Conservation of Photographic Print Collections

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THE CONSERVATION OF PHOTOGRAPHIC materials is an extremely new field; its current primitive state is not at all surprising. Like all other conservation specializations, it has not sprung forth fully formed; but unlike the well-developed conservation specialties, photographs have not been in existence long enough for a craftsmanly restoration tradition based on trial and error over time to have developed. Further, over the approximately 140 years of photography's existence, very few individual prints have been perceived to hold enough intrinsic value as objects for the application of conservation techniques to be seriously considered or attempted; even 20 years ago photographs were "conserved" primarily by copying—and frequently the original photographs were altered, damaged or endangered by the process of making the copies. Since the early 1960s, with increased awareness of conservation generally and with greatly increased market values of some photographs, that situation has changed; curators and archivists are now committed to preserving collections of original photographs, and copying is thought of as an adjunct technique to document and publish collections and to reduce the handling of original material.

This rapid change in approach has created a sudden demand for conservation and restoration techniques applicable to all kinds of photographs, and for people capable of applying them. Clearly, this is a large demand—perhaps unreasonably large, given its suddenness and the enormous complexity and diversity of the materials involved.

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The only pre-existing restoration methodology had been developed in the photographic processing literature, and consisted of formulas designed for use by amateur and professional photographers to correct the results of poor processing or mistaken exposure/development on their own new gelatin materials.[1] These were relatively drastic, last-resort formulas to intensify or reduce the image density of otherwise unprintable negatives, and to remove various stains from negatives and prints. Nevertheless, they were taken over without modification for use on age-weakened, irreplaceable prints in the earlier articles on restoring photographs, which typically provided formulas and instructions for such operations as intensifying calotypes and other prints, removing stains by bleaching and redevelopment, or removing surface "silvering" with strengthened hypo solutions.[2] In practice, these formulas are impossible to apply successfully to prints of value for a variety of reasons—the reactions are uncontrolled and irreversible, for instance, or image structure, particle size and color are significantly changed—and they remain fascinating theoretical possibilities which may be developed into useful treatments in the future only after considerable research. A basic problem is that these treatments are addressed only to the silver constituent of a print, and their effect on other constituents, such as gelatin or paper, is frequently extremely destructive. More recent articles and books on preserving photographs tend to append caveats to such formulas (which are nevertheless included), and they frequently recommend that the curator or archivist contact "an experienced technician or conservator" for such treatments.[3] Still more recently, conservators have begun applying paper conservation techniques to photographs, and while some of these treatments are excellent and all are chemically less radical than the silver treatments, they address only the paper constituent of the print, neglecting the silver and albumen or gelatin constituents, and frequently damaging them.

Concerning the silver treatments, Swartzburg writes: "well-intentioned but incompetent people practicing restoration can cause irreparable damage. Weinstein and Booth point out that even in the hands of an experienced technician, a photograph can be destroyed during the complex restoration process, as uneven results and a high mortality factor are real possibilities."[4] As far as it goes, this assessment of the situation is correct. But surely it is obvious that, whether in the hands of "incompetent people" or "experienced technicians," restoration processes which show "uneven results" and "a high mortality factor" are themselves inherently unacceptable. Their use would not be tolerated in the longer-established areas of paper or painting conserva-

tion. Why, then, is the use of such treatments considered feasible for photographs, which are usually much more fragile, both structurally and chemically, than most paintings or ink and paper prints?

One unavoidable answer and, indeed, a reason for much of our difficulty in thinking about preserving photographs is that we are still in the early stages of a transition from a time when photographs were assigned little "value"; their archival value was unknown since historians and other serious researchers hardly used them, and their market value among art collectors was insignificant. Some of that, of course, has changed. Recently a rare, multiple print panorama from the 1870s, previously owned by a public library, was sold at auction for $37,000—despite the fact that it had been dry mounted to poster board and perforated for hanging by the library. The price made headlines—we are surprised that photographs should bring so much. We are also disappointed that the library did not recognize the "value" of this rare piece enough to mat and frame it properly. The inconsistency of these reactions points to the basic problem: when we are not totally convinced of the value of an object, however we may like it, we expend less of our attention and budget on its care, and we are less critical of treatments done to it.

