VISUAL EXAMINATION

6. Visual Examination (May 1986)

Encompasses non-sampling examination methods for support and media, surface and underlying layers, by direct or magnified observation using a variety of illumination sources and techniques.

This outline is intended to provide a brief summary of the tools and techniques of visual examination as they are used to study the manufacture and condition of, and in the treatment of art and artifacts on paper. (See 2. Media Identification; 3. Media Problems; 4.Support Problems; 7. Authentication; 23. Consolidation/ Fixing/Facing, et al.).

6.1. Purpose

6.1.1 To determine the original materials of the work of art and the characteristics of these materials.

6.1.2 To determine the history of the object based on the evidence of its physical condition.

6.1.3 To determine the presence of alterations and their implications for the physical security and longevity of the object.

6.1.4 To determine the presence of components or conditions that may influence conservation treatment and to aid in the evaluation of ongoing treatment.

6.2. Factors to consider

Visual examination is the first line of approach to study of an artwork because it does not require that the surface be touched. It precedes and directs instrumental analysis in which the structure and composition of the artwork is determined by analytical methods requiring sampling. (See 9. Instrumental Analysis)

6.2.1. Can provide information about the materials, manufacture and condition of the support.

6.2.2. Can provide information about the materials, structure and condition of surface media layers and, possibly, information on the internal media layers, including underdrawing.

6.2.3. Accessibility of expertise in-house or from outside resources.

6.2.4. Accessibility of equipment in-house or from outside resources

6.2.5. Funds available for simple low-cost techniques only or no financial limitations.

6.3 Materials and Equipment

6.3.1. The Eye as Tool/Direct Observation

Encompasses direct visual examination of support and media using visible light (400-700nm), i.e. the range of electromagnetic radiation to which the human eye responds and which gives us sensations of colour, texture, transparency, etc.

During visual examination the object must be seen in as much detail as possible; strong illumination is needed (cp. requirements of gallery lighting of works on paper). The human eye is very adaptable and interprets color and brightness relatively rather than according to absolute standards. Therefore, it is important to know the effects of different illumination types on visual acuity and color discrimination. Various light sources are available (see 6.3.3. Light Sources - Visible Range). The object may be illuminated from one of several angles (see 6.4.2.B. Examination by Varying the Angle of Illumination). Information may be recorded photographically.

6.3.2. Magnifiers

A. Hand-held Magnifiers: These consist of a single lens or lens combination. Placed between object and eye, a convex lens restores image sharpness, increasing apparent object size. Magnification is usually in the range 1.5 to 20 times. Field of view (area of object seen) is directly related to the diameter of the lens. For the largest possible field of view hold the lens as close as possible to the eye. With or without built-in light source.

1. Single Lens Magnifiers
   a. Pocket-sized lens that folds into an attached protective case; lens is often small in diameter, e.g. 17 to 35 mm.
   b. Reading-glass type lens:
      - Usually has a large lens, e.g. 80 to 100 mm in diameter for a circular lens or 50 x 100 mm for a rectangular lens, or
      - Pocket-sized, e.g. a 45 mm lens.
   c. Magnifiers attached to adjustable desk-top stand: Lens can be up to 100~~0~~ mm in diameter or sometimes greater.

2. Multiple Lens Magnifiers: More complex; consist of double or triple combination of lenses designed to eliminate certain optical errors. Upper magnification limit is about x 20; usual values are x 6 to x 10.
   a. Magnifiers on miniature tripods.
   b. Watchmaker's magnifier.
   c. Linen testers.
   d. Measuring magnifiers - contain reticles
   e. Magnifier-telescope systems: used as magnifiers they have magnifications that are higher than for other types, e.g. 25 times or greater.
   f. Binocular magnifiers designed to fit, visor-fashion, on the head; magnification x 1.5 to x 35 or higher.

3. Illuminated magnifiers: single and multiple lens systems.
   a. Hand-held flashlight magnifier with multi-lens system. Usually battery operated. Usually x 5 to x 10 but more sophisticated models can be x 30.
   b. Magnifiers on adjustable desk-top stands: Lens size will vary as for 6.3.2.A.1.c

B. Stereomicroscopes

1. Microscopes

Consist of two separate optical systems, one for each eye, and two objectives built into one mechanical unit. (A regular binocular microscope uses only one objective at a time, although different ones are available on the objective turret.) Both microscope systems focus on the same area of the object but at an angle to each other.
The stereomicroscope is limited to relatively low magnification. Maximum meaningful magnification is about x 140. The stereomicroscope can achieve up to about x 300 with supplementary lenses but image quality deteriorates.

Imaging mode: 2 slightly different images are produced by the 2 separate systems. The image pair is observed by the eyes and is fused in the brain to create the perception of a single 3-D image with a pronounced spatial quality.

Stereomicroscopes range in quality and complexity from fixed magnification to step-type magnification changes to variable zoom magnification.

Optional fully automatic camera for photomacrography; TV camera.

2. <u>Stands</u>
   Various types available which permit maximum accessibility to object, scanning of wide areas, viewing in reflected or transmitted light.

   Inclinable drive and tilt controls allow operator easy, rapid orientation of focus planes with artifact planes; minimizes amount of adjustment taking place immediately above the artwork. Stability important.

   <u>Table mount, long arm stand</u>: Allows viewing of small works in horizontal position.
   When mounted on an easily-made bridge, allows viewing of large flat objects (E.W.)

   <u>Floor stand, large swinging arm</u>: Can be used in horizontal, vertical or intermediate position. Rollability provides flexibility in moving it to object. Static versions available.
   Includes large special tripods developed for use in medicine which consist of a heavy base plate and long solid column. This provides a vibration-free support for the instrument, very suitable for photography.
   Some floor stands very heavy and difficult to transport (as opposed to roll).

3. <u>Eyepieces, lenses, etc.</u>:
   Attachment lenses: enable viewer to increase and decrease magnification as required. Increase in magnification decreases working distance and field of view, and vice versa.
   Eyepiece graticules: various designs are available including micrometer scales, grids. Are used in eyepieces of microscopes for measuring, counting (wiremark spaces, particle sizes, etc.).

4. <u>Other apparatus</u>:
   For photomacrography: camera, electronic flash, fibre optics, phototube, cine tube.
   For expanding observation opportunity: TV screen onto which the subject being studied may be projected, second observer tube, and attachment for an assistant's microscope.

5. <u>Microscope Illuminators</u>: Light source may be mounted on the microscope or may stand separately, on a transformer base.

