting, especially when there is insufficient vacuum or poor stripping.

Evenness of illumination over the exposure surface: Light intensity from a point source will vary from the center to the edges of the vacuum frame; but, this can be corrected some-what by reflector design. Place the light at a distance from the vacuum frame equivalent to the diagonal of the vacuum frame. A light meter can also be used to check light uniformity. Greater distances produce more uniform illumination; but, exposure time will be lengthened since light intensity varies inversely with the square of the distance.

Cleanliness: Dirt is a platemaker's worst enemy. A light source should be used that creates a minimal amount of dirt. Carbon arc lights are obsolete and should not be used. Where open-flame carbon arc lamps must be used, they should be vented to exhaust the carbon ash and noxious fumes generated.

Pulsed-xenon lamps: Pulsed-xenon lamps are high-pressure discharge (arc) lamps that are commonly used in process photography; however, they are not recommended for exposing plates because they are relatively weak in ultra-violet output.

Metal-halide lamps: Metal-halide lamps are mercury-vapor lamps with certain metallic compounds added. The diazo metal-halide lamps are particularly efficient for exposing diazo coatings; they also effectively expose photopolymer coatings. Dual-spectrum bulbs may be used to expose both coatings. For exposing plates, a metal-halide lamp gives about twice as much useful light as a conventional mercury vapor lamp, 21/2-3 times as much as a carbon arc lamp, and 4 times as much as a pulsed-xenon lamp, based on equal wattage.

Integrating light meters: Integrating light meters, or light integrators, for controlling platemaking exposures were used as early as 1940, but they did not come into general use until after World War II. Integrating meters control the exposure in terms of total light units reaching the plate. They integrate or cumulatively measure the light intensity with time, much like a water meter measurs water volume in cubic units regardless of its rate of flow. Then, most integrators turn off the light automatically, when the preset amount of light has reached the plate.

Light and power lines: All lights are influenced by line voltage variations. If voltage drops, the integrator will sense the loss of power and increase the exposure to compensate.

The integrator, however, will not sense the change in color or spectral distribution of light. From voltage variations that can cause major changes in exposure. In some areas, power companies have separate service lines for light and power. The voltage in the light line is usually more stable than the power line. If the plant has the option, the light source should be operated from the light line. The intensity of the light will not vary nearly as much as it will when the light source is supplied from the power line.

vi. Automatic Plate Processors

Equipment for automatically processing plates has come into almost universal use. Essential in high-volume situations, automatic processors increase productivity, improve consistency, and reduce chemical consumption. Automatic processors are most valuable where speed of production is vital, as in the case of web offset newspapers, which work on edition deadlines. Automatic processors reduce downtime and the number of makeovers from plate failures on press.

Some plate processors are designed for plates of specific manufacturers. Other processors are capable of processing plates from various manufacturers. Some processors are not adjustable and maintain standard conditions for a specialized situation.

Most plate processors are automated to the extent that they develop, desensitize, gum, and dry the plate. Chemistry is applied automatically and automatic replenishment is common; it may have continuous filtration and recirculation. A plate processor must be operated and maintained according to its manufacturer's instructions.

III. PLATEMAKING MATERIALS

The materials for litho plates consist of the metals used for the plates, the mixture of substances used for coating them, and the chemicals used for processing them.

Unlike letterpress, flexography, or gravure, in which the difference between image and nonimage area is achieved mechanically, lithography maintains this difference chemically by the principle that grease (ink) and water generally do not mix.

Lithographic Plate Metals

Today, most lithographic plates are thin metal sheets. Aluminum is the most common metal used. Bimetal and trimetal plates can be aluminum, stainless steel, mild steel, or brass.

Plates are usually the full size of the press cylinder and must be thin and flexible enough to wrap snugly around the cylinder. Aluminum thickness varies with press size. Standard thicknesses range from 0.0055 to 0.020 in. (0. 14 to 0.51 mm), and sizes go up to 59 x 78 in. (1.5 x 2.0 m).

Aluminum used for litho plates is a pure, high-quality alloy that is reduced to final thickness by cold rolling on smooth rolls. The coils of aluminum are carefully annealed to obtain the proper temper or hardness. They are then inspected to ensure that (1) they meet the required gauge tolerance; (2) they are flat; and (3) any side to be used for a printing surface is free from dents, scratches, and other surface defects.

Uniform thickness and flatness: Uniform thickness and flatness of plates are extremely important. Plates should not vary in thickness by more than ± 0.0005 in. (0.013 mm).

Flatness is important to ensure good register. Buckles or waves in the metal plate prevent it from lying flat on the photocomposing machine, the vacuum frame, or the press cylinder. Any movement of the buckle or wave results in misregister on multicolor work, or misfit where diecutting is involved. Buckles and waves are also a prime causes of metal fatigue and cracking on web presses. Vacuum backs on photocomposing machines are required when making plates for multicolor close-register work.

Graining or surface preparation of metal

Before a metal can be used as a base for a lithographic plate its surface must be properly prepared. This can be done by roughening the surface mechanically, or treating it chemically or electrolytically. If this is not done, the plate will not coat or perform properly in the lithographic process. The roughening process, weather it is done mechanically or chemically, is called graining. The only exceptions are anodizing and the chemical treatment used for pre-sensitized plates.

Graining: There are a number of mechanical methods for roughening a metal surface. They are “rotary tub” graining, “sandblasting”, “dry brush graining”, “wet brush graining”, and a combination of rotary tub and wet brush called “ball brush graining”.

Rotary tub graining is sometimes called ball graining, because it is done in a graining machine which consists of a tub with a rotary motion. Small steel marbles which are usually reject ball bearings are rotated over the surface of the plates. Water is added and then an abrasive material. The actual roughening is done by the abrasive. The character of the grain is determined by: (1) the hardness of the surface of the metal; (2)t he amount of water used; (3) the weight and uniformity of the marble load; (4) the nature, amount, and size of the abrasive, (5) the speed of the grainer. The problems with this type grain are inconsistency from plate to plate, scratchiness, dirt, and imbedded abrasive.