We have had a hard time convincing ourselves of the intrinsic value of photographs; and it is primarily the marketplace prices that have begun to change our thinking. Photographs are apt to be perceived as a single group—as members of a process class rather than as individual objects; and "photos" is clearly a group dominated numerically by entirely disposable, throw-away pictures. It has been considerably more difficult for archivists and curators to establish and apply archival criteria for value in their photographic collections than in their manuscript or book collections. A major reason is that very few photo collections have yet seen even the beginnings of proper utilization, which would have done much to establish agreed-upon archival "value." While it is obvious that these collections hold important information, few researchers have had well-developed ideas about how to extract or use it. Recent history publications, for example, are much more often decorated than informed by the photographs they reproduce; pictorial information is infrequently translated into words and integrated with other verbal information; and photographs are almost never treated as primary sources of historical information or cited as evidence for theories or ideas.

This, then, is the situation: many collections include very large numbers of photographs which have come from a large variety of

sources and which have a large range of possible uses and archival values. They are generally perceived and treated as members of the generic class "photos," and are all stored and handled alike, usually poorly. If collections of photographs remain in fine condition, it is usually because they have had little use. Though the existence of their information value has scarcely been acknowledged by serious researchers and they are an almost completely unused information resource, their actual physical use and handling are increasing rapidly, frequently for frivolous, repetitious purposes. Very few photographic collections are adequately prepared for handling by the public. Additionally, as physical objects, photographs are unusually fragile and complex, both structurally and chemically, and few successful restoration treatments have yet been developed to repair or strengthen them. It is a real possibility that many preservation/restoration problems for photographs will never be really successfully solved, and that, to some extent, the inherent fragility and incompatibility of their materials will defeat all efforts to preserve them.

There are several lines of action archivists and curators can take to improve this critical situation in their own collections. First, reassessment of one's own judgments about the value of the collection may be needed: to what extent is the information in the collection unduplicated elsewhere? To what extent is its research value to many different areas of study known? The entire class of photographic material is often undervalued because the negative-positive generation system implies replaceability; but to what extent is the collection actually replaceable—that is, to what extent are high-quality, archivally processed and stored negatives of the collection available, and to what extent would replacement prints function as well as the originals?

Second, the most essential physical action one can undertake is to control the environment of the collection: silver photographs are considerably less stable chemically than most other paper items. The American National Standard for the storage of microfilm (the area of photography where requirements for "permanence" have been taken most seriously) best describes the particular requirements of silver photographic materials for increased dryness, environmental cleanliness and air purity.[5] The highest priority requirement of any institution serious about preserving a photographic collection is environmental control. Institutions on very small budgets possibly need such control more than anyone else, since they are less able to acquire similar objects to replace deteriorated pieces, are less likely to have adequate archival negatives from which copy prints can be made, and will be less able to

purchase restoration services in the future. To some extent, low-cost environmental controls are feasible, and are far better than no controls: inexpensive refrigeration dehumidifiers and room airconditioners can be extremely effective in a closed photographic collection room, for instance.

Third, collections need to be properly prepared so that damage is avoided in handling and use. The handling of unprotected pieces should not be allowed. In general, protective packaging should provide a rigid, nonbending support (usually of two- or four-ply nonacid museum board), secure attachment to that support (by hinges of long-fibered Japanese tissue adhered with starch paste, or by folded paper corners), and surface protection (usually a mylar sleeve or encapsulation, or a mylar or tissue interleaving sheet). The package should allow a print to be easily moved and examined without touching the photographic surface. Indeed, the package should obstruct touching, since people have an inexplicable tendency to touch print surfaces unnecessarily, and since skin oils are acidic, attract and hold dirt and affect emulsion deterioration. Requiring researchers to wear white cotton gloves, a practice many photgraphic collections follow, has some excellent results (primarily avoiding the finger-marking of mats and housings), but it increases rather than decreases the need for adequate protective packaging of prints, since the gloves reduce manual dexterity, making handling more awkward and dangerous. Handling thin, unmounted prints while wearing gloves is particularly dangerous.

In the current absence of many satisfactory conservation treatments, the role of archivists and curators in providing intelligent preventive care assumes an even larger importance in photographic collections. In order to provide such intelligent care, very specific information is needed about the varying materials and processes of photography. Because of space limitations, I will cover only the major types of silver prints on paper—salt, albumen, collodion, and gelatin prints.