General purpose. Incandescent or fluorescent. Various types of illumination provided including an intense spotlight ideal for highlighting deep holes, cracks; broader, more diffuse illumination of larger fields of view, illumination of reflective surfaces, etc.

Fiber Optics (see: Light Sources 6.3.1.E.1).

Xenon - electronic flash used for photomacrography. Puts out a considerable amount of UV radiation; use UV absorbing filter when photographing museum objects.

6.3.3 Light Sources - Visible Range

Light sources may be characterized by:
Color Temperature (C.T.): the temperature (measured in degrees Kelvin) at which a heated black-body radiator would produce light giving a similar color appearance and spectral distribution curve to that of the light source itself. The color of an object appears different under warm (low C.T.) and cool (high C.T.) illumination from different light sources.
Colour Rendering Index (C.R.I.): a measure of the deviation of the spectral energy distribution of a light source from that of a heated black-body radiator: 100 indicates a perfect match. As the C.R.I. decreases in value, because of irregularities in the spectrum, deviation from the black body standard increases. The color of objects will differ under lights having the same C.T. but very different C.R.I.'s (important with fluorescent lamps).

A. Natural Light/Daylight
Range of wavelengths from 300nm (ozone layer prevents shorter wavelengths from reaching earth) into the IR. Common window glass will cut off UV radiation below 300-325nm region.

1. Direct Sunlight
C.T. depends upon height and direction of sun and time of year, e.g. noon winter sunlight, Washingon, D.C.: C.T. 5077^{o}K; noon summer sunlight, Washington, D.C.: C.T. 5740^{o}K (source: Evans, p. 25). Southern exposure provides the most direct sunlight; east-west light has a strong raking component.

2. Indirect Light
e.g. clear sky (north light) circa 6000^{o}K; bluer than direct sunlight; highest % UV/unit energy. clouded/overcast sky through window glass: C.T.

5,000 to 7,000°K.

B. Artificial Light

1. Tungsten Incandescent

Source: Incandescence of a coil of tungsten wire heated electrically; glass envelope. Ordinary bulbs are filled with a mixture of inert gases; low wattage lamps may contain a vacuum.

Produces a warm yellowish light, low in UV; C.T. distribution of energy: 2,400°K to 3,000°K, depending on wattage; C.T. is very accurate and does not decrease with use. Very high C.R.I. so is good for color rendering. Emits less than 75 watts of UV radiation therefore UV filtering is unnecessary. Most lamps run directly from the electricity supply; low voltage lamps require transformers. Significant thermal qualities because of IR emission.

Dichroic Reflector Spotlights. Direct only visible radiation at object; transmit IR through back of lamp. Provides slightly cooler lighting than regular incandescent without disturbing color rendering.

2. Tungsten Halogen/Quartz Halogen

Source: as for tungsten incandescent. Lamp is able to operate at higher temperatures because introduction of small amount of halogen vapor prevents loss of tungsten filament and burning out of lamp at these temperatures. Quartz envelope: needed because of higher operating temperatures. Quartz allows transmission of UV all the way to the far end. UV filters are strongly advised. Constant color temperature.

Fibre Optics: Light from a quartz halogen lamp enters a bundle of precision-drawn glass fibres and travels down its core by internal reflections. The glass fibers reduce UV transmission. Stepless regulation of light intensity without affecting color temperature. Gooseneck light guides (which contain fibre bundles) bend as required, will remain in given position. Options: one to three arms or ring light.

Color, daylight conversion, fluorescent and polarizing filters available.

3. Fluorescent

Source: Current applied to tungsten filaments at each end of tube generates flow of electrons. Latter collide with and excite mercury atoms present in the tube (together with a rare gas). Excited mercury atoms emit electromagnetic radiation, mainly UV, at specific wavelengths. This UV radiation strikes the phosphor-coated interior wall of the tube. The phosphors absorb the UV and re-emit it as visible light. Combining different phosphors creates lamps with different color temperatures.

Common C.T.'s:
2,700-3,100°K - "Warm White" - yellowish-white light similar to incandescent -
4,200°K - "Cool White" - commonly used in office lighting
- 6,000°K - "Daylight", with bluish cast, is used to complement natural day light -C.R.I. and C.T., available from manufacturer, will vary, affecting color rendering properties. C.R.I. above 85 will render colors well.

Available usually as glass tubes with variety of diameters, lengths, wattages.

Variable UV output depending on manufacturer and type. If more than 2-3% UV is emitted, UV absorbing filters must be used. Specially designed, low UV emitting lamps are available; expensive.

Cannot be operated directly from room electricity supply; need control unit to provide stability, special starting conditions.

4. Mixed Incandescent/Fluorescent

Combination lamp is claimed to balance the two types of light approximating the color spectrum of daylight. Color matching is best done by checking with three different illumination sources.

5. Limited Wavelength Sources

Monochrome Sodium Arc Lamp: Volatile sodium is excited by electrons accelerated between two electrodes as a result of an applied voltage. Collisions between the excited gaseous metal atoms produce luminescence which yields a great deal of visible light. Emission spectrum contains some very intense sharp emission lines rather than a broad, continuous spectrum (fixed wavelength doublet, with rays at D1 589 nm, D2 589.6 nm; plus an invisible doublet in infrared band, D1 818.3 nm, D2 819.4 nm).

Lamp consists of U-shaped tube with positive electrode in vacuum. When sodium vapor is excited electrically it produces yellow-orange light.

6. Miscellaneous Apparatus

Light Box: Usually consists of box frame holding fluorescent tubes (to reduce heat build-up, characterisitc of incandescent, which could damage objects) set under diffusing glass. Can place sheet of UV filtering Plexiglas over light box to help protect object from UV. Some models feature color correction to facilitate comparisons of color transparencies (C.T. 5,000^{o}K; C.R.I. 90).

Protective cover will prevent damage to glass, provide another work surface when light box not in use. For use of light box with incandescent source see: 6.3.4.B.4. Miscellaneous Apparatus.

6.3.4. Radiation Sources - Outside Visible Range

A. Ultraviolet Radiation: invisible electromagnetic radiation at wavelengths shorter than visible light. Range is roughly 10-400 nm wavelength region of spectrum and can be subdivided as follows:

400-320: Near or long wave UV; UV-A "tanning" lamp region; BLB region most useful.
320-280: Middle UV; UV-B; "sunlamp" region - possibly useful.
280-200: Far or short wave UV; UV-C' "Germicidal" lamp region.
200-10: Vacuum UV. Range below 280 nm is not useful and is damaging.
400-320 nm is the useful band for examination of media and support but, nonetheless, must be used with some time constraints because of the acknowledged damaging effects of UV radiation on cellulose, dyes and other organic materials.

