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PRESERVATION OF INFORMATION MATERIALS
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# 19th Century Photograph Preservation

## A Study of Daguerreotype and Collodion Processes

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Photography is the process of using light to record images. The human race has recorded the images of experience from the time when painting pictographs on cave walls was the only available medium. Humanity seems driven to transcribe life experiences not only into language but also into images. The birth of photography occurred in the 19th Century. There were at least seven different processes developed during the century. This paper will focus on two of the most prevalent formats. The daguerreotype and the wet plate collodion process were both highly popular and today they have a significant presence in archives, libraries, and museums. Examination of the process of image creation is reviewed as well as the preservation and restoration processes in use today.

The daguerreotype was the first successful and practical form of commercial photography. Jacques Mande' Daguerre invented the process in a collaborative effort with Nicephore Niepce. Daguerre introduced the imaging process on August 19, 1839 in Paris and it was in popular use from 1839 to approximately 1860. The daguerreotype marks the beginning of the era of photography. Daguerreotypes are unique in the family of photographic process, in that the image is produced on metal directly without an intervening negative.

Image support is provided by a copper plate, coated with silver, and then cleaned and highly polished. Placed in an enclosed box, the silver plated support was exposed to iodine vapors to create a light-sensitive surface. Next, the sensitized plate was placed in a camera and exposed to light. The exposure time was originally five to seventy minutes. It was soon discovered that if the plate were further sensitized by exposure to fumes of bromine, chlorine or other compounds of halogen, the exposure time could be reduced to five to forty seconds. This shortened exposure time made the process ideal for portraiture. Image development occurred when the plate was placed in another box at a forty-five degree angle over a pan of mercury that was heated to $167^0$F. Development was monitored by the photographer through a small hole in the box allowed the photographer to watch the development process. The mercury condensed on the plate wherever light hit it during the exposure time. When the image was successfully developed, the plate was removed from the mercury box and washed with a solution of water and common salt or hyposulfide of soda. The solution would dissolve the silver-iodide layer that was without mercury condensation to produce the light tonalities of the image created by the mercury deposits.

The darker tonalities of the image were formed by the mirror-like reflections on the surface of the plate. Because the silver plate acted as a mirror, the image could appear positive, negative or not at all depending on the angle of light and the angle of viewing. The developed image was a mirror image of the subject. Lettering would appear reversed and wedding rings appeared to be on the right hand instead of the left. Daguerreotypists could use a prism in front of the camera lens to alleviate this effect but often chose not to due to the increased exposure time required. "Another improvement in the process was a treatment with gold-chloride which enhanced the contrast of the image, altered the cold hue of the image to a warm one, and helped to mechanically stabilize the delicate film of mercury, thus enabling color application with a brush" (Eaton 1985, 26). After a plate was processed it could be colorized by hand if desired.

Daguerreotypes were available in a variety of sizes that were based on a full plate size of 8 ½ inches by 6 ½ inches. The most common sizes were the quarter plates measuring 3 ¼ by 4 ¼ inches and the sixth plate measuring 2 ¾ by 3 ¼ inches. To protect the delicate silver and mercury forming the image, the plates were put under glass, but separated from the glass by a mat spacer made of metal or paper. This mat protected the image surface from being scratched by the glass. The ensemble of plate, mat and glass was sealed airtight around the edges with paper or an intestine membrane. The ensemble was placed in a protective case made of embossed paper or wood covered with leather, plain or tooled. In 1854, the industry saw the introduction of Union cases made from thermal plastic. The case type and manufacture could aid in dating images, but caution should be employed in verifying the originality of the case to the daguerreotype as subsequent owners could have replaced them.