Preservation Problems Relating to Structure

All of the types of prints included consist of an image of finely divided silver metal contained in or on an organic colloid layer (albumen, collodion, gelatin, or starch), present as a discrete coating or as sizing, on a paper support. All share the problem of the chemical instability of finely divided silver, which oxidizes and tarnishes, as well as the problem of cellulose deterioration, and the problem of colloid deterioration, which is presently entirely unstudied. The physical prob-

lems caused by the delicate laminate structure of the materials are less familiar, though they have probably caused at least as much damage as silver image fading.

Salt Prints

These prints, so named because table salt was used in their preparation, were commonly made in the early years of photography—from the early 1840s through the 1860s—and to a lesser extent, became popular for a second time about the turn of the century as part of a return to handmade materials. To make a salt print, one chose an appropriate paper: a rag fiber paper, smooth-surfaced, well sized and without metallic impurities—generally a machine-made letter paper. The paper was treated with a solution of sodium chloride, dried, and treated with a silver nitrate solution, forming silver chloride in and on the surface of the paper. Silver chloride is a light-sensitive, insoluble silver salt still used as a major component of many modern photographic printing materials. The paper had to be used within a short time of sensitizing in the silver solution; consequently, salt papers were prepared by photographers rather than manufactured commercially. After drying, the paper was exposed to light under a negative to form the image, almost always by "printing out" (i.e., the entire image was produced by light reduction of silver chloride to silver metal, rather than by chemical reduction, termed "development"). Unexposed silver chloride was removed by treatment in a solution of sodium thiosulfate (modern "fixer" or "hypo"). The print was sometimes toned with sulfur or gold, altering the color. Finally, it was washed and dried.

Salt prints have the simplest physical structure of all silver prints: the image of tiny silver particles lies on and within the surface paper fibers and sizing. The depth to which the image penetrates the paper surface varies somewhat from print to print, but is always confined to the top fibers. Salt prints are the only silver prints where the texture and surface of the paper are obvious and unobstructed. The color of their images ranges from yellow-brown to red-brown, brown, and purple-black, but is never neutral gray. The edges of a salt print almost always show some fading (loss of image density), a shift in image color toward yellow, and sometimes a slight silvery surface deposit, visible in shadow areas—these are the typical appearances of deterioration in silver images. Examined under a microscope, the superficial fibers of the paper are clearly visible in great detail without a coating covering them.

Salt prints have many fewer structural problems than albumen or gelatin prints; the major problems are their vulnerability to abrasion

damage and the ease with which dirt is embedded in their surfaces. Both problems are related to the poor storage and handling photography collections frequently receive. Under the microscope, salt prints commonly show roughed-up, protruding surface fibers, as well as local areas, most visible in shadows and midtones, covered by a network of white lines: these are losses where individual surface fibers carrying image density have been abraded off the surface.

Because of the special vulnerability of their surfaces, it is important that salt prints be given adequate surface protection in storage and use. Matted salt prints should be provided with a smooth interleaving sheet, preferably of mylar, between the window layer of the mat and the print; and unmatted prints should be stored in a mylar sleeve with a generously sized rigid backing of museum board to provide support. It is extremely difficult to clean the fragile surfaces of dirty salt prints without causing damage, and many salt prints simply cannot be cleaned. All such cleaning should be left to conservators experienced in treating salt prints.

Because they are among the earliest photographs, products of a time when photography was on the leading edge of scientific, technological and artistic culture, and because they were made for only a short period and were never a medium of massive portraiture, early salt prints have an intrinsic interest and rarity not found in other classes of prints. They are frequently more fragile and difficult to care for as well: since they were made in a period when photography was far more experimental than it was even a decade later, one cannot have the certainty about their processing methods that one has for other types of prints. The fading caused by exhausted fixing baths, which were frequently used for toning in the 1840s and 1850s, is common among salt prints. It is wise to be particularly conservative in caring for salt prints; they should not be exposed to unnecessary light, low-humidity storage is particularly important, and they should be inspected frequently.