Sandblasting is used for roughening plates both for wipe-on and other platemaking process. The plates are mounted on a rotary drum and a dry abrasive is impinged on the surface at an angle to the plate at right angle to the direction of rotation of the plate. Nozzle wear can cause variations in grains with this method, and imbedded abrasive can also be a problem.

Dry Brush Graining is used for treating some plates prior to presensitizing. This can be done with brass or steel wire brushes. The main advantage is that dry brush graining can be done in line with the treating and coating of presensitized plates.

Wet brush graining takes a special machine in which the plates are fed on to a conveyor belt under nylon brushes and the graining is done with a mixture of pumice and water. Even with new aluminium plates, several passes through the machine are needed to get an evenly grained surface without indication of rolling- mill streaks. The grain is very fine and is usually too fine for good moisture control on larger presses.

Ball Brush Graining is a combination of rotary tub and wet brush graining. In this type of graining good depth is obtained in the tub graining operation and a fine, even texture is produced by the wet-brush technique. These plates have the texture for good quality printing and the depth for good moisture control on large presses.

Chemical and Electrochemical graining: Several methods of roughening plates chemically and electrochemically are in commercial use. They are used primarily for treating plates prior to coating in the manufacture of presensitized plates. The most widely used method is the electrochemical treatment of aluminium in a solution of hydrofluoric acid. This produces a fine grain which is used as a base for wipe-on and presensitized plates. It is also used as a preliminary treatment to anodizing.

Aluminium Anodizing: Aluminium anodizing is a process by which a very thin, uniform layer of extremely hard aluminium oxide is produced eletrolytically on the grained aluminium. This anodic layer has many extremely small pores, similar to a honey comb, that must be sealed before the photosensitive coating is applied. Hot solutions of sodium silicated are used for sealing, which makes the surface hard, inert to most chemicals abrasive resitant, and highly water-receptive.

Chemical Treatment: In addition to roughening the surface, chemical treatments are also needed for some processes, especially negative diazo presensitized plates.The diazo compounds for sensitizing these plates, which are ink receptive when exposed, will in themselves react with metals. The diazo compounds can only be used if the metals are specially treated to prevent or inhibit this reaction.

When positive presensitized diazo plates are made, special surface treatments are not necessary, although cleaning and usually some type of fine graining precedes the application of these positive working diazos.

Some comparisions of Positive - Working and Negative Working Plates

Costs: Plates made from negatives are almost always cheaper from the standpoint of labor and materials (especially film).

Dirt: Positive plates, films, and vacuum frames must be kept meticulously clean to keep dirt to a minimum. Positives that have been used over an extended period become marred and dirty, requiring excessive time to inspect plates and remove dirt after development. Many printers use burnout masks to cover all image areas while reexposing the plate. Negatives can be retouched by opaquing pinholes; there-fore, it is usually unnecessary to inspect and clean negative-working plates.

Photocomposing: Positive-working plates permit the operator to see the last exposed image. Positive-working plates permit white lettering in multicolor areas to be shot out in exact register by superimposing films.

Press performance: Most positive plates can be baked or thermally cured at high temperatures for longer press life. This cannot be done with most negative plates.

Positive-working plates sharpen while negative plates gain when compared to the film. Thus, positive-working plates have the capacity to carry excess ink and/or dampening solution and still print with reasonable sharpness.

Press Life: With the exception of bimetal negative plates and some photopolymer plates, the deep-etch or positive working plates, are completely acceptable for long-run jobs.

Sharpening: Positive plates can be sharpened by increase exposure. This allows more shadows to be open and help burn out cut lines and dirt specks. Highlight dots, however can disappear by increasing highlight contrast.

5.3. CHEMISTRY OF PLATEMAKING

The lithographic process is based on plate chemistry. Chemical reactions are involved in producing the image, which is then affected by light, wettability of the image areas by ink, and Wettability of the nonimage areas by water.

Control of the Platemaking

Good plates are essential for high-quality printing. With the increasing use of color and ever increasing quality demands, the successful (profitable) printer must know that plates are good before going to press. Therefore, Good platemaking procedures and accurate test objects are essential for high quality printing.

Plate sensitivity guide: The first sensitivity guide for platemaking was introduced in the 1940s. The sensitivity guide is a simple photographic measuring device that integrates the effect of many variables: the plate coating, its exposure, and development. As soon as the plate is developed, the guide indicates if the image areas are properly exposed and developed and if the nonprinting areas are likely to cause trouble.

A plate sensitivity guide is usually a narrow strip of a special transparent continuous-tone stepped gray scale. With one guide, there are twenty-one different density steps. These steps are numbered from 1 to 21, with the low numbers at the clear, or transparent end of the scale. With many guides, the density difference is about 0.15 between steps, and 0.30 between every other step. This means that the light transmission of every other step is cut in half or doubled, depending on whether the numbers increase or decrease. Step 7 on the scale has about one-half the light transmission of step 5, and step 4 lets through about twice as much light as step 6.

The plate sensitivity guide is stripped into the flat or onto the photocomposing machine glass. Any prominent place on the plate is satisfactory as long as all transparent or plastic sheets used over the plate also cover the sensitivity guide.

When surface plates are exposed and developed, a number of different steps of the guide will distinctly show. Ordinarily, on negative-working plates, solid step numbers 1 through 5 or 6 (on a twenty-one-step guide) indicate proper exposure and development for maximum run length. If step 5 is the highest-numbered solid step, steps 6, 7, and 8 (and perhaps more) will be scummy or retain decreasing amounts of coating as the numbers increase.

On negative-working plates, the highest-numbered solid step is the critical step. On positive plates, the lowest- numbered clear or clean step is the critical step. With the same exposure, the position of the critical step changes when the sensitivity of the coating changes or when the amount of dark reaction, or development changes. Almost all plate manufacturers specify the critical step required for best plate performance. On negative-working plates, exposures must be long enough to harden the coating for good image durability even though dot gain increases with higher guide numbers. On positive-working plates, exposure does not influence plate durability so plate images can be sharpened by overexposing the plate.

A plate sensitivity guide is the most important test object the platemaker has. With this device, the platemaker can monitor the entire platemaking process to ensure consistent image fidelity and maximum trouble-free press life. The guide indicates when a change in coating sensitivity, exposure, or processing has occurred and how much of a change has taken place. However, a platemaker must rely on experience to determine the cause of the change.