Health Hazards and Precautions:
Long Wave UV: exposure can cause severe sunburn and eye damage (conjunctivitis); prolonged exposure may result in skin cancer and cataracts. UV-B and UV-C

are far more dangerous to eyes and skin than UV-A. (Probably to objects, too, but many variables here.) Short Wave UV: thought to be a health hazard because of the large amount of ozone generated. Its use must be accompanied by adequate ventilation.

1. Sources:
   Wavelengths available.
   long wave ultraviolet: 365 nm
   short wave ultraviolet: 254 nm
   mixed wave: 365/254 nm

   a. Long Wave Ultraviolet - UV-A:
      Fluorescent tubes: 'BLB' designation "black light' or "low-pressure" mercury vapor lamp. The discharge of electricity through a carrier gas, e.g. argon, heats and vaporizes the mercury. Then the mercury ionizes, radiating visible light and ultraviolet in the long and short wavelengths. The tube is coated (and normally contains a filtering salt in the glass) so that mainly long wave radiation is emitted. ("BLB" has internal filter to filter out visible light. "BL requires external filter). Tubes are available in lengths of up to 48 inches, and can be operated in standard fluorescent light fixtures. These are suitable for broad area UV coverage and for photography. Smaller hand-held, table top, or clamp-on lamp styles, containing short tubes with filters, are useful for visual examination.

      Mercury Vapor Lamps: "high pressure". Mercury vapour is produced in small, tubular quartz envelopes under a pressure of several atmospheres. These lamps emit mainly long wave ultraviolet with some shorter wavelengths. High visible light output. Most high pressure Mercury black ligh lamps require external filtration of visible light emitted. Mercury high intensity discharge lamps ("street lights") are used in larger units with external visible light filter. Special electric current and transformers are required.
      Produces intense UV illumination of a limited area.
      Hand-held and tabletop models.

   b. Short Wave Ultraviolet - UV-C:
      Visual source is low pressure Hg germicidal bulb, "G" designation, with external

visible/long wave/medium wave UV filter.

c. Mixed Wave (254/365 nm): Several models combine separate shortwave and longwave UV light sources in one housing.

d. Options: Lamps with magnifiers: "for observance of even minute traces of fluorescence", in long wave, white light/longwave, shortwave/long wave models.

Battery operated longwave or shortwave models. Very portable.

2. Detectors: for UV excited visible fluorescence.

a. human eye: (see: 6.3.4.A Health Hazards and Precautions, also see: 6.3.4.A.5.a UV filtering goggles).

b. film: UV radiation has a strong reaction on photographic materials making it easy to record photographically. Any panchromatic B/W or color reversal film is suitable. Note that exposure times are often long. Fast films will reduce exposure times but slower films will give sharper images. Allow for film reciprocity failure.
camera: 35 mm single lens reflex, range finder, or view camera.

3. Filters

a. Exciter filters: Some exclude all radiation except UV; others transmit visible light, e.g., 47A, which causes fluorescence. Some pigments react more to 380-440 nm than to radiation below 380 nm. Filters are normally not necessary for black light-tubes: the tubes have filters incorporated into them and residual blue light can be removed with a barrier filter (see below). If a high pressure mercury vapor lamp lacks a filter, use a Kodak 18A or Corning 5840 filter.

b. Barrier filters: remove all residual exciting UV and any blue light transmitted by the exciter filter. You may have to select the filter carefully, in order to filter out this blue light but also trasmit blue fluorescence from the object. Depending on the lights, the following filters are recommended:

fluorescent lights - Kodak 2E
mercury vapor - Kodak 2A

Placement of filters is important: The two series should be in front of the color filter to prevent fluorescence of the filter dyes.

5. Miscellaneous Apparatus

a. UV filtering goggles: to protect eyes when viewing with UV light. Note that goggles change color of observed fluorescence.

b. Long-term timer, visible in dark, for multiminute exposures for UV photography.

B. Infrared Radiation

1. Sources

Most photographic lights have high IR emission. Visible light intensity does not normally have to be greater for IR than for regular photography. "Heat lamps" are poor sources of actinic IR radiation. Fluorescent bulbs are very poor sources - almost no IR is emitted.

a. Ordinary photographic tungsten photofloods, 3200°K or 3400°K, are the most efficient incandescent source, having high IR emission. Use for IR photography or IR examination with vidicon or image converter unit.

b. Tungsten/quartz halogen lamps mounted in aluminum reflectors, e.g. 500 watt, 3200°K, incandescent photographic Fresnel spotlight, can provide the intense light sometimes needed for transmitted (Kushel, Studies.) IR examination and photography. Are more efficient than photofloods for use with vidicon. May be too intense for direct use with paper.

c. Fiber optic units (see 6.3.1.B.2) are generally relatively poor IR sources, especially units with long fiber bundles. They can, however, be used to illuminate small areas for reflected or transmitted IR examination or photography where heat is a concern.

d. Electronic flash. Coolness, short exposure time recommend this source for reflected or transmitted IR photography. It is the best source for indoor IR color photography.

2. Detectors

Only the region of the IR quite near the visible red is photographically actinic.

a. B/W IR sensitive film: used to record IR radiation emitted from an object. This radiation is not visible to the naked eye. The film's emulsion has been made sensitive to IR by addition of certain dyes which activate the silver halide crystals extending their spectral response. Each film type has specific properties of sensitivity and contrast (see technical information on film package). Practical useful upper limit exists about 900 nm although extreme infrared-sensitive materials exist for recording IR up to about 1200 nm at longer wavelengths, some intermediate means - usually electronic - is used to obtain an image which can then be recorded photographically (see: 6.3.4.B.2.c IR vidicon unit). These films must be loaded in total darkness and can be fogged by the heat from human hands. They have a short shelf life and require before-use storage in refrigerator or freezer (expensive).

b. Kodak Ektachrome Infrared Color Transparency film. Gives a "false color" image which is a combination of visible light and IR (to 900 nm) images. Very different application than B/W IR materials which require total elimination of visible light; therefore color materials are usually very ineffective in seeing beneath visually obscuring layers and poor in bringing out inscriptions.