Albumen Prints

Albumen prints were first made in the early 1850s, became the dominant printing material from 1860 until the turn of the century, and did not disappear from use until the late 1920s. This is the major printing process of the nineteenth century; prime examples of its use include the classic, large, Western landscape views, such as those of Muybridge, Watkins, Jackson, and O'Sullivan. Prints with glossy surfaces made before 1890 are almost certain to be albumen prints.

Paper stocks similar to those for salt prints were used. A sodium chloride solution was mixed with egg whites, beaten and filtered. The paper was floated on the surface of this solution and dried, forming a thin, even, shiny albumen coating on the surface. From the 1870s on, as a surface of higher gloss became fashionable, papers were frequently floated twice, forming a thicker, shinier layer. Most such papers were commercially prepared; from the late 1850s, papers albumenized in factories were available; by the late 1860s, it was unusual for a photographer to albumenize his own paper. Evidence of hand-coating, such as drips and slight unevenness of gloss, can frequently be found on early prints. Shortly before printing, the paper was floated on a silver nitrate solution, forming light-sensitive silver chloride within the albumen layer. After drying, the paper was exposed to light in contact with the negative until the image was fully printed. Then it was toned with gold, fixed, washed and dried.[6]

In addition to problems with the chemical stability of the silver image, albumen prints show severe structural problems. As albumen coatings age, a network of tiny fissures develops, dividing the layer into very small, unevenly shaped segments. A microscope must be used to see the fissures easily. In a well-preserved, unmounted albumen print, the fissures will usually not have opened and will be difficult to see. Examining a midtone area with raking light and about 20X magnification will show it most easily; internal reflections at the fissure surfaces make the fissures apparent. In poorly preserved, mounted prints, especially prints which have been thickly albumenized, the fissures will be somewhat visible without magnification, and the microscope will reveal open cleavages, through which white paper fibers are visible around the edges of the segments of albumen, which frequently show "cupping" (i.e., the albumen coating pulls up at the edges forming a concave segment). Such a surface, showing cleavage and cupping, is seen in figure 1. The tough, protruding edges of the albumen segments easily catch against other surfaces and are sometimes scraped or pulled away, leaving behind a patch of rough, broken paper fibers. The effects of the fissuring and cleavage are an initial loss of the surface fineness and gloss of the print, a serious weakening of the print (the albumen layer provides much of the physical strength of the laminate), and eventual loss of segments of the image.

Albumen prints can be best identified by the presence of this network of fissures in the thin, shiny surface coating. These prints show the characteristic colors of gold-toned, printed-out silver images, ranging from yellow-browns and red-browns to purple-blacks. The highlights

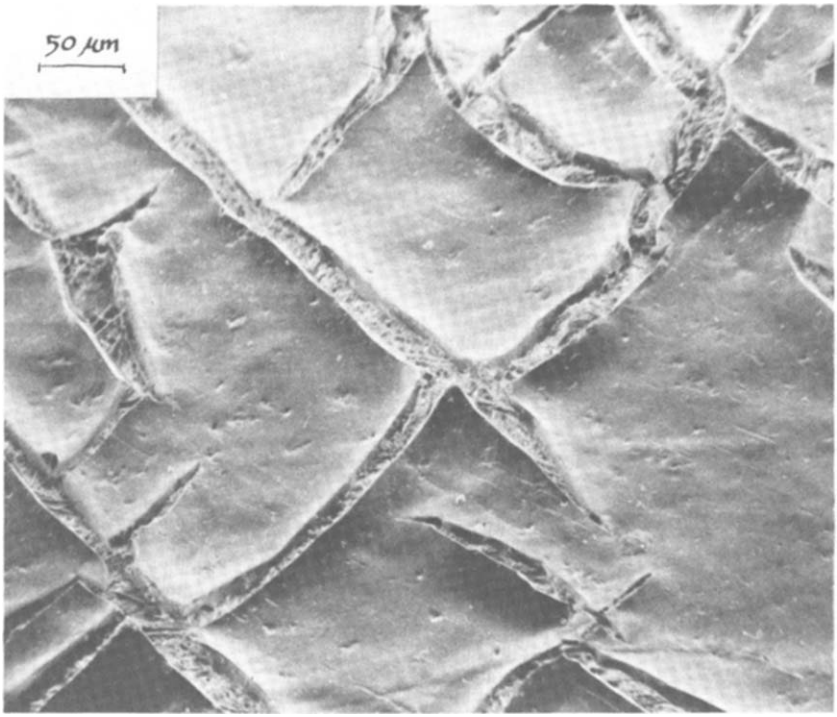

Fig. 1. Secondary electron micrograph of the surface of an albumen print, showing fissuring, cleavage and cupping.

typically have a yellow cast, though later albumen prints usually have a pink tint, which is frequently the result of a pink dye added to the albumen coating to intensify the appearance of gold-toning.