Control of Tone Values in Platemaking

GATF Star Target. The GATF Star Target is a small wheel-shaped design (5/8-in. or 10mm diameters containing 36 wedge-shaped spokes that radiate from the center of the target. Because of its design, it quickly indicates:

Dot gain: Slight thickening of the image causes the tips of the spokes to join together to produce a solid hub in the target center. Thickening may be caused by poor vacuum frame contact, overexposure of negative-working plates, or overdevelopment of deep-etch and multimetal plates.

Dot loss: Slight sharpening of the image causes the tips of the spokes in the target center to break down, giving a visual impression of a white spot. Image sharpening may be caused by poor vacuum frame contact or overexposure of positive-working plates.

The actual amount of spreading or sharpening is magnified 23 times. A magnifying glass or microscope with calibrated reticle must be used if numerical values are to b obtained. With experience, platemakers and press operator can learn to evaluate dot gain or sharpening from original Star Targets.

The GATF Dot Gain Scale II: This small target consists of number of squares and circles or dots. When the edges of the dot expand to touch the squares, the percent midtone dot gain will be shown under that specific image. This target can be used to measure dot gains of 1, 2, 5, 10, I 5, 20, and 3 0% on both plates and prints. It can be included in the image area unobtrusively or hidden in a center fold.

UGRA Plate Control Wedge: This test object contains a sensitivity guide, positive and negative microlines from 4 to 70 microns, halftone dots from 1/2% to 99 1/2%, and a slur target-all in one 6 7/16 x 9/16in. (175 x 14mm) test object. Dot values are accurate in 10% increments from 10-90% so it can be used for plotting plate reproduction curves, determining reproduction characteristics of plates at different exposures, detecting slur or doubling, and determining dot gain or loss on both plates and prints.

It is an all-purpose test target that is unexcelled in any area. For optimum results, every high-quality printer should use this simple but thorough test object for evaluating lithographic plates, exposure conditions, plate development, and print quality.

UGRA PLATE CONTROL WEDGE

This is another multi-purpose quality control wedge that may be used for both negative and positive working plates. The wedge is divided into five sections, each section, responsible for monitoring differing reproductive characteristics.

Section 1 provides the indication of exposure variation. There are 10 steps of continuous tone, ranging from 0.15 to 1.50 in density. By consulting a chart test exposures may be accurately increased or decreased to provide optimum exposures.

Section 2 provides the means of assessing the dot shape and tone reproduction, visually or densitometrically. The computer drawn dots at 60 and 1201ines/cm are sharp and geometrically regular in shape.

Section 3, dot gain or loss is monitored by the manner in which the 10 circular patches are resolved at the platemaking stages. The critical geometric feature is the line width ranging from 3 to 69 micron. The space between the lines is exactly 4 times their width. Three variables that will result in circular line change when used on positive working plates are:

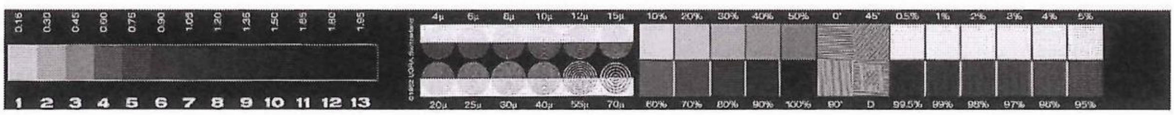
(a) undercutting by light.

(b) insufficient resolution power of the light sensitive coating.

(c) under/over development.

Section 4. Line patch. Designed to control an intentional undercutting by light. The 10 adjacent negative and positive lines range from 0.035 mm to 1.0 mm.

Section 5. Circular slur target. This aid visually amplifies the printing faults of “slur” and “doubling”. The target consists of concentric circles whose distance is equal to line width. Line thickening causes easily recognised patterns to occur in the target.



Control wedge for positive and negative-acting offset plates (Ugra Plate Control Wedge 1982, UGRA)

The GATF Dot Gain Scale: The GATF Dot Gain Scale contains numbers from 0 to 9 using 200-fine tints with graduated densities against a uniform 65-line tint. On the original film, the number “2” has the same background therefore it is invisible at normal reading distances. With dot gain on the plate (or prints) the fine 200-line screen dots gain more than the coarse 65-line dots, so progressively higher numbers become invisible with increasing dot gain. On positive-working plates, the number decreases since these plates sharpen. With good reproduction, the invisible number should never exceed 3 on negative-working plates or 1 on positive-working plates. The invisible number on high-fidelity prints will be around 5-7.

Since slur will always give higher readings, the Dot Gain Scale contains a section with horizontal and vertical lines that spell “SLUR” if there is slur or doubling on press. Although slur is, not a common plate problem, under unusual conditions, the vord “SLUR” may show up on the plate. Also, smooth plates may contribute to slur on press.

5.4.1 PRESENSITIZED PLATES :

Introduction

Presensitized plates are so called because they come already coated and are ready for exposure and processing when purchased. Presensitized plates are used for the making of one press plate if they are coated on one side, or for two press plates if they are coated on two sides. These plates are not regrained and coated again, but they can be stored after use for later reprinting of the same image.

Presensitized plastic coated plates were originated in Germany by Kalle and Company just prior to World War II. The base of the plate was plastic-coated paper. These early plates, and those which are now used, are coated with a diazo sensitizer. Such sensitizers are not affected as much by temperature and relative humidity as bichromated coatings, as long as temperatures do not exceed 120^{O}F (49^{O}C).

PS Plates - Graining or Plate Treatments

Presensitized aluminium plates are available with a variety of treatments. The earliest presensitized metal plates were made on aluminum with a chemically produced grain. Presensitized plates are available either with chemically, elctrochemically or mechanically produced grains. For longer runs, presensitized aluminium plates are usually grained and then electrochemically hardened.

After the plate is grained the surface is coated with sodium or potassium silicate or aluminium oxide (anodizing). This forms a barrier layer between the metal and diazo compound to prevent harmful reaction which would otherwise reduce its shelf life.