Frederick Scott Archer introduced another major photographic vehicle in 1851. Archer discovered a functional process using collodion, which was a cellulose nitrate, dissolved in ether and alcohol. The wet plate collodion process was a vast improvement on earlier process and became very popular, very quickly. The process began with a glass plate that was coated with a thin layer of liquid collodion that carried dissolved iodide or bromide salt. Because the collodion was applied by hand, there were often tidal marks and varying thicknesses. When the collodion layer was set, the plate was then immersed in a silver nitrate solution bath. The bath resulted in a silver iodide or silver bromide collection in the pores of the collodion. Maximized light sensitivity required that the glass plate be exposed while it was still wet, hence the process name of wet plate collodion. The plate was developed with pyrogallic acid. Fixing of the image was done by use of potassium cyanide or sodium thiosulphate, which was commonly referred to as "hypo" by members of the photographic industry. This produced a finely detailed and very transparent negative image. The negative was often varnished in order to protect it from airborne reactants. It was the use of wet plate negatives to produce positive images on albumen paper that dramatically affected the photography industry.

An application of the wet plate collodion process was the ambrotype. An ambrotype was produced when a sensitized glass plate was underexposed in the camera, and then bleached after development. This bleaching process produced a white silver image as opposed to the traditional black silver iodine image. In order for the plate to appear positive, it was backed by some sort of black material such as cloth, paper, metal, paint or varnish. The black backing would show through the negative image and the thinnest part would appear dark and the darker areas of the image would appear light because none of the backing would show through. The black backing was avoided occasionally by using dark purple, blue or red glass as the image support. The image produced in the ambrotype was a mirror image like the daguerreotype. Ambrotypes were usually turned over before backing to protect the emulsion and the glass side was facing the viewer, which resulted in correcting the reverse image. Another form of protection for the emulsion was a second piece of glass bonded to the image plate using Canada Balsam, a natural transparent resin, to the emulsion side of the ambrotype. The ambrotypes were often called "daguerreotypes on glass" because they "were also direct positives---non-reproducible, unique items" (Ritzenthaler and Vogt-O'Connor 2006, 35). They were often colored by hand and placed in cases similar to the daguerreotype case. It is a simple observation to differentiate between the two because the ambrotype does not exhibit the same reflective silver surface and an ambrotype image is not dependent on angles for viewing.

A major use of the Collodion Wet Plate process was to produce negative images on glass for printing out positive images on albumen paper. "The wet collodion negatives marked the shift from direct positive images to the negative/positive process" in the photographic industry" (Ritzenthaler and Vogt-O'Connor 2006, 37). Albumen prints that were produced by the wet plate negative "compromise approximately 80 percent of the extant prints in nineteenth-century historical collections in the United States" (Ritzenthaler and Vogt-O'Connor 2006, 38). An advantage of the albumen paper prints was the match between the high-contrast, fine-grain quality of the wet plate to the tonal range and lack of grain in the paper. Albumen papers were the first machine-made papers mass-produced for the photographic industry (Hendriks 1984, 18).

Albumen was an emulsion of beaten egg white and sodium or ammonium chloride. Paper was coated with this emulsion and then dried. After the drying process was complete, the paper could be stored for long periods before actually being light sensitized. In the contemporary literature of the day, albumen paper was described as having a gloss finish. This gloss finish was actually a sheen by modern definition. True gloss finish did not evolve until albumen paper had to compete with gelatin paper at the end of the 19th Century. Immediately before use, the albumenized paper was sensitized by floating it in a solution of silver nitrate. The sensitized paper was exposed in the printing out process by placing it in contact with the glass negative, placed in a printing frame, and left in direct sunlight until the image developed to the desired darkness. Once the exposure was completed, the print was washed in water, toned in a bath of gold chloride and fixed using a hypo bath. The albumen paper was very thin and was commonly trimmed to the edge of the image to minimize the expense of the gold toner. The thinness of the paper made it susceptible to tearing and curling so the photographer often mounted them on card stock.

The most popular form of albumen print presentation during the 19th Century was photographs mounted on cards called cartes de visite. The cartes de visite measured 4 ¼ by 2 ½ inches. A special camera with four, eight or more lenses and a movable plate holder was used to create as many images as possible on a single plate. These images were then developed onto a contact print that was most commonly on albumen paper. The images were then cut apart and mounted onto cards. These cards allowed for the mass production of photographs of prominent public figures. These cards remained popular into the twentieth century, but the albumen images were later replaced with gelatin papers. These card images were often also forms of advertisement for studios and photographers. Accompanying studio and photographer names were often their address, awards and specialties printed directly on the card. This information has become important to the archival dating process of photographic identification.