The severity of the fissuring and cleavage appears most directly related to the thickness of the albumen layer. The only albumen prints I have seen completely without fissuring are prints from the 1850s and 1860s, so thinly coated that they have almost no gloss and are sometimes mistaken for salt prints. Yet a more thickly coated spot on such a print will show the usual fissuring and cleavage, and the amount and severity will depend on the thickness of the spot.

The severity of fissuring and cleavage also seems to be affected by the paper stock of the print—particularly the extent to which it expands and contracts upon wetting and drying. Indeed, for most albumen prints, the fissures are oriented in the predominant fiber direction of the

paper (i.e., in the machine direction). This dimensional orientation is frequently pronounced in mounted prints, which were attached in a wet state with water-based starch or gelatin adhesives to dry, rigid boards, and dried under weight, causing much tension in the dried prints. Such prints show cleavages oriented in parallel lines along the machine direction of the print paper, as though the dimension of greatest contraction opened the most fissures. The surface of such a print is shown in figure 2.

Another group of albumen prints shows just as decided a dimensional orientation ninety degrees to the machine direction (i.e., in the cross direction). These prints show an even more precise and regular arrangement of parallel, straight fissures than do the prints with machine-direction orientation. These prints are thickly albumenized, and date from about the late 1870s through the turn of the century. They have an unusually high gloss to their surfaces, and one suspects that the fracturing and fissuring of the albumen was caused in the original finishing of the prints by the use of rolling presses and burnishers. These presses, some of which were heated, consisted of two parallel rollers between which the prints were passed, rather like the wringer on an old-fashioned washing machine. Such treatment would have exerted a moving line of great pressure and tension in the print, capable of creating the fracture pattern one sees now.

There is much variability in the extent of fissuring and cleavage in mounted prints—it seems reasonable that the degree to which the albumen layer had aged before mounting would affect the extent of cleavage. Albumen prints which have been heated and desicated badly, or which have been exposed to years of severely cycling humidities seem to show more severe fissuring and cleavage. The condition is not aided by rehumidifying, as is some brittleness of gelatin emulsions. It seems rather to be an aging process specific to albumen.

When an albumen print is wetted, the fissured layer swells along with the paper support, the cleavages fill in, and their cupped edges relax. As the print dries, the albumen and the support contract again, forming cleavages usually considerably wider than before. Their severity is very much affected by the drying method: the more even the drying and the more freely the print can move and contract as it dries, the less severe the cleavage, though it always seems worse than before the print was wetted. The largest increases in cleavage occur when wetted prints are dried under tension, such as occurs when a print is backed with a pasted support paper and dried on a drying board or other rigid support, or when a print is pasted to a rigid mount board and dried under weight.