The type of grain on the plate surface is something which manufacturers do not appear to agree upon as different methods of graining are employed. The main aim is to produce a surface roughness which will increase the water-carrying properties of the plate, and provide an anchorage for the image material. Those who advocate a coarse grain for improved damping must concede a loss of image resolution especially in the reproduction of fine line and highlight half-tone dots. On the other hand, smooth surface plates which give high image resolution, may give damping problems on the press. A compromise between these two is necessary to provide a balance between the requirement of the platemaker and pressman.

The advantages of presensitized plates over whirler coated plates are listed bellow:

(i) Factory coated plates produced under controlled conditions result in standard sensitivity and thickness.

(ii) They are relatively unaffected by variations in humidity and temperature.

(iii) At least six month shelf life is expected with modern plates.

(iv) Plates may be purchased economically to suit a variety of requirements-negative or positive working plates, choice of plate substrate (paper or metal and choice of plate coating).

(v) The processing of presensitized plates is simple, requiring less craft skill than whirler coated plates and yielding consistent results.

(vi) Less capital investment in plant and equipment is necessary. The whirler is an expensive piece of equipment which requires electrical, water and drainage services. It requires regular cleaning and maintenance and will need replacing every ten years.

(vii) Production speed is greatly increased. Most plate can be press-ready within three minutes of exposure.

The basic features of the presensitized plate are as follows :

- They are available for exposure to negative and positive photographic film.
- Plate coatings are based on their diazo compounds or photopolymers.
- Presensitized plates are sometimes designated by the manufacturers as being additive or subtractive. These terms are descriptive of differences in the processing procedures. A presensitized plate is an "additive" type when the platemaker adds image-reinforcing materials to the image areas during processing. The coating on nonimage areas is either removed or rendered water-receptive during processing. With some additive presensitized plates, image reinforcing is optional; if the run is short this step in processing may be skipped. A presensitized plate is a "subtractive" type plate if it comes to the platemaker with the image-reinforcing material already on it (applied at the time of manufacture). During processing, the platemaker removes the unexposed coating from the background. The image-reinforcing material on the unexposed coating comes away at the same time.

The disadvantages associated with presensitized plates are listed below:

- Additions to a finished plate may be difficult, impractical or impossible.
- Many plates do not produce a visible image after exposure; this can prove awkward with certain types of work, e.g. multiple image jobs.
- The old system of re-graining used plates for further use cannot be used with presensitized plates. Once used the plate becomes scrap.
- The patent rights covering presensitized plates prevents an open investigatory analysis of the platemaking materials and solutions. There are, however, a number of basic principles which can be considered.

PROCESSING OF POSITIVE-WORKING PRESENSITIZED PLATES

All positive-working presensitized surface plates are subtractive where coating remains on the unexposed image areas and the exposed coating is removed during development from the nonimage areas. The steps in processing the positive-working presensitized-plates are as follows:

1. Exposing. Exposure is the same as with negative-working plates except that positive films are used. Thus, image areas are unexposed and the nonimage areas are degraded or depolymerized by light so they will be soluble in the developer. Plates normally are exposed and developed to a clean step 4 or 5 on a 21 -step sensitivity guide.

2. Developing. The plate is developed with a special solution that is wiped over the plate until the exposed coating is removed. Then, the plate is usually washed with water.

3. Fixing. Fixing is seldom needed today, but some plates may be fixed with a special solution that stops the action of the developer or renders the coating insensitive to light.

Most positive-working plates should be protected from light for maximum press life, unless they are to be heat-treated for extended press durability. Any deletions on the plate must be made before heat-treating.

4. Gumming. Gumming is done with a gum arabic solution or other finisher, such as AGE (asphaltum-gum-etch). Special inorganic finishing solutions must be used instead of gum on any plates that are to be thermally treated.

More information on the various presensitized plates is available from the manufacturers of the individual plates.

The following list indicates the solutions and agents used for plate development.

Diazo resin coatings (negative working)	-	Water development.
Diazo oxide coatings (negative working)	-	Acidified solution.
Diazo oxide coatings (positive working)	-	Alkaline solution.
Photopolymer coating (positive and negative working	-	Organic solvent.

Deletions : The removal of unwanted work is no problem with presensitized plates. Of course, "prevention is better than cure" and with a perceptive approach much of the unwanted work, film edges, etc., can be avoided.

Deletions can be made with an abrasive stick or rubber but the superior method is the use of chemical deletion fluid which does not damage the plate grain. The plate should be desensitized after making a deletion.

Post process, heat fusing of presensitized plate image : In more recent years a technique has been introduced to extend the "press-life" of presensitized plates.

The potential of a normally processed plate may be multiplied as much as ten fold, giving runs up to 1,000,000 impressions. The treatment is to cure the image in a special oven, the effect is to produce an exceptionally hard image. one word of warning! Film edges or unwanted dirt must be removed before fusing stage. One technique suggested is to process the plate, proof it, reproof, wash out, redevelop and fuse.

Having established the image by heat fusing, there is no chemical method of deleting available.

5.4.2 THE WIPE-ON PLATEMAKING PROCESS

Wipe-on plates are supplied uncoated, the light sensitive diazo resin coating is applied by the platemaker prior to use. The platemaking department which does not posses a whirler may on occasion have the need to coat a plate, either for dropping in additional work on a finished plate or simply as an alternative to the presensitized plate. The wipe-on process fulfills this need and bridges the gap between the presensitized and whirler coated plate.

An additional advantage of the wipe-on coating is that it can be used to produce half-tone images on inexpensive, non-sensitized paper plates used for short runs on small offset presses. For paper plates the same procedure for exposure and processing is used as for aluminium plates.

The characteristics and processing of wipe-on plate is similar to that for presensitized plates. At present most of the wipe-on process offered to the trade are negative working, but at least one manufacturer is conducting field trials of a positive working wipe-on process.

The plate : Modern wipe-on plate substrates are electrolytically grained, anodized and surface silicated.

Mixing the coating : Coating will oxidize and become unusable if the ingredients are mixed together and allowed to stand for any length of time. It is therefore necessary to mix only sufficient coating which is required for immediate use. Coating ingredients are supplied in two separate bottles, one containing the diazo resin and the other the solvent and wetting agent. The coating is prepared for use by carefully pouring the diazo resin into the bottle containing the solvent, which is thoroughly shaken until the diazo is dissolved.