Preservation and restoration of photographs are lengthy and time consuming processes. The first step in preserving a photograph collection is to minimize or halt further degradation until restoration can take place. Four principal factors contribute to the deterioration of photographs. The Library of Congress Preservation information leaflet identifies them as "poor environmental storage conditions, poor storage enclosures, rough or inappropriate handling that results in unnecessary wear and tear and shelving conditions" (The Library of Congress 2006, 2). If these factors can be controlled, and solutions implemented in an economically feasible manner, it can reduce the amount of additional damage that could occur while images in the collection wait for individual treatment.

Factor one is environmental conditions. Conditions of temperature, relative humidity (RH), light and housekeeping are all part of a collection's environment. The RH, if too high, can result in a gelatin binder becoming soft and sticky. Low RH can result in the shrinking or curling of the binder. Temperature, if maintained at too high of a level, will speed up the rate of deterioration. A combination of high RH and high temperature, especially if compounded with air pollutants, are even more damaging to silver images and can cause fading and discoloration of dyes. Another detriment created by high temperatures and high RH is the growth of mold spores. Mold spores can grow on the image layer as well as on the support layers. Once mold has infested a photograph, it can be nearly impossible to remove without damaging the photograph. Mold will most certainly grow if the RH factor is greater than 60% and the temperature is above

75-80$^0$ F, but can grow at lower temperatures, even in a refrigerator that is too damp. Cycling, where RH and temperature fluctuate, of storage conditions can also result in both chemical as well as mechanical damage to photographs. “The ideal RH for storage of a mixed collection containing historical photographic prints, slides, and negatives is a set point of between 30% and 50% without cycling of more than +/- 5% a day. If only photographs are stored in a given area, 30-40% RH is best” (The Library of Congress 2006, 2). Photographs that contain cellulose should be stored in cold storage with as low a temperature as possible for extended storage. This temperature should be from 50$^0$ - 60.8$^0$F for cool storage, 35.6$^0$ - 46.4$^0$F for cold storage and freezing storage is anything below 32$^0$F. Ideal temperatures can be expensive to maintain so consideration to what is the coldest storage attainable that can be cost effectively maintained must be made.

Air pollution is also an environmental factor that comes in various forms including oxidant gases, particulate matter, acidic and sulfiding gases and environmental fumes. Oxidant gases are particularly damaging to silver photographs. They are produced by the burning of fossil fuels such as coal and oil. Particulate matter such as dust, soot and manufacturing byproducts enter into the collection buildings or areas through windows, doors, heat, ventilation and air conditioning systems. These particulates can settle on shelving, containers and directly on photographs that are open to the air. These particulates can be greasy, abrasive, chemically active or biologically active and can abrade images or interact with the photographic elements in a chemical reaction. Air filtration processes is a primary defense against air pollutants, but care should also be taken to keep the storage area free from ozone creating photocopiers, fume producing cleaning materials or paints and anything with a chlorine component.

Light also contributes to the environmental factor in that photographic materials are vulnerable to deterioration caused by prolonged exposure to light. Photographs should never be permanently displayed as light damage is a cumulative process and by rotating displays, damage can be minimized to a collection. The visible light spectrum of blues between 400 and 500 nanometers as well as ultraviolet spectrum of 300 to 400 nanometers are especially damaging. Sunlight and unshielded fluorescent light fixtures are both sources of light in the ultraviolet spectrum. The lux is a measurement of the apparent intensity of light hitting or passing through a surface. Light levels in a display area should be kept between 30 and 100 lux. Windows and fluorescent lights should be covered with an ultraviolet shield in working areas. Covers of mat board, heavy card stock or dark cloths should be available to cover photographs when not in active use but are out of their storage protection.

The final contributing factor of environmental control is housekeeping. As with all archival materials, damage wrought by insects and rodents can permanently destroy photographs. Keeping storage areas clean, with a policy of no food or drinks can help to minimize pest infestations. Storage containers should be kept off floor level and an intentional pest control plan should be in place.