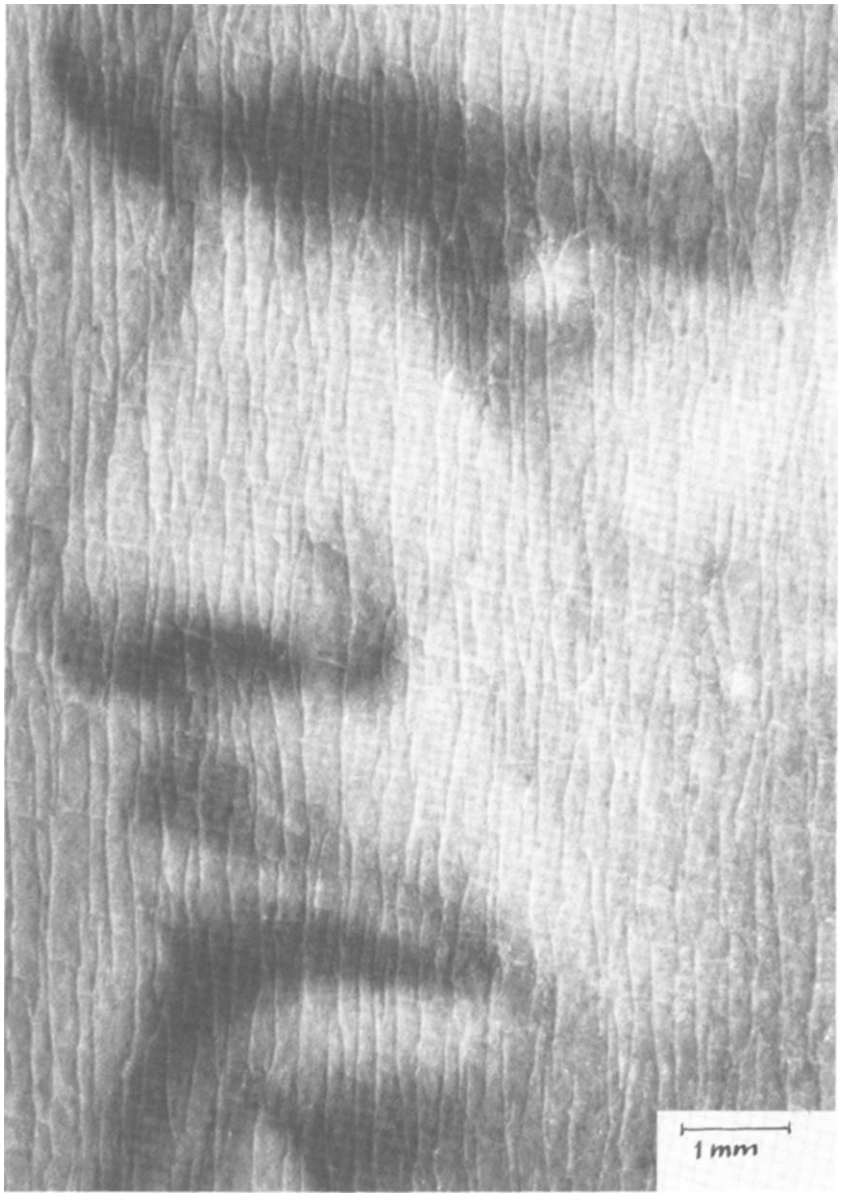

Fig. 2. Light micrograph of the surface of an albumen print, showing typical, severe fissuring.

A second structural problem, connected to the fissuring/cleavage problem, is the strong tendency of albumen prints to curl. Unless restrained, unmounted albumen prints tend to curl into tightly rolled cylinders with the emulsion on the inside of the curve and the axis of the curve parallel to the machine direction of the paper. The thicker the albumen coating and the thinner the paper stock, the tighter the curl. After wetting and drying, prints tend to curl more and are harder to restrain. It seems likely that water treatment of aged albumen prints may cause or promote contraction or shrinkage of the albumen.

These two physical problems—the opening of fissures and increased curling with wetting and drying, and the strong curling tendency of unmounted prints—combine to obstruct most of the treatments one would like to do for these prints. Many albumen prints, for instance, are mounted on brittle, acidic, ground-wood-core boards which are frequently badly warped, torn or foxed; the prints need to be removed from such boards. Yet most albumen prints require mounting, especially the larger ones—the thin, weak paper provides very inadequate support for the tough, curling, brittle albumen layer—and presently one cannot safely remount most albumen prints on new boards. The traditional starch or gelatin adhesives require wet mounting, producing serious cleavages as the print dries. The only presently available alternative seems to be some type of heat-set adhesive—and the heat required for this is damaging to the albumen coating as well. This is an area that will require some inventiveness and much work. It may be that we shall have to abandon the historical mounting format altogether. In the meantime, small prints can be hinged into mats with mylar interleaving sheets tacked in position over them to restrain curling and movement when the mat is opened; or they can be placed in museum board/mylar packages quite successfully. Large prints are simply not safe hinged into mats, however; their tendency to curl and move is too great, and becomes less manageable with increased size. Museum board/mylar packages are safe (specifically, the print is hinged or attached with corner supports to a generously sized four-ply backing, which is then sleeved or encapsulated with mylar), but they do not lend themselves to framed display and interfere with direct visual access to the print surface, and for these reasons many institutions and collectors find them unacceptable.