The above films are used in reflected or transmitted IR photography. They are exposed in SLR (can use when lights are filtered), range finder (use if lens is filtered), or view camera.

c. IR Vidicon Unit. "Vidicon" is an industry acronym for "video image converter", a highly sensitive video tube housed in a TV camera. The vidicon tube captures the invisible IR wavelengths, and translates them into electronic signals which are rendered visible to the naked eye by generating a black and white image (reflectogram) on a closed circuit monitor. Different models offer different wavelength response (up to 2,200 nm) and resolution. (To 1800 nm: gives better resolution so is normally bought cp. to 2200 nm: extended response but lower resolution).

200mm lens may be used to facilitate the study of details. Less expensive and sharper optics may be obtained using a simple adapter on a camera to convert the TV lens mount to a Nikon or other lens system (T.V.).

To obtain a permanent record: Polaroid camera attachment to photograph reflectogram on monitor, or videotape recorder with optional sound recorder.

d. <u>IR image converter unit</u> (e.g. FJW Find-R-Scope; military sniperscope) A completely self-contained unit which converts the image formed by invisible IR radiation into a visible image. It comprises on objective lens, image converter unit (photocathode),tube with phosphor screen (battery-powered), eyepiece with shield, handle, and battery or electrical power options. Some models feature a built-in lamp/light source with IR filter. Otherwise a separate tungsten lamp with IR filter is used; Kodak Safelight Filter No. 11 supplies the necessary IR radiation for viewing. Optional tripod or head mounting.

Focus is from 6 inches or one foot to infinity. Spectral response is from 400 to 1200 nm; peaks around 800 nm (near IR) depending on model.

Available also as microscope attachment to expand its visual range into the near IR (700 to 1200 nm). Consists of scope, microscope attachment, IR filters; models for use with stereo-binocular microscopes.

3. <u>Filters</u>

Use to cover camera lens or light source to block unwanted visible light and UV radiation yet pass IR radiation emitted, reflected or transmitted by the object. Are required because IR sensitive films are also sensitive to UV and visible light.

Choice of filter depends on sensitivity of film emulsion to particular wavelengths: Kodak No. 87, transmits from 740 nm; Kodak No. 87A, transmits from 880 nm; Kodak No. 87C, transmits from 800 nm. Choice also depends on type and configuration of lights: Corning 9780 for IR luminescence photography, Kodak No. 12 with color film and electronic flash; for photofloods and color film additional filtering is required (see Kodak, Applied IR Photography p. 27)

4. Miscellaneous Apparatus

Easel: to hold object vertically for viewing with IR vidicon unit.

Scanning rig: to allow horizontal and vertical movement of vidicon unit, to facilitate examination of large works and of works *in situ*.

Light box: with incandescent source for transillumination.

C. Beta-rays

1. External source of beta-rays is a Beta-radiography plate, a polymethyl methacrylate (plexiglass) sheet with approximately 5 microcuries of radioactive carbon-14 embedded in it.

2. Dectector/film. X-ray film: Kodak X-OMAT AR film (very high speed radiographic film); also No-Screen (high speed) medical radiographic films; Kodak No-Screen medical has been discontinued. Size of film used is determined by size of Beta-plate.

   a. safety equipment: Storage box for plate. Quarter-inch Plexiglas will completely block Beta-rays (CB). Manufacturer recommends use of shipping container for storage. Government regulations may also apply. Note: 5-mil mylar blocked Beta rays during a 5 hour test exposure. (N.A.).
   Gloves: thick rubber or thin latex containing 30% lead (CB) to protect hands from exposure to beta rays. Latter are very expensive. Polyethylene gloves transmit beta rays.

   b. Other: Dark room with dark red photographic safe light. Light-tight box or opaque black cloth wrapping (for protection from light during lengthy exposure time). Weights.

D. X-rays.

1. External source of X-rays: X-ray machine which will operate in the 4 - 7 kV range, with beryllium window to prevent absorption in the window tube of such very soft x-rays.

2. Detector
X-ray film: For permanent recording. Any high quality industrial radiography film (may be slow, high resolution, very fine grain), e.g. Kodak Type M or AA. If close-up inspection of radiograph is anticipated it may be helpful to use single-side emulsion radiographic films (D.K.).
Video camera: For display. Use vidicon capable of direct conversion of X-ray to electronic image (T.V.).

3. Miscellaneous apparatus

a. Covering material: Must have very low absorption characteristics. Bridgeman suggests Kodak Vacuum Register Board covered with clear acetate sheet 0.025 mm. thick; film must be in direct contact with artifact. There must be no paper, other than artifact, or material of similar density between the tube and film.

b. Other
Stiff, tightly woven plastic screen.
Black polyethylene (garbage) bag.
Vacuum cleaner and hose (to fit hole in register board).
Light-tight container.
May require setting up under safelight.

6.3.5. Equipment for Other Specialized Techniques

A. Dylux

1. External source. Long wave ultraviolet light source such as black light fluorescent tubes (see Radiation sources - UV 6.3.) or 6-watt handheld UV lamp. Source of visible light.

2. Detector. 503
Dupont Dylux photosensitive paper: a yellow coated paper sensitive to both visible light (in the 400-500 nm range) and to UV light (in the 200-400 nm range).

3. Miscellaneous apparatus
   Hinged frame with glass front.

B. Hindeman Collator

6.3.6. Photographic Equipment

A. Cameras
B. Film
C. Lights
D. Filters
E. Tripod for long exposures in gallery conditions.

6.4. Methods of Examination

6.4.1. Direct Observation
Should be starting point of every visual examination. Reveals subject matter, details of artist's technique, structure and color of paper. Reveals age of work, its condition, presence and degree of deterioration, presence of restoration, history of display and storage.

Advantages: large field of view, complete depth of focus, unlimited working distance, familiar image, stereovision, interpretation based on past experience.

6.4.2. Examination Using Illumination - Visible Range

Encompasses daylight, incandescent and fluorescent light sources as they are used in the examination of works of art. Used in combination with both direct and mangified observation.

A. Light Sources

1. Natural Light/Daylight

Advantages: Expansive source of intense radiation. Permits best clear field of viewing to detect minute changes in texture, indicating watermarks, damages, surface polishing from album storage, etc. The most satisfying light source aesthetically/visually; cheap too.

Disadvantages: High UV content, significant thermal qualities. Not a constant light source - shifts and changes constantly depending on angle of sun, conditions of atmosphere and degree of scattering from clouds or dust particles.

2. Artificial Light

Provides standardized illumination which is inert, unvarying, easy to regulate.

a. Tungsten Incandescent

Advantages: Quality and general appearance of the light emitted varies little from one make of bulb to another. Good color rendering properties.