To prolong the freshness of wipe-on sensitizers it is recommended that the diazo powder, in its original packing, be kept under refrigeration at 7^{o} C(45^{o} F) until it is required for mixing with the solvent.

Wiping-on the coating : A quantity of coating is poured on to the centre of the plate and then smoothed evenly over the whole surface using a special lint-free wiper which has been folded to form a pad.

In the case of a small image, it is possible to coat the local area only. The coating should be smoothed with long straight strokes rather than a circular action, and fanned dry with warm air. Unevenness or streaks in the finished coating will have little adverse effect upon the quality of the image. When dry, wipe-on coatings behave in a similar manner to presensitized plates, and are unaffected by humidity and temperature changes. They require short exposure times and have slow dark reaction. Because of this latter characteristic, it is possible to coat and dry a bench of plates which must then be stored in a light proof container for later use. In this way sufficient plates for up to one week's work can be prepared.

All coating and developing solutions should be performed under yellow safelight conditions.

Exposure : The exposure time is similar to most presensitized plates being approximately one minute when using a 3 K.W. metal halides lamp at a distance of 1 metre(39").

Exposure should obtain a solid step 6 on a 21 step Stouffer wedge. Exposure will produce a visible image of good contrast.

Plate inking : Using a pad of cotton wool apply a small quantity of inking-in solution and rub down evenly over the image areas.

Development : A quantity of developing solution is poured on to the plate and swabbed until all the non-exposed coating is removed from the surface. Some developers contain a desensitizing agent which prevents the ink on developed areas from attaching to the plate. A special developer which contains a lacquer may be used to reinforce the image for longer press life.

Rinsing off : Aluminium plates are washed under running water. Paper plates are washed clean with cotton wool and a minimum of water. Gumming is required as for presensitized plates.

Additions and deletions

Additions to the plate may be made in the following way :

Rinse off the gum and apply a 2 percent sulfuric acid solution for half a minute. Wash off with water and dry the plate quickly.

- Apply the wipe-on coating to the requiring additional work.
- Expose and process in the normal manner.

Deletions are easily made using the special deletion fluid recommended by the supplies of the wipe-on process.

Roller coating for the wipe-on process : An alternative to the hand application of wipe-on coatings is the use of the roller coating machine. This machine is uncomplicated and easy to use. It produces a smoother and more consistent coating in a shorter time than coating by hand. A powerful controlled drying system helps to accelerate the individual plate production time and the design is such that a minimal loss of coating solution takes place.

Plates may be coated at a speed of 3.5 metres (137 3/4") per minute and machines are available in a range of sizes from 360 mm to 900 mm (14" to 35 1/2") in width.

Manufacturers claim up to 60 percent saving on materials with less risk of splashing or dripping when using a roller coating machine.

High speed plate punch/coaters are now available. In addition to applying the plate coating, these machines register, punch, dry and stack plates at a rate of over 300 plates per hour.

5.5 PLATEMAKING TROUBLES

Today, printers are fortunate to have so many excellent plates available. These plates are quickly and easily made and are relatively inexpensive. Most of these plates offer excellent image fidelity with wide exposure latitude, exceptional durability, and consistency on press. When the proper equipment and chemicals are used and the manufacturer’s instructions followed, most problems can be avoided. But despite all this, problems do occur.

This section describes some of the common troubles, their probable causes, and suggested remedies.

5.5.1. Wipe-on Plates

Wipe-on plates are very popular with newspapers and some other printers because they are relatively inexpensive. The supplier furnishes a treated (but uncoated) plate along with the chemicals and coating needed to sensitize the plate. Since the printer must apply the relatively unstable coating, these plates are more troublesome than most presensitized plates. The most commonly encountered problems are discussed below.

1. Scumming: Scumming is a major problem on wipe-on plates. In addition to all of the sources covered under presensitized plates, scumming on wipe-on plates can result from:

(i) Wipe-on Coating: Most wipe-on coatings should be used within a couple of days after mixing. They deteriorate rapidly specially at elevated temperatures. The dry diazo also deteriorates with age and causes scumming, especially in hot, humid weather. Thus, scumming is much more common in the summer. After coating, the plates should be used within 24 hours.

(ii) Incomplete development: Incomplete development may also cause scum. To test the processed plate, cover a portion of the nonimage area and re-expose the plate. Residual diazo appears as a yellow ink-receptive stain. For best results, this stain should be minimal or absent after redeveloping the plate with an additive developer.

(iii) Quality problems: Since wipe-on plates are less expensive than presensitized plates, the manufacturer's quality control may not be as good. Problems can result if the quality of the base metal is not consistent. An uncoated plate right from the box that scums when developed with additive developer is more likely to scum on press. A good wipe-on plate should not accept ink when rubbed up with water and press ink or wipe-on developers.

(iv) Inadequate finishers: Gum used on newspaper plates is formulated to be removed immediately by the press dampeners, so it may be inferior to gum or finishers used on presensitized plates. For high-quality printing, some printers expose the finished (gummed) plates to harden the gum and thus reduce or eliminate scumming on press.

(v) Press and miscellaneous: When a newspaper press goes down, the plates generally are not gummed. If the plates are left ungummed for more than a few minutes and completely dry, they will probably scum on startup, especially if the residual diazo in nonimage areas is excessive. The neutral or alkaline fountain solutions used by many newspapers can contribute to this scum. Most acid fountain solutions better resist scumming. With some newspaper presses, ink must be applied to the plates before the fountain solution wets the plate. Most news inks are formulated to pick up a lot of water. If the water pickup is too low, the plates will scum.

2. Streaked and chalked coating: Streaks and chalkiness result when the coating is too thick. Coating rollers must be kept clean and properly adjusted for best results. Manufacturer's instructions should be closely followed with respect to coating the plate.

3. Dirt or lint in the dried coating: Dirt or lint from any source can cause problems.A major source of dirt results from using old diazo or reusing diazo coatings that have been drained from the coating pan.