A third, related structural problem is the difference in stiffness and strength between the albumen coating and paper support, which causes much functional brittleness. Most unmounted albumen prints show small, crescent-shaped "pinch" creases, caused when a print is picked

up or handled without support. Such creases frequently form a new pattern of fissures in the albumen layer, with open fractures along stress lines; consequently, such creases cause permanent damage. Prints are very frequently creased in the machine direction of the paper, and when the albumen fissures are oriented identically, and with few paper fibers lying in the cross direction, such creases quickly become tears. Albumen prints need secure attachment to a rigid support—a mount, a hinged window mat, or a museum board backing in a sleeve—if creases, folds and tears are to be avoided. Sleeves without backings provide inadequate support for unmounted prints, which typically fall partially out of the sleeve at one end, ruffling and tearing the protruding edge.

Extremely gentle surface cleaning, using soft erasers and working under a microscope, is very useful for albumen prints in which the system of fissures has not yet opened. Once cleavages have opened, surface treatments may not be possible.

Collodion Prints

Collodion prints were in common use from the early 1890s to about 1910. They consist of a collodion (cellulose nitrate) layer containing the silver image, a gelatin-barium sulfate layer underlying the emulsion, and the paper base, which is usually similar to that used for albumen prints. Collodion paper was commercially prepared and did not require sensitization before use, as did albumen paper. Collodion prints usually have a very high gloss and a perfectly smooth surface; though matte-surfaced collodion papers were manufactured, they are much less common. The surface has a distinctly "plastic" look and feel. Collodion images were formed by printing out, and their image colors are similar to those of albumen prints.

Collodion prints were made during the period of transition from albumen to gelatin papers, and following the same turn-of-the-century aesthetic, they resemble both. Under the microscope they are easily differentiated, however, since they show no network of fissures, unlike albumen prints; and their surfaces, unlike gelatin prints, are relatively impermeable to water. If a small droplet of water is placed on the surface and watched, a gelatin print will be seen to absorb the droplet and swell, while a collodion print will neither absorb it nor swell—although the droplet may seep away through breaks in the collodion surface if a scratch, abrasion or other damage is present. In this case, one will see a darkening in immediately adjacent highlight areas as the baryta underlayer wets. The diphenyl-benzidine spot test, while destructive, is an extremely sensitive chemical test for nitrates, and is very useful as a

learning exercise in identification; the reaction of a tiny fragment of material will identify collodion prints and nitrate film bases as well.[7]

Less is known about the care of collodion prints than other types of silver prints. Fortunately, they show none of the radical instability of cellulose nitrate film bases. Many solvents soften, deform or dissolve collodion emulsions; any solvents being considered for treatments need to be thoroughly tested before use. Water-based treatments are problematic, since water has uneven, limited access to the emulsion. Abrasion, surface dirt and functional brittleness caused by differences in stiffness between the layers of the laminate are the major problems of collodion prints. They require rigid support and surface protection, which can be provided by museum board and mylar mats and packages.

Gelatin Prints

Gelatin printing materials were first introduced in the 1870s, became popular at the turn of the century, and have been the dominant printing material ever since. Their use spans enough time, with changing photographic fashions and technological developments, that many different types are commonly seen: gelatin emulsions designed for printing out or development have been coated on thin or thick paper stocks; gelatin print surfaces may be smooth or textured, and glossy or matte, in any combination or permutation; image colors range from yellow-browns, red-browns and purples (for printing out papers) to warm, cold or neutral blacks (for developing papers), and many other colors are possible with toning. Gelatin papers have frequently been designed to resemble other printing materials, especially albumen, collodion and platinum papers. They are not difficult to differentiate, however: under a microscope they show none of the fissuring found on albumen prints, and their swelling behavior with water separates them from collodion prints. They usually show some signs of silver image deterioration (fading, yellowing, surface "silvering") which separates them from platinum prints. A miniaturized hydroxyproline test for gelatin can be used for confirmation of visual identifications while one is learning, but is unnecessary in practice.[8]