Disadvantages: Significant thermal qualities because of IR emission. If allowed to heat paper, it will accelerate its rate of chemical change and cause desiccation, contraction of heat sensitive materials.

b. Tungsten Halogen

Advantages: Increased efficiency and/or longer lifetime than tungsten incandescent. Good color rendering properties. Slightly whiter light; more compact.

Disadvantages: Emits very high levels of short and longwave UV and much heat. Heat absorbing glass filter will cut down on heat and reduce shortwave UV. Lamp will still emit twice as much UV as tungsten incandescent.

c. Fiber Optics

Advantages: Provides high quality light necessary for working effectively with stereo-binocular microscopes: intense, high color temperature, cold light illumination (prevents heating of object because light source is in physically separate illuminator unit).
Provides flexible lighting with possibility of precise positioning and variety of angles for surface texture observation, etc.
No vibration transmitted because cooling fan for light is in illuminator.

Disadvantages: Expensive.

d. Fluorescent

Advantages: A cooler light source than tungsten; prevents heat build-up problems of that source with possible consequent damage to are work but, n.b., quite a lot of heat is emitted by control unit. The latter should be separated from the lamp where heating is a problem. More efficient in terms of amount of light produced for a given power input than tungsten. Cheaper, longer lasting.

Disadvantages: Luminous efficiency is gained at the expense of color fidelity. Also the quality and general appearance of light emitted differs drastically from type to type. Illumination is flat, diffused and generally difficult to work under. Peaks in spectra cause harsh quality.

B. Examination by Varying the Angle of Illumination

Sources: Diffuse natural daylight and/or tungsten and/or fluorescent artificial light. Higher levels of artificial illumination and dayligh are more satisfactory for examination viewing than low levels but are more harmful to works of art.

1. Normal

Light beams of equal intensity (equidistant from the object) are incident to the surface of the object at approximately right angles to each other (45° to the object) to give as even an illumination as possible.

Reveals design, coloration of paper and of media/ image; gross topography, deformations; damages; stains; additions (accretions, repairs).

2. Raking

Light source is located to one side of the object at a low (raking) angle so that the light is projected across its surface.

Examination with raking light through 360° is often very useful. The standard 10 o'clock position used in photography may only give part of the information. However, for photography or viewing with one eye (e.g. with magnifiers illumination coming from the top or left side will prevent the optical illusion of depth reversal. For photography, the raking illumination should be as even as possible (see also D. Kushel, Photodocumentation, p. 28).

Uses

Surface textures of paper and media cast shadows and show sharp relief. This reveals detailed character adn topography of paper and media, including surface textural irregularities and planar deformations. To study paper, to locate watermarks, felt and mold impressions particularly if an object has been lined; to study prepared surfaces, e.g. metalpoint - degree of smoothness, burnishing, to reveal indentations made in prepared surfaces on paper, especially when drawing line color has faded; to study depth/detail in embossing, e.g. print techniques, blind stamps; to study platemarks - depth and condition of; to determine/study damages to paper - surface burnishing, rubbing abrasion, skinning - and to media - surface burnishing, tenting, flaking; to determine if media surface has been fixed or consolidated.

3. Transmitted

Paper is transilluminated on a light box, or is held a safe distance from a light source.

Uses

To reveal thickness and opacity of paper, variations in sheet thickness, paper structure, method of manufacture, presence of watermarks; may reveal information or drawings on the verso, concealed by linings; may reveal presence of underlying medium (preliminary design), e.g. monotypes under pastel (A.M.); should reveal damages, e.g. tears, holes, thinned areas, losses and previous treatments e.g. repairs, fills; to verify use of the same plate, woodcut or paper mold by superimposition of two images (see also 6.4.7.B. Hindeman Collator)

Not satisfactory for examination of paper structure and watermarks when overlying support is heavily drawn or printed or when primary support mounted on card (see 6.4.6. Radiography).

6.4.3. Magnified Observation

A. Hand-held Magnifiers: Simple magnifiers suffer from aberrations that affect peripheral parts of field of view.

1. Single Lens Magnifiers: For preliminary examination, especially in the field.

   Advantages: Inexpensive, simple to use, compact, very portable, wide field of view, can give upright images.

   Disadvantages: Limited: fixed magnification and foucs, short depth of field, limited resolving power. No built-in light source.

2. Multiple Lens Magnifiers

3. Illuminated Magnifiers

   a. Hand-held flashlight magnifier: Higher magnification of smaller details than is possible with handmagnifier.

      Advantages: Inexpensive, easy to use, compact, very portable.

      Disadvantages: Main disadvantage is low numerical aperture which limits resolving power. This magnifier must rest on a flat surface to be precisely focussed, therefore, it is of limited use with art works unless a protective mask can be laid safely over them. Monocular: continuous use of one eye is tiring.

   b. Magnifiers on adjustable desk-top stands: For carrying out examinations and certain conservation operations under minimum magnification.

      Advantages: Large field of view. Models with stands leave both hands free for work. Long extension arms allow large free work surface. Relatively inexpensive.

B. Stereo Microcopes: Reasonable working distance, good depth of field, wide field of view, 3-D imaging. For observation of artifact itself rather than sample. Stereoscopic effect at low magnification aids in interpretation and manipulation of object.

   1. To aid in distinguishing media (See 2. Media Identification). With a stereo microscope and raking light one may distinguish media through characteristics not readily apparent to the

unaided eye: character of line, surface, (indentations, optical differences, and shape, color and dispersion of particles, etc.)

2. To study details of technique, media distribution.

3. To study details of support and media condition:
   - to test for localized and/or minute areas of flaking paint by touching suspected area with soft 000 brush.
   - to study details of abrasion, other damage, former fixation and consolidation.
   - to identify restorations indicated by different characteristics of lines: reinforcement of original image e.g. drawn lines on printed image.

4. To guide in selection of areas for spot tests.

5. To select, separate, manipulate and mount samples of media and paper fibers for 9. <u>Instrumental Analysis</u>.

6. To test for and perform conservation treatments where precision in local application and/or manipulation is crucial.
   - application of consolidants to discrete areas of flaking or tenting.
   - inpainting
   - realignment of tears.

C. <u>Close-up Photography</u>: (See Kodak, <u>Close-up Photography</u>).

1. <u>Close-Focus</u> (without accessories): 35 mm SLR with 50 mm focal length lens will focus as close as 60 cm to the subject.

2. <u>Close-up</u> (macro lens, extension tube): 35 mm SLR with 50 mm lens extends from where closest focus of standard lens leaves off to <u>x</u>1 (1:1).