4. Weak image: A weak or uneven image will result if development is incomplete. Plates must be developed until a strong, uniform image is obtained. Additive developers must be thoroughly mixed before being put in the processor. Excess water in the developer, a developer that has lost solvent, or a bad plate can cause a weak image or one that refuses to accept lacquer or ink properly during the developing procedure. White spots can result from silicate gels due to poor quality control by the plate manufacturer. Small round spots can be caused by water droplets on the unexposed plate.

Plates that have not been properly pretreated will not work satisfactorily with the diazo coatings used for most wipe-on processes. The pretreatment is required on both anodized and unanodized plates, and it must be compatible with the coating and developing chemicals. Pretreated plates have an indefinite shelf life, provided they are stored in a cool, dry location.

5.5.3. PRESENSITIZED PLATES TROUBLES

With presensitized plates, the supplier treats the metal and coats the plate using mass production procedures, which require excellent quality control. In addition, the manufacturer supplies processing chemicals specifically developed for optimal performance with a particular plate. Automatic plate processors produce high-quality, consistent plates quicken and reliably. But despite all this, trouble in making and running litho plates still occurs too frequently. Some of the common problems that occur with presensitized plates are outlined below.

1. Scumming: Scumming occurs on press when the nonimage areas accept ink. Several reasons for scumming include:

(i) ***Fogging:*** Most negative-working plates are easily fogged when exposed for more than a few minutes to daylight or room light. Even yellow plate room lights can fog many plates in a surprisingly short time.

- Positive-working plates might scum if the plates are not exposed long enough To a clean step 4 or 5 on a 2 1 -step sensitivity guide).
- In both cases, scumming results from residual coating left on the nonimage areas after development. A residual coating problem may be difficult to detect until after the plates have run for a while on press. Too often, it is assumed that the scumming is a press problem, because the plates ran clean for as many as 20,000 impressions before the problem appeared.
- To avoid this problem, always keep plates stored in their original light-tight package in a closed cabinet or drawer until ready to use. Be very careful to keep light exposure of the plates to a minimum until after development.
- Fogging during exposure often occurs when the next plate to be exposed is left face up near the vacuum frame. Always remember that a lithe plate is actually a special type of photographic film and should be treated like film.

(ii) ***Incomplete development:***

- Unless the plate is fully developed, very small amounts of coating may remain and cause scumming on press.
- Also, this is frequently the cause of excessive dot gain in halftone areas; so whether processing by hand or machine, overdevelopment is always preferable to underdevelopment.
- Hand-develop plates carefully and avoid contamination from water, dirty swabs, or dirty sinks.
- Be sure that the temperature, speed, chemical concentration, and maintenance of plate processors is correct according to the manufacturer's recommendations.

(iii) ***Fountainin solution:*** Scumming may occur on press if the ink is too greasy for the fountain solution. To balance greasy ink, add more fountain solution concentrate and upto one ounce of 14° Be gum arable solution per gallon of fountain solution.

- The pH of acid fountain solutions should be below 5.5 when gum arable is used as the desensitizing agent. Ink dot scumming results when acids in the fountain solution attack the plate by etching small, deep holes into it.Ink dot scumming is relatively rare on anodized aluminum plates, but it can occur if excessive fountain solution is left plates when shutting down the press. Excessive pressure or abrasion on press may also cause scumming.

(iv) ***Defective plates:*** On very rare occasions, the plate may be defective, such as old plates, plates that have been stored at very high temperatures and/or humidities, or plates that were defective when manufactured.

(v) ***Emulsion developer:*** On presensitized additive plates, scumming may result if the emulsion developer is bad, if the processor has not been properly maintained, or if the plate is rubbed up until it is too dry. Dirty or contaminated sponges or swabs can also cause problems. On heat-treated plates, the use of an improper finisher before heating can cause scumming.

(vi) ***Improper gum application :*** improperly applied gum can cause scumming. Plates should be gummed up on press anytime the press will be down for more than 30 min.

2. Poor reproduction: Good image fidelity is necessary for all critical jobs. Proper exposure and processing is essential for good reproduction. The images on all negative-working plates gain as exposure is increased, while on all positive- working plates, images sharpen with increasing exposure.

- Be sure to use only hard-dot or contact film. Camera films with dot fringes cause dot gain on negative-working plates and excessive sharpening on positive-working plates. Most . scanner film is hard-dot film. An improperly operating scanner can leave scanner streaks that resemble fogging in image areas of negative plates.

- Unless development is thorough, plates requiring good mechanical action for complete development may tend to plug in the shadow areas. Incomplete development on some plates may leave a very thin, almost invisible halo around the dots. Although these plates look acceptable in the plate room, they print too full on press. Again, overdevelopment is preferable to underdevelopment. Additive plates are the exception; prolonged development with lacquer type droppers can cause dot gain and plugging.

3. <u>Image gain or sharpening:</u>

- Poor contact between the plate and film allows light under opaque. areas of the film t and causes image gain or sharpening, depending upon whether positive- or negative-working plates are being used.
- For good contact, all plates should be drawn down for over 30 sec. at a minimum of 25 in. (635 mm) of vacuum before starting the exposure. Since the vacuum gauge may not correctly indicate vacuum in the frame, view the surface of the vacuum frame at an oblique angle. The appearance of Newton's Rings, which resemble an oil slick with rainbow colors, indicates good contact.
- Photocomposers must also provide proper vacuum, especially when large chases are being used. Overexposure greatly aggravates problems resulting from poor contact.
  - Thus, all exposures should be made with a light integrator to produce the recommended step on the plate sensitivity guide. Placing a sheet of clear plastic between the flat and vacuum frame glass improves contact. Grained or frosted plastic with the frosted side of the sheet toward the film improves contact while diffusing light. The frosted plastic causes some dot gain negative-working plates and sharpening on positive-working plates.

4. <u>Premature plate wear:</u> Premature plate wear on press has many causes.

- The images on underexposed negative-working plates are too weak for good press life and wear out prematurely.
- Some unbaked positive-working plates fail prematurely due to light degradation caused by excessive exposure to light after development. On most positive-working plates, the developer destroys the light sensitivity of the plate so that this does not happen.
- Strong solvents, UV inks, or electron-beam (EB) inks can attack some plate coatings and must not be used on those plates.
- Other causes of excessive wear include excessive printing pressure, abrasives from ink, paper, or other sources, and excessive relative motion (or slip) between the plate and blanket, Delta rollers, and hickey-picking rollers.
- An additive developer can be used on press to extend the life of most plates if wear has not progressed too far.