The restoration process of collectible photographs is a painstaking and delicate process that should only be undertaken by trained professionals and conservators. Each type of photograph has specific requirements due to the physical and chemical process used in its creation. There are however preliminary steps that should be employed for all photographs regardless of the type before any restoration process is attempted.

The condition of the photograph should be documented at the time of receipt. "The documentation should at least fulfill the requirements of the Ethics and Standards committee of the American Institute for Conservation, 'Procedures for Engaging in and Reporting of Examination and Treatment of Works of Art by Professional employees of Institutions'" (Eaton 1985, 124). There should also be a documented agreement with the owner of the photograph if it is anyone other than the institution performing the restoration that clearly states the risks of restoration and waives the responsibility of the institution in the event the restoration is not successful.

A full examination of the photograph should be performed. The physical condition should be examined for identification of the type of photograph and for any physical weaknesses that may factor into the restoration treatment. If the photograph is fragile, then wetting it in a solution treatment could adversely affect the paper fibers and cause the photograph to fall apart. If there are discolorations or stains then they should be carefully examined and identified, if possible, in order to determine the best treatment and to avoid an adverse chemical reaction.

The second and third principal factors of deterioration must be addressed in the storage mediums for the original image as well as the shelving accommodations. These factors are closing related and influence each other directly. The types of storage containers chosen are often dependent on the ability to shelve them appropriately. "Never use enclosures made from unprocessed woodpulp paper, glassine, or polyvinyl chloride (PVC) to house or store photographs" (The Library of Congress 2006, 4). The preferred method of storage is to store the photograph individually in an acid free sleeve that does not contain lignin, dyes, sizing agents, or other harmful additives. Small groups of sleeves can then be placed in folders and groups of folders placed into document boxes and then shelved.

Shelving units and other storage systems are greatly dependent on economic considerations. Care should be taken, if possible, to implement storage furniture made of stainless steel, anodized aluminum or steel with a powder-coat finish as cabinets and shelves made of wood or wood products may contain lignin, peroxides or oils that could migrate or offgas to the photographs.

A photographic copy should be made after the examination to further document the condition of the photograph before any treatment is undertaken. Any loose dirt should be dusted or air blown from the photograph, if it can be done in such a way as to not disturb the image or cause additional damage, before the copy is made. An ultraviolet filter should be used if the copy is made using a photocopy machine. The use of an image copy addresses fourth principal factor of image deterioration. The image copy can be safely used for research and study as an additional means of protection from wear and tear or rough handling of the original.

The restoration process of daguerreotypes has gone through many changes since the first attempts at cleaning and restoration in the 1930s (Table 1). The daguerreotype image is extremely fragile. The surface of the image should never be touched because the image can be removed or altered by the slightest touch of blown air or tactile contact. The primary degradation problem affecting daguerreotypes is surface tarnish. Direct conservation of daguerreotype images should only be performed by a photographic conservator. Many of the daguerreotype cleaning methods resulted in the loss of or irreparable damage to the images being cleaned. “Photographic conservation literature once recommended that daguerreotypes be cleaned with various solvents, including a thiourea phosphoric acid cleaning solution that was in fairly common use. Unfortunately, after many collections had been subjected to this treatment it was determined that this method leaves permanent spots on the image and removes image silver; its use was thus discontinued” (Ritzenthaler and Vogt-O'Connor 2006, 242).

**Table 1. Daguerreotype cleaning methods** (Turovets, Maggen and Lewis 1998, 90)

| | **Years of Usage** | **Damage of the image** | **Damage to the micro structure** | **Use of chemicals** | **Treating of colored and ungilded plates** | **Equipment cost** |
|---|---|---|---|---|---|---|
| Cyanide cleaners | Until 1930-40 | High | High | Yes | No | Low |
| Thiourea cleaners | 1940-70 | High-medium | High-medium | Yes | No | Low |
| Aluminum galvanic cell | 1980-85 | High | No | Yes | No | Low |
| Low temperature plasma | 1982-87 | No | Low | No | Yes partly* | High |
| Electro cleaning | 1985-96 | No | No | Yes | No | Low |
| Laser cleaning | 1995- | No | No | No | Yes | High |