Gelatin papers were commercially prepared, allowing their structure to be far more uniform and complex than the earlier, handmade materials. Most consist of four layers: the paper base, a gelatin-barium sulfate layer, the "emulsion" containing the image, and a protective gelatin supercoat. The paper bases of earlier gelatin prints were thin rag papers similar to those used for albumen papers; then thicker paper stocks were adopted to better support the thicker gelatin layers. Modern

paper bases are high α-cellulose, wood-fiber papers containing additives to provide wet strength and water and chemical resistance. The first coating over the paper base is a layer of gelatin containing the white pigment, barium sulfate ("baryta"), along with gelatin hardeners, and sometimes optical brighteners or dyes; its function is to provide a smooth, opaque, white base over which a uniformly thick image layer can be coated. The light-sensitive layer, termed the "emulsion," is coated next. This is the functional layer of the paper and contains crystals of silver chloride and/or silver bromide of given sizes, forms and light sensitivities in a gelatin medium, along with gelatin hardeners and various additives to control sensitivity and developability under varying conditions. When the paper has been exposed, developed, fixed, washed, and dried, this layer contains tiny particles or tiny masses of filaments of metallic silver forming the image, contained in a gelatin matrix. The last layer is a protective coating of gelatin and hardeners, called the supercoat. A matte-surfaced paper is usually obtained by adding a "matting agent"—starch or colloidal silica—to this layer. There have been many variations on this four-layer structure: some papers have omitted the baryta layer, others have omitted the supercoat.[9] A common modern variant is resin-coated paper; here the paper base is coated on both sides with polyethylene, and the emulsion and supercoat are coated over the polyethylene layer. Although this material washes more thoroughly in less time, providing better image stability against sulfiding from intrinsic contaminants, its use in archives should probably be avoided since "RC" paper is not a time-tested material. It has already shown emulsion oxidation problems, and should be expected to suffer worse emulsion bonding difficulties and structural problems than conventional papers.

Several major conservation problems are closely related to the laminate structure of gelatin papers. First, the expansion and contraction of the different layers with changes in humidity varies, with the emulsion and supercoat expanding the most, and the paper base the least. As a result, humidity changes cause curling and local plane deformations in unmounted prints. Most archivists are probably familiar with the sight of curled gelatin prints set out on a table, with the image on the inside of the curve in the winter when the heat is on and the humidity low; but when humidity is high, the same prints curl with the image on the outside of the curve. The amount of curl is primarily controlled by the ambient humidity and the thickness of the various layers.

Many gelatin prints are seriously damaged by fluctuating humidity. I sometimes see framed prints which have warped or deformed to the extent that they have contacted the framing glass and adhered to it. Local deformations in unframed prints are even more common. If the warps are recent, such deformations can be removed from unmounted prints by humidifying the print to relax it (or by wetting it completely if the warping is severe—but wetting involves several problems) and pressing it between photographic-grade blotters under a plate-glass weight. The print must afterward be stored flat in an environment of even humidity and restrained from curling, or deformations will recur. It is obviously essential that humidity be controlled in storage and use areas of photographic collections.

The problems of curling and deformation have traditionally been dealt with for gelatin prints by "dry mounting," that is, adhering the print to a rigid mount with a heat-set adhesive in a heated press. In an environment of uncontrolled humidity, however, dry mounting sometimes makes the problem worse—in effect, it adds a still less humidity-reactive layer on the less humidity-reactive side of the laminate, increasing the tension on the more reactive side, the emulsion. I have sometimes seen an emulsion under such tension, because of low humidity, that it had split its paper base in two layers, curling up with the baryta layer and the top half of its paper base, and separating from the lower half of the paper, which remained firmly dry mounted to the rigid mounting board. Much more common are dry-mounted prints stored at high humidity which have separated locally from their mounts in "bubbles" and patches. The emulsion must expand in response to elevated humidity, and the weakest bond between expanding and non-expanding layers will fail, usually at the dry mount tissue/mount interface. I should also mention that dry mounting has several other serious problems, including the difficulty, damage and expense of removing damaged mounts which have been attached by this method, and the damage to emulsion and image caused by the initial heat and pressure of the mount press, seen as color shifts in the