- Be sure to test the developer on a scrap plate before using it an a live job, since this type of dropper will remove the image on some plates.

5. Blind images: If the image looks strong but doesn't accept ink, the problem is probably blinding instead of wear.

- Some plates may blind when the pH of the fountain solution is too low or when too much alcohol is used in the fountain.
- On rare occasions, a whitish salt will deposit over the plate image and cause blinding. The salt can usually be removed temporarily with a good plate cleaner but will return unless the source (usually ink or fountain solution) is found and corrected.
- On very rare occasions, paper can cause blinding on some plates. Blind plates can usually be brought back with plate cleaner or an additive developer that is compatible with the plate.

Plate cracking: on web presses, plate cracking results when the plate does not conform to the press cylinder. The plate must be bent and mounted properly to conform precisely to the cylinder without flexing.

UNIT – V – OFFSET PLATE PROCESSING

PART – A ***2 Marks Questions***

1. What are PS plates?

Presensitized plates are so called because they are already coated by the manufacturers and are ready for exposure and processing when purchased.

PS plates print with exceptionally high quality.

2. State the advantages of wipe on plates.

Wipeon plates don't need whirelers for application of coating. An additional advantage of the wipe-on plates is that it can be used to produce good halftone reproduction images on inexpensive, non-sensitized paper plates used for short runs on small offset presses.

3. What is the use of step and repeat machines?

The Step and Repeat machines are used to expose multiple images from a single film in accurate register on the plate. Images may be repeatedly exposed to the plates in different location.

4. State the advantages of automatic plate processors.

Equipment for automatically processing plates has come into almost universal use. Essential in high-volume situations, automatic processors increase productivity, improve consistency, and reduce chemical consumption. Automatic processors are most valuable where speed of production is vital, as in the case of web offset newspapers, which work on edition deadlines. Automatic processors reduce downtime and the number of makeovers from plate failures on press.

5. What is graining?

The process of roughening the plate surface is called as graining. Before a metal can be used as a base for a lithographic plate its surface must be properly prepared. This can be done by roughening the surface mechanically, or treating it chemically or electrolytically. If this is not done, the plate will not coat or perform properly in the lithographic process.

6. What is CTP technology?

Computer-to-plate technology. CTP, or direct-to-plate as it is sometimes called, is a digitized plate-imaging process. Publishers provide all editorial and advertising content (images) in digital form (either on disk or by sending the data over internet) to printers who, in turn, digitally produce printing plates, eliminating all the traditional intermediate film-preparation stages.

7. Expand CTPP.

Computer to Polyester Plate

8. Name some light sources used for CTP plates exposure.

i. Conventional high-powered yttrium aluminum-garnet (YAG) water-cooled laser,

ii. Argon ion (Ar), laser

iii. Helium-neon (HeNe) laser,

iv. Frequency-doubled YAG (Fd:YAG) laser,

v. Solid-state devices such as laser diodes (LD) and light-emitting diodes (LED).

9. State the disadvantages of photopolymer CTP plates.

The disadvantage of photopolymer is that it requires light-sensitive developing solutions that have a tendency to foam. In addition, the plate has to be heated after exposure and yet does not offer the best light sensitivity.

10. State the drawbacks of flatbed platesetters.

The matching (stitching) of the adjacent exposure areas is difficult, and the naked eye can often see a distortion pattern caused by an error a micron or smaller in size.

- Spot distortion across the image area from the laser beam starts to become a problem with image sizes greater than 22 inches.

PART – B ***3 Marks Questions***

1. State the different types of offset plates.

- Bichromated albumin and casein plates
- Presensitized plates
- Wipe-on plates
- Deep-etch plates
- Bimetal and trimetal plates
- Direct-image plates
- Photo-direct plates
- Electrostatic plates

2. Write notes on step and repeat machines.

The photocomposing machine, sometimes called the step-and-repeat machine, is used for exposing lithographic plates or films. The machine produces a series of exposures in register on the same plate or on successive plates. The same precautions as described for conventional vacuum frames hold true for the photocomposing machine.

3. Name the light sources used for offset plates exposure.

- Pulsed Xenon lamps
- Metal Halide lamps
- Carbon arc lamps

4. State the advantages of Automatic plate processors.

Equipment for automatically processing plates has come into almost universal use. Essential in high-volume situations, automatic processors increase productivity, improve consistency, and reduce chemical consumption. Automatic processors are most valuable where speed of production is vital, as in the case of web offset newspapers, which work on edition deadlines. Automatic processors reduce downtime and the number of makeovers from plate failures on press.

Most plate processors are automated to the extent that they develop, desensitize, gum, and dry the plate. Chemistry is applied automatically and automatic replenishment is common; it may have continuous filtration and recirculation.

5. Write notes on metals used for offset plates.

Today, most lithographic plates are thin metal sheets. Aluminum is the most common metal used. Bimetal and trimetal plates can be aluminum, stainless steel, mild steel, or brass.

Plates are usually the full size of the press cylinder and must be thin and flexible enough to wrap snugly around the cylinder. Aluminum thickness varies with press size. Standard thicknesses range from 0.0055 to 0.020 in. (0. 14 to 0.51 mm), and sizes go up to 59 x 78 in. (1.5 x 2.0 m).

Aluminum used for litho plates is a pure, high-quality alloy that is reduced to final thickness by cold rolling on smooth rolls. The coils of aluminum are carefully annealed to obtain the proper temper or hardness. They are then inspected to ensure that (1) they meet the required gauge tolerance; (2) they are flat; and (3) any side to be used for a printing surface is free from dents, scratches, and other surface defects.

6. What is aluminum anodizing?

Aluminium Anodizing: Aluminium anodizing is a process by which a very thin, uniform layer of extremely hard aluminium oxide is produced eletrolytically on the grained aluminium. This anodic layer has many extremely small pores, similar to a honey comb, that must be sealed before the photosensitive coating is applied. Hot solutions of sodium silicated are used for sealing.