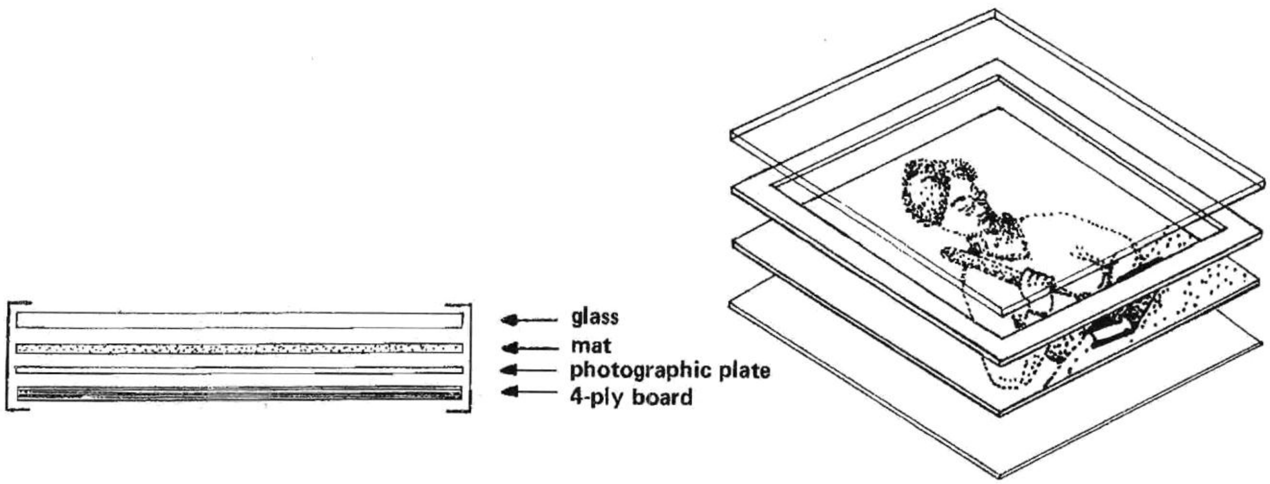
*Areas of colored plates without paint could be cleaned

The image support, glass, mat and case can be preserved and restored in the 19th century formats. A photographic conservator or specifically trained conservation technician can remove a daguerreotype from its casing for restoration purposes Dirt, dust and debris from the surfaces of all layers except the image emulsion itself can be removed using hand held blowers and/or soft brushes.

If the existing glass is stained or dirty it can be carefully washed and with soap and water. Glass cleaners that contain ammonium hydroxide should never be used. It is preferable to reuse the original glass but if the glass cover is missing or damaged, it can be replaced using modern window glass. Modern window glass is susceptible to conditions of high relative humidity and for this reason the vintage glass should be reused if possible.

A damaged or degraded support board can be replaced with museum board that has been cut to the same size as the image plate. The original mat, if made of paper can be possibly restored if it has become acidic. The mat should be replaced if it is damaged or too fragile to continue its responsibility as a separator and emulsion protector. If the mat is replaced it should be replaced with a mat cut to the same size as the original from four-ply alkaline buffered museum board.

**Figure 1**. **Daguerreotype housing package** (Ritzenthaler and Vogt-O'Connor 2006, 241)




Once all the layers surrounding the daguerreotype plate have been restored or replaced then reassembly can be carefully begun (Fig. 1). The layers are assembled and clamped together on the short sides of the assembly. The long sides are taped using a tape that makes use of an inert polyvinyl acetate adhesive. Once the long sides have been taped, then the clamps are removed from the short sides and the short sides are taped. Taping holds the layers together and seals the image package from external pollutants and contaminants. Restoration of the original casing should also be done if possible. Casing hinges should be repaired or replaced. Interior linings were often made of silk or velvet. If the lining has been torn and can be mended than repair should be attempted before replacement is opted for. Exterior surfaces and corners are often scratched and worn over time. If the actual structure of the case is too fragile or damaged to be restored than a replacement can be constructed from a 100% ragboard that is sulfur-free and has a neutral pH. Replacement of the casing should be a last resort option. The completed image package can then be returned to the restored or replaced casing. Once a restored daguerreotype is completed, storage should be done in a carefully considered manner. The case should be wrapped in alkaline buffered tissue paper and then placed in a flat document box or shallow document drawer with the glass side facing down to protect the emulsion plate from future damage should the glass or mat layer deteriorate. The storage environment should ideally be maintained at 40% RH and 65-70$^0$F (Eaton 1985, 134).