3. <u>Ultra Close-up</u> (accessory lenses, spacers, special lens, precise techniques): 35 mm SLR extends range to <u>x</u>6. Steady camera mountings required.

4. <u>Photomacrography</u> (special techniques): magnification ranges up to x50 to show special features that are not usually visible to the naked eye. Includes photography through

stereobinocular microscope. Problem of vibration at higher magnifications may make it difficult to obtain sharp photos. (See 6.3.2.B.2. Floor Stands). For lighting see 6.3.2.D.5. Fibre Optics, Xenon.

5. Specialized illumination

Monochrome Sodium Arc Lamp (narrowly limited wavelength) Properties are similar to those of infra-red light (See 6.4.5).

1) Chromatic aberrations are suppressed; color is abstracted so viewer can concentrate on design elements.

2) Variations in reflection of surface are revealed. Varnishes and glazes are penetrated; retouching and preliminary stages of work may be detected.

3) Invisible doublet in IR band can be used as light source for IR photography.

6.4.4 Examination Using Radiation Outside Visible Range: Ultraviolet Radiation

Luminescence: Certain materials, when subjected to short wave electromagnetic radiation will emit longer wavelength radiation, part in the near UV and part in the visible spectrum depending on the chemical structure of the material. This phenomenon of induced light emission is called luminescence: there are two distinct types, fluorescence and phosphorescence.
Fluorescence (UV induced visible fluorescence): The phenomenon is so-called when luminescence ceases within a very short time (10^{-8} sec.) after the exciting radiation is removed.
Phosphorescence: The phenomenon is so-called when luminescence continues for some time (even hours) after the exciting radiation is removed.

Fluorescence varies in intensity and color in different organic compounds. It also depends on the nature of the exciting radiation. Fluorescence provides information about support and media. It can be seen with the naked eye and may be recorded photographically.

Absorption is a taking in rather than a reflecting of UV and shows up as a deep purple or black.

UV absorption/reflection: UV photography, i.e. photography of UV light itself, not of visible light produced. Requires normal B/W film with visible light absorbing UV transmitting filter (e.g. Kodak 18A - see Filters 6.3.2.A.3.a). Special quartz camera lenses are needed to photograph UV of 320 nm or less (see Kodak, Ultraviolet and Fluorescence Photography, M-27).

UV examination is done in a darkened room. Use special lamps to generate fluorescence, see Lamps 6.3.2.A.1.

A. Uses of UV (generally long wave UV) induced visible fluorescence

   1. Characteristic fluorescence reflection or absorption may help identify specific materials (see: de la Rie, Studies...Parts 1.2.3)

      These include certain pigments, natural resins, oils and fibers. Characteristic responses are cited below. It is invaluable to make up your own card with samples of material which exhibit characteristic fluorescence to use as a reference when examining works under UV because color designation is subjective and different equipment gives different results.

      a. Media (see also: 2. Media Identification):

         1) Pigments include: calcium carbonate - medium purple; titanium dioxide - deep purple; lead white - reddish purple; leaded zinc white - deep yellow orange with slight greenish tint (T.V. with "Black Ray" UVL 56, 366 nm, fluorescent bulb on modern white watercolor paper). Zinc white - yellow green; cadmiums - red and IR; genuine rose madder - red (see de la Rie, Studies, Part 1).

         2) Inks: Some inks appear to have characteristic fluorescence colors; others have the property of absorbing without fluorescing, e.g. iron gall ink which appears black (Fletcher). Dyestuffs in colored inks fluoresce distinctively.

      b. Oil and transparentizing substances: Long wave (ca. 366 nm) causes these to fluoresce - orangish, bluish, yellow-greens.

      c. Varnish: Old varnishes, e.g. mastic, dammar, fluoresce characteristically; intensity of fluorescence may vary with age - orangish, bluish, yellow-greens.

d. <u>Adhesives</u>: Various adhesives fluoresce characteristically; may aid in detection of adhesive residues - e.g. dextrins: blue-white; gum arabic has little fluorescence; glue: yellow. May reveal discontinuities in size, e.g. gelatin.

2. <u>Foxing/mould</u>: UV examination may reveal presence and extent of cellulose/media deterioration resulting from foxing or mould (see Cain & Miller, <u>BPG Postprints</u>, 1982).

3. <u>To study details obscured</u> by darkening of support, faded inks, suspected alteration or removal of inks (bleaching, erasures) including palimpsests, collectors stamps.

4. <u>To detect alterations</u> and discontinuities in the homogeneity of paper, media or varnishes which result from erasures, loss (faint graphite may be enhanced), local treatments, repairs, retouches, fading (metalpoint). Color of old paper changes dramatically upon washing; a trained eye could detect such recent treatment (see M. Cohn, <u>BPG Postprints</u>, 1982).
Has been used to detect residual borates from local sodium borohydride treatment on green paper. Residues fluoresced whitish (would not have been detectable on white paper). Paper rinsed locally until fluorescing matter gone (N.A.).

As materials age characteristic fluorescence changes because of changes in the materials themselves caused by absorption of UV energy over time.

B. <u>Uses of Short Wave UV radiation</u>: Not of particular value in the examination of paper artifacts. Visible fluorescence of most art materials (e.g. resins, oils, paper, parchment) is induced much more strongly by LW UV (UV-A).

C. <u>Equipment</u>:
Protective eyewear
UV lamp: selection of a lamp depends to some extent on application
Photograhic recording equipment: camera, film,

filters.

6.4.5. Examination Using Radiation Outside Visible Range: Infrared Radiation

These energies occur in a broad range beginning at the low-energy side of the visible region of the spectrum. Infrared radiation can often penetrate visibly opaque varnishes and thin paint films to reveal underpaint, drawings, retouched areas, changes in composition. This is because its wavelength is longer than that of visible radiation and it is therefore less efficiently scattered by small particles, e.g. in a varnish film. It can penetrate and overcome the opacity of these layers. (Brill, Light) Also, is not absorbed by most media, oils, and resins even if visibly discolored or obscuring. Absorbency by pigments also may be very different than visible light, (e.g. absorbed strongly by carbon-containing media but not by most reds and whites). N.B. Whites, especially lead, will scatter it, however, reducing tranparency.