7. State the advantages of PS plates over whirler coated plates.

The advantages of presensitized plates over whirler coated plates are listed bellow:

1) Factory coated plates produced under controlled conditions result in standard sensitivity and thickness.
2) They are relatively unaffected by variations in humidity and temperature.
3) At least six month shelf life is expected with modern plates.
4) Plates may be purchased economically to suit a variety of requirements-negative or positive working plates, choice of plate substrate (paper or metal and choice of plate coating).
5) The processing of presensitized plates is simple, requiring less craft skill than whirler coated plates and yielding consistent results.

6) Less capital investment in plant and equipment is necessary. The whirler is an expensive piece of equipment which requires electrical, water and drainage services. It requires regular cleaning and maintenance and will need replacing every ten years.

7) Production speed is greatly increased. Most plate can be press-ready within three minutes of exposure.

8. Write notes on heat fusing of PS plates.

Post process, heat fusing of presensitized plate image : In more recent years a technique has been introduced to extend the "press-life" of presensitized plates.

The potential of a normally processed plate may be multiplied as much as ten fold, giving runs up to 1,000,000 impressions. The treatment is to cure the image in a special oven, the effect is to produce an exceptionally hard image. one word of warning! Film edges or unwanted dirt must be removed before fusing stage. One technique suggested is to process the plate, proof it, reproof, wash out, redevelop and fuse.

Having established the image by heat fusing, there is no chemical method of deleting available.

9. What are the various components of CTP systems?

Components of a computer-to-plate system include

- a raster image processor, or RIP;
- a plate-holding area;
- systems for slip sheet removal, punching, and loading and unloading plates;
- a platesetter; and a post-processing system.

PART – C ***10 Marks***
Questions

1. Explain the procedures involved in preparation of Wipe on plates.
2. Describe the construction of printing down frame with the sketch.
3. Write notes on (a) PS plates preparation (b) Automatic plate processor.
4. List down the wipeon plates troubles. State the causes and remedies for the same.
5. List down the PS plates troubles. State the causes and remedies for the same.
6. Explain briefly the quality control aids used in platemaking department.
7. How will you control the platemaking variables by using plate sensitivity guide?
8. How will you control the tonal values in platemaking by using quality control aids?
9. Explain briefly the quality control aids used in platemaking department.
10. Explain the UGRA Plate Control Wedge with the diagrams.

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GLOSSARY

ALUMINUM PLATE A thin sheet of specially grained aluminum used as a lithographic image carrier.

BIMETAL PLATE A lithographic printing plate made from two metals, one forming the ink-receptive image area (usually copper) and one forming the water receptive nonimage area (chromium, stainless steel, aluminum, zinc, etc.).

COLOR PATCH Small samples of the inks that will be used for a process color job. They are printed on the required paper stock and attached to the original art to serve as a reference in the color separation process.

COLOR REPRODUCTION GUIDE A test image containing examples of solid primary colors, secondary colors, three- and four-color images, and tint areas that serves as the standard for correcting defects in printing ink pigments and the color separation process.

CTP (Computer-to-Plate): Digitised Platemaking process - In plate making, Computer-to-Plate systems or plate setters eliminate the need for having a separate film-to-plate exposure system.

Digital plates: Printing plates imaged using lasers or other high-energy sources driven by digital data in a plate setter.

Digital printing: Printing by plateless imaging systems that are imaged by digital data from prepress systems. Includes toner, ink-jet, and other processes.

DIRECT-TO-PLATE TECHNOLOGY Those imaging systems that receive fully paginated materials electronically from computers and expose this information to plates in platesetters or image setters without creating film intermediates.

Dot gain: In printing, a defect in which dots print larger than they should, causing darker tones or stronger colors. The optical increase in the size of a halftone dot during prepress operations or the mechanical increase in halftone dot size that occurs as the image is transferred from plate to blanket to paper.

Exposure: In photography and platemaking, the step in photographic or photomechanical process during which light or other radiant energy produces the image on the photo-sensitive coating. Light exposes; lasers image.

IMAGE AREA On a lithographic printing plate, the area that has been specially treated to receive ink and repel water.

IMAGE CARRIER The device on a printing press that carries an inked image either to an intermediate rubber blanket or directly to the paper or other printing substrate.

IR: Abbreviation for Infra Red radiation above700 nm (nanometers) used in laser platesetting.

Layout: The drawing or sketch of a proposed printed piece. In platemaking, a sheet indicating the setting for a step-and-repeat machine.

NEGATIVE-WORKING PLATE A printing plate that is exposed through a film negative. The plate areas exposed to light become the image areas.

NONIMAGE AREA The portion of a lithographic printing plate that is treated to accept water and repel ink when the plate is on press.

Photomechanical: In platemaking, pertaining to any platemaking process using photographic negatives or positives exposed onto plates or cylinders that are covered with photosensitive coatings.

PLATE A thin metal, plastic, or paper sheet that serves as the image carrier in many printing processes.

PLATEMAKING Preparing a printing plate or other image carrier from a film or flat, including sensitizing the surface if the plate was not pre sensitized by the manufacturer, exposing it through the flat, and developing or processing and finishing it so that it is ready for the press.

POSITIVE-WORKING PLATE An image carrier that is exposed through a film positive. Plate areas exposed to light become the nonimage areas because they are soluble in the presence of developing agents.

Presensitized plate: In photo mechanics, a metal, film or paper base plate that has been pre coated for exposure to light or laser imaging.

QUALITY CONTROL The day-to-day operational techniques and activities that are used to fulfill requirements for quality, such as intermediate and final product inspections, testing incoming materials, and calibrating instruments used to verity product quality.

Sensitivity Guide: A continuous-tone gray scale with numbered steps used to control exposures in plate making and lithfilm photography.

Step-and-repeat: In photomechanics, the procedure of multiple exposure using the same image by stepping it in position according to a predetermined layout or program. Now done with electronic imposition programs.

UGRA test target: A measure of image resolution and dot size on plates and in printing. UGRA is the Swiss Association for the Promotion of Research in the Graphic Arts Industry.

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