In 1982, the Materials Research Laboratory at Pennsylvania State University began a study of the corrosion products and mechanisms involved in daguerreotype deterioration. "This study altered the understanding of daguerreotype deterioration and led to a new approach to daguerreotype care" (Barger, et al. 1986, 15). Electrocleaning can remove tarnish, dirt and debris from gilded daguerreotypes without damaging the image and can undo some of the damage that was caused by earlier cleaning treatments. The steps of the MRL electrocleaning process are as follows:

1. Dry cleaning: using a small vacuum cleaner to suck away surface debris. The image is not in danger because there is no direct contact with the image surface.
2. Water wash: an approximately five minute bath of deionized or distilled water to remove water-soluble corrosion with the bath being rocked to draw contaminants away from the image surface.
3. Electrocleaning: place the daguerreotype into the holder apparatus and submerge in an ammonium hydroxide bath (two parts water and one part ammonium hydroxide) with at least one-inch coverage of solution. The holder is connected to a direct current power supply whose voltage can be adjusted. Starting voltage should be about

two volts but can be increased to a maximum of five volts. A silver wand electrode that is also attached to the dc power supply through a double-pole-double-throw switch becomes the cathode and the daguerreotype is the anode in the first switch position and the second switch position the reverse is true with the daguerreotype as the cathode and the silver wand the anode. The silver wand is passed over the daguerreotype in the solution above but not touching the corroded areas of the surface. When the daguerreotype is in the cathode position, the applied voltage form silver oxide thin films on the image surface. The silver oxide film is extremely unstable due to its thinness, its solubility in the ammonium hydroxide solution and the pH 12 measurement of the electrolyte solution. When the polarity is reversed, the silver ions at the image are reduced to silver and the tarnish is lifted from the image surface. This switching of anode and cathode is repeated until there is no visible longer any visible tarnish removal or additional improvement in the appearance of the daguerreotype.

4. Final washes: the daguerreotype is removed from the electrolyte bath and rinsed under running water. This is followed by rinses of deionized or distilled water. The final rinse is done in acetone. The daguerreotype is then carefully dried with a hair dryer to prevent spotting.
5. Recasing: the daguerreotype is recased using a mat (original or replaced), cover glass (original or facsimile) and archival tape to bind the layers together. The sealed unit is then ready to be replaced in its original case or if the original is beyond repair a replacement case that has been carefully constructed to match the dimensions of the original.

The MRL electrocleaning process has been subjected to extensive field-testing and has shown great promise. The greatest danger of the process is if the silver electrode accidentally touches the daguerreotype image. The direct contact of the wand causes irreversible damage. Another limitation of the process is that it cannot be used on ungilded daguerreotypes or daguerreotypes that have been colored because the immersion in the alkaline solution will damage the color layers.

The most recent process of cleaning a daguerreotype image is with an excimer laser (Fig. 2). Turovets, Maggen and Lewis state that (1998, 89), "Lasers offer a number of advantages when compared to more conventional techniques:

1. Laser energy is a very 'clean' form of energy so that no contaminating materials come into contact with the object.
2. Laser beams can be focused onto very small areas, permitting localized treatment.
3. The laser beam may be controlled with ease and directed into relatively inaccessible places.
4. Most of the laser energy is deposited very near the surface of the target, thus enabling shallow surface regions to be treated without necessarily affecting the bulk."

The type of laser that performed the best in the 1998 study was an ArF excimer laser. The method has proved successful in "cleaning gilded and ungilded daguerreotypes when the daguerreotypes have not been damaged by previous 'cleanings'. Tarnish layers can also be removed from toned or colored daguerreotypes in the areas that have no paint" (Turovets, Maggen and Lewis 1998, 98).