Use to:

- Detect information visually incoherent, indistinct or invisible to the naked eye; underpainting, underdrawing, underlying monotypes, slightly obscured layers of pastel (e.g. Whistler, Dewing), obscured inscriptions, underlying carbon-containing media (carbon black ink, graphite, charcoal) which absorb IR strongly.
- Read through back of paper, e.g. read printed page adhered face down to book board (D.v.d.R.).
- Read through dirt (ground-in dirt, heavy grime), provided grime does not have high carbon content.
- Detect discontinuities, damaged areas, retouches, erasures.
- Reveal details of technique, changes in composition.
- May have potential for identifying certain pigments and inks because substances react differently to near IR than to visible light. Use tables of reaction to IR and known samples to identify, distinguish various pigments.
- Reveal superimposition of image layers to facilitate sampling.

B. Reflected Infrared

1. Photography: Electromagnetic radiation in the near IR range (750-900 nm) is invisible to the unaided eye but may be recorded photographically.

Uses:
B/W:
color: "false color" can be used to emphasize the differences between objects or object parts that are visually quite similar

Advantage of IR photography over UV: IR rays do not cause varnish to fluoresce, therefore their penetration is better.

Disadvantages: Not all of underdrawing is revealed. Best results are obtained through reddish, white and brown media areas. Cannot penetrate azurite, malachite.

Equipment:
Camera: view, SLR, range finder.
Film: one with IR sensitive emulsion (see: 6.3.2.B.2).
Filter: dark red to "black" in color, gelatin; not made in glass anymore (see: 6.3.2.C.3.).
Lighting: ordinary photographic tungsten lamps, 3200^{o}K or 3400^{o}K (see: 6.3.2.B.1.).

2. Vidicon Unit (IR reflectography)

The type of light striking the surface of an artwork determines its appearance in terms of the degree of opacity or transparency of the media. The degree of transparency depends on:

- the wavelength of the light; in general, the longer the wavelength the greater the tranparency due to reduced scattering of light. The vidicon tube is sensitive to 2,400 nm. Photographic film cannot record directly in this range; it is not good beyond 900-950 nm.

- the pigment present in the media; carbon black, thick white lead, metallic gold and silver leaf cannot be penetrated.

- thickness of the media

1. Uses

   a. Reveals underdrawings executed in carbon black in Indian and Byzantine miniatures; possibly also those of Persian miniatures; southeast Asian cloth painting, tangkhas. (reflected IR).

b. Reveals printed and written texts hidden by collage elements, secondary supports, etc.

c. Distinguishes among certain inks which are made visible/ invisible because of variations in their IR reflections.

2. Advantages

a. Extended IR range gives superior penetration resulting in better detection of underdrawing than with conventional IR photography.

b. Extends reading of underdrawing (if executed in carbon black) beneath blue, green pigment areas.

c. Ease of access and use.

3. Disadvantages: Lower resolution than conventional IR photography. Equipment expensive.

4. Equipment:
TV camera with IR sensitive vidicon
IR filter lamps
TV monitor
Permanent recording equipment
B/W photographs are assembled into a photographic mosaic.

C. Image Converter Infrared Viewer

Radiation in the near IR is converted into visible light: IR reflected or emitted from subject is focussed by the objective lens at front of viewer onto the photocathode tube which in turn forms an image on the tube's phosphor screen. This image is viewed through the eyepiece and is seen as yellow-green in color (P-20 Phosphor).

For preliminary sorting out of best areas to photograph with IR. Although screen can be photographed with special adaptation systems, I.C. units are generally an examination, not a documentation tool.

Advantages

- Inexpensive to purchase and easier to operate than vidcon.

- Compared to conventional reflected IR, the results can be seen immediately.
- Better penetration through paint layers than with IR photography (Heiber).
- Acceptable resolution.

Disadvantages

- Its IR response and sensitivity is limited compared to vidicon unit.
- Does not penetrate azurite or malachite well.

D. Transmitted Infrared Photography (film) or Transmittography (Vidicon)

When objects are transilluminated the radiation passes through each layer only once and in a direction generally perpendicular to the laminate so its layers have less opportunity to absorb or scatter or otherwise attenuate image-forming IR radiation, cp. reflected IR techniques.

With elimination of surface reflections, apparent transparency is maximized; ability to image differences in IR absorbency of materials is improved (Kushel, Studies, P. 2)

Uses: Similar to reflected infrared but this procedure makes use of a specialized configuration of illuminating source and recording camera (see Kushel, Studies, p. 2). For initial examination the vidicon is recommended because of extended sensitivity and convenience. If maximum resolution is desired, film is recommended for documentation provided that the penetrating IR radiation is of short enough wavelength (not greater than 900 nm).

Advantages: Can reveal, often with great clarity, media hidden beneath other media, even when these are not revealed by X-radiography and reflected IR; also can reveral inscriptions hidden under secondary supports.

Equipment:
Film: Kodak High Speed IR (b/w)
Camera: View, SLR, range finder
Lights: a. 500 Watt Reflector Photoflood plus and electric fan to keep the object cool or
b. Electronic flash unit to reduce risk of damage from heating.
Studio: Basic setup comprises an enclosure for the light and a window or opening over which the object

is placed (See Kushel, Studies, for details).

E. Infrared Luminescence Photography

Infrared luminescence is excited in certain materials when they are illuminated by blue-green light. This phenomenon is invisible to the naked eye but can be detected photographically. The proceedure involves excluding IR from exciting radiation and visible light from the film so that the IR image formed on the film only from radiation emitted by the object.

Uses: Inks, pigments and other materials that appear identical to the naked eye may appear different in an IR photograph. Try this method when a reflection photograph does not yield all the information hoped for.

Use to examine altered documents including differentiation of inks, e.g. ballpoint inks, and to recover traces of erased or chemically bleached inks and of inks on charred, blackended or worn supports.

Use to examine restored paintings. May assist in identification/differentiation of following pigments in oil medium even under thick varnish: cadmium yellow plus barium, cadmium yellow (cp. chrome yellow which does not luminesce), rose madder (cp. alizarin crimson); lead, zinc, titanium whites. So far experiments have only been done with pigments in oil; medium will probably affect luminescence.

Equipment:
Film: Kodak High Speed IR (b/w)
Camera: View, SLR, range finder
Lighting: photographic tungsten lamps
Filters: a. blue-green glass IR absorbing filter (Corning 9780) is placed over the lights to prevent all red and IR wavelengths from reaching the object (which would result in an IR reflection photograph). Protect blue-green filter from heat of bulb with a heat-absorbing Corning glass Filter No. 3966.
b. opaque IR filter (e.g. Kodak Wratten No. 87) is needed over the camera lens.
Studio: must be light-tight; otherwise a light-tight box may be used (See Kodak publication, Applied IR Photography, M-28).

6.4.6. Examination Using Radiation Outside Visible Range: Radiography

Aids in determining condition, identification of material, stylistic and aesthetic investigation. Used to reveal details of paper structure including watermarks, laid and chain lines, thin areas, damages, deterioration, restoration, discontinuities. Discussion is limited to most useful techniques for paper artifacts.

A. Beta Radiography

Beta particles emitted in the distintegration of some radioactive elements have energies that can be used to radiograph thin sheets of material, such as paper.

A precise contact image of the structure of paper is produced using a carbon-14 source and variations in paper density on a sheet of x-ray film. Mass rather than optical density differences in the paper are exploited.

Object to radiographed is placed between the radioactive plate and film and the sandwich is left to expose. Very close contact between object and film is required to ensure sharp image on film (use weights, etc.). Exposure time is relatively lengthy (hours) and depends on mass of material traversed by beta rays; as mass increases, time increases exponentially.

Used to obtain precise contact image to record details of paper structure, watermark, etc. May be used to "search" in area of a partially visible or suspected watermark.

Advantages:

- Produces a precise same-size contact image of all details of paper structure including chain and laid lines, sewing dots plus any damages, resorations or unusual characteristics. Reproduction is so precise that change in the watermark produced by wear (alteration of the wire configuration) can be detected.

- Beta radiographs can be superimposed upon each other and transilluminated to determine whether watermarks are identical, i.e. papers come from same mold.

- Design layer, if thin in physical density, is rarely registered by beta rays, even if in a metallic pigment. Therefore the image does not interfere with the study of paper and watermark.

- Convenient to handle and use.

Disadvantages:

- Plate is very expensive

- Radioisotope license is required to own plate; obtain from Nuclear Regulartory Commission (U.S.A.) or Atomic Energy Control Board (Canada).

- Size of individual radiographs is limited by size of source plate (4" x 4"). Large watermarks may be recorded following the procedures outlined by Ash. 1982.

- Unless film/subject contact is perfect, image sharpness will be unacceptably poor because, unlike in Grenz radiography (6.4.6.B), source is diffused and unfocussed.

- Limited to relatively thin, low density artifacts. Heavy adhesive or thick layered papers will block rays yielding poor contrast image.

- Limited to high speed, lower resolution and coarser grain films because of weak output of source.

B. X-Radiography

Uses soft x-rays (Grenz rays) to exploit variations in absorption of X-rays by different areas of the paper which result from variations in thickness, density, and compostion. The variations in X-ray absorption at low voltage (4-10 kv) will be recorded on film as differences in contrast, i.e. thin (wire) areas will not absorb X-rays to the same extent as paper formed over interstices and thus will appear darker on film.

Film is sandwiched against the paper object so that no other layer, however thin, intervenes. To obtain maximum contact and resolution, this procedure is done in a vacuum.

Caution: with friable media, object must be strong enough to be handled in the dark and, at one point, to be taken off its temporary support.

Used to obtain a precise contact image of all details of paper stucture, similar to that obtained by beta-radiography.

Advantages:

- Image is sharper than that obtained by Beta-radiography since the radiation source is sharply focussed. It is thus much more tolerant of less than perfect film/subject contact.

- Design in carbon ink and most other media (except those containing metallic pigments) does not absorb lower energy X-rays appreciably; therefore design image will not obscure details of paper structure.

- Can produce an image of an entire sheet of paper; only limit is size of film (cp. Beta-radiography where plate is limiting factor). In actual practice, for best results (highest potential contrast) one is limited, by atmosphere absorption of lower energy Grenz rays, to a maximum tube/film distance of about 15 to 20 inches which means a coverage area of about 8 x 8 to 10 x 10 inches with most X-ray tubes (D.K.).

- Can use slow, high resolution, very fine grain films with much shorter exposure times than for Beta-radiographs.

- Can handle much thicker, laminar structures than Beta-radiography; not only better able to penetrate, but image will be much sharper, e.g. use for radiographing paste prints (C.B.).

- Allows for great control over image contrast (small KV change results in appreciable contrast change).

Disadvantages:

- Even more expensive than Beta-radiography.

- Design printed with metallic medium will likely absorb X-rays and may obscure image of paper structure or watermark.

C. Electron Radiography

Generally like Beta-radiography in results. Beta (electron) source is a lead foil screen irradiated with very high energy X-rays (160-250 kv). Much shorter exposure times than Beta-radiography requires since source output is much greater.

6.4.7 Other Methods

A. Dylux 503 Photosensitive Paper

(1) Paper is exposed to visible light projected through the object. This light passes more quickly through the watermark and other thin areas of the paper structure, causing the yellow coating to become white and inert to further UV exposure. (2) The sheets are separated and the Dylux is passed under UV light which causes the unexposed parts of the coating to turn deep blue. A low intensity UV source is best to control rapid development of the blue and maintain contrast between blue and white.

Exposure time depends on time required for light to pass through object to underlying photosensitive paper. Great variations: e.g. (1) 1-5 minutes (2) 1 minute.

Used to record variations in density of paper, watermark, mould impression and their relationship to image.

Advantages:

- Exact size reproduction; this is a dry process - there is no paper shrinkage as with wet processing methods, e.g. Beta-radiography, X-radiography (6.4.6.).

- Inexpensive.

- Quick, easy and very portable method.

- Watermark and design layers are recorded as superimposed images. This is valuable if the exact location of watermark on page is significant.

- Room light (incandescent, 'Cool White' fluorescent) has little immediate effect on Dylux photosensitive paper which is unaffected by up to 10 or 15 minutes exposure. This allows the handling of fragile items in sufficient light and lessens the risk of damage to them. Caution: sunlight will quickly destroy the reactivity of this paper.

Disadvantages:

- Ink creates barrier which reduces or prevents passage of light. Superimposition may obscure significant details of watermark and paper structure.

- Dylux image is impermanent

- The print will last for some years; to obtain a more permanent record, photograph the Dylux print using a red filter, e.g. Wratten No. 25, and high contrast film.

- Thickness of paper may prevent good image from being obtained.

- Image is diffuse compared to that obtained with Beta or Grenz rays.

Hint: Place UV-filtering mylar under object to help cut incidental UV radiation transmitted by fluorescent bulbs. This protects object, helps give a clearer image.

B. Hindeman Collator: Used at Folger Library (Washington, D.C.) to compare Shakespeare folios.

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6.6 Special Considerations

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