**Figure 2. Daguerreotype cleaned with excimer laser**
(Turovets, Maggen and Lewis 1998, 95)

Wet plate collodion positive images that are ambrotypes exhibit two main types of conservation problems. The black varnish commonly used to back the image will reticulate and the cover glasses are commonly broken.

Reticulating varnish was traditionally thought to be caused by poor quality varnish. The image itself, in order to be seen as a positive is dependent on the black backing, so reticulation causes the image to be dislocated and seen as partly positive and partly negative. Examination of the varnish under low magnification can show white crystals pushing up through the varnish causing eruptions in the varnish. The cover glass deteriorating over time forms these white crystals. “The black varnish sometimes appeared to stretch, forming a raised blister before cracking which implies that some black varnishes can undergo significant plastic deformation” (Clark 1998, 231). These cracks in the varnish may be partially responsible for glass deterioration by allowing damp air to access the glass. A simple solution to the reticulation of the varnish is to introduce a separate black backing that does not alter the ambrotype but does give it a completely positive image. A suitable additional backing can be constructed of “exposed, archivally-processed photographic paper” (Clark 1998, 232).

The white crystals signifying glass deterioration can appear without magnification as a white dust and the misplaced assumption can be that the cover glass is just dirty. Another standard convention has been to replace degrading cover glass with new glass. The replacement of the cover glass has been called into question because the cause of the deterioration was unknown. If the cause of the deterioration could be identified then an effective cleaning treatment could be devised. Susie Clark studied the glass compositions and degradations and was able to determine that most of the damage was the direct result of poor storage environments, not unstable glass compositions. Clark also discovered that there was no direct evidence of a reaction between the cover glass and the backing paints or varnishes. The only reactions Clark observed were directly related “to be between glass and moisture in the air, or between glass deterioration by-products and external materials” (Clark 1998, 236). The suggested method of cleaning original glass is a process of using cotton wool swabs and deionized water and then industrial methylated spirits.  The washing is followed by a polishing using cerium oxide. The removal of the polish is accomplished with clean cotton wool swabs and deionized water. The decision between cleaning the original glass cover if intact and replacing with a facsimile glass cover is a decision that should be jointly made by the conservator and the curator or archivist in charge of the collection.

**Figure 3. Ambrotype before conservation showing a broken cover glass** (Clark 1998, 234)

**Figure 4. Ambrotype after conservation with facsimile cover glass** (Clark 1998, 238)

The National Archives has developed a program of care for its 19th Century collodion negative plate collection. "The primary preservation objectives involved in this project are: cleaning the negatives, removing tape from them as appropriate, duplicating them, rehousing them, and storing them in appropriate cabinets and facilities" (McCabe 1991, 47).

The image side of a collodion plate is extremely fragile and sensitive to moisture of any kind. "Washing collodion plates can be very damaging and should not be attempted" (McCabe 1991, 48). The image side can be dusted with a soft-hair brush if the image shows no sign of softening or flaking. Dirt on the non-image side of the plate can be cleaned with deionized water. There is no evidence in conservation testing that any cleaning solution performs better than water. The creation of duplicate negatives of the highest quality necessitates the original plate to be as clean as possible so that the duplicate image is of the highest quality possible with the greatest amount of retained image detail.

Broken plates are often mended with various types of adhesive tapes. The tape should be removed if it can be done in such a way that the image emulsion layer is not affected. Tape on the non-image side should be removed and any residual adhesive should be removed using an appropriate solvent carefully applied with a cotton swab. Water, ethanol or acetones are the solvents of choice. Great care must be exercised in the use of solvents to avoid any contact with the image side of the plate. Removal of tape on the image side should only be attempted mechanically and without the use of solvents, if removal can be done without disturbing the image. Once a broken plate is cleaned and tape removed, repair using adhesives for glass objects should not be attempted because the action of liquids between glass joints is difficult to control and could damage the image layer.

The process that produces the maximum image quality duplicate of the negative plate is a two-step process. The first step creates two interpositives made by contact printing the negative onto film. One of the interpositives is exposed to produce all the highlight, middle tone and shadow detail so that the entire tonal range of the original plate is matched (Fig. 5). The second interpositive is “exposed to create a positive ‘shadow mask,’ (Fig. 6) which is a high-contrast rendering of only the shadow detail” (McCabe 1991, 49). After the two interpositives are created, they are placed in proper relationship together and then they are exposed together onto another sheet of film in order to create the duplicate negative (Fig. 7). The duplicate negative created is of extremely high quality and can produce images on modern developing-out paper that are nearly as pristine as a print from the original collodion negative.

**Figure 5. The image of an interpositive on film appears very similar to the final print** (McCabe 1991, 71)

**Figure 6. The interpositive's "shadow mask" high contrast rendering of only the shadow detail of the image shown in Figure 5** (McCabe 1991, 71)

**Figure 7. The duplicate negative of the image shown in Figure 5** (McCabe 1991, 71)

The storage of collodion plates is dependent on the condition of the plate. Intact plates in good condition can be stored in a vertical storage system. Plates should be enclosed in seamless four-flap paper enclosures that meet archival standards. Four-flap enclosures allow safe access to the plates by unfolding the flaps as opposed to sliding it out of a sleeved enclosure. The four-flap enclosures should be constructed without adhesive since known deterioration of silvered images can be caused by adhesive seams. If the four-flap enclosure is larger than the plate a support sheet of thin, rigid archival paperboard should be inserted with the plate. The enclosure can then be stored on the long side of the plate on shelves. Plates that are broken or have image damage should be stored horizontally and protected individually with archival paper on sink mats that match the size of the plate. The sink mats are designed to provide the broken plate a rigid horizontal support. The sides of the sink mat are built higher than the plate so the cover does not come in contact with the image layer. Sink mats can be layered three to six deep within horizontal storage boxes depending on the size and weight of the plates. The storage boxes can then be stacked on shelves two or three deep as long as the shelf weight tolerance is not exceeded.

Albumen prints are very prone to deterioration. Damaged albumen prints have the general characteristics of fissures or cupping in the albumen layer of the image. These fissures are often visible without magnification. Any flexing of the photograph during handling can intensify the damage. Current aqueous treatments for cleaning of heavily soiled prints do result in additional damage to the fissures on the microscopic level. "The perceived benefits of aqueous treatment are: (1) aqueous surface cleaning is a quick and effective means for removing dirt and accretions; (2) aqueous immersion is often a reliable method for removing albumen photographs from degraded, damaged mounts; and (3) the washing of albumen prints may reduce the presence of degradation products in the paper support and may decrease the yellow-brown discoloration in the albumen layer" (Messier and Vitale 1994, 257). This damage may be preferred due to clarification of the image that is produced by such methods. Aqueous treatments also reduce the print gloss at a level that is apparent visually. "In many cases this damage may be acceptable, if a greater preservation aim is served" (Messier and Vitale 1994, 276). Direct treatment of albumen prints should only be undertaken by a knowledgeable photographic conservator after a thorough evaluation of the prints in question. Careful consideration as to the possible addition damage should be weighed against the improvements in visible clarity.

Storage housing of albumen prints that have good integrity can be done in individual archival paper envelopes or sleeves. The envelopes or sleeves can be stored in folders and then placed in document cases or filing cabinets. Envelopes and sleeves should be slightly larger than the prints so that there is no risk of pressure on the photograph during insertion or removal. Prints that have flaking or chipped emulsions should be stored in archive quality four-flap enclosures. Unmounted or thinly mounted prints require a rigid support within its enclosure to provide additional protection against further damage. Supports can be made of alkaline-buffered board or heavyweight archival folder stock. If a print is mounted on a support that has curled or bowed, it should not be forcibly flatten due to addition damage being inflicted on the emulsion layer. They should be stored in a flat storage that does not exert any pressure on the mounted print.

The preservation process of 19th Century photographs is a highly complex field of study. Preservation and restoration processes are continually being revised, improved and even discarded as increased understanding and research dictate. Improvements in technology can provide new insights into the creation of completely new processes for restoration. Conservation efforts must combine resources from history and science in order to successfully preserve pictorial artifacts for future generations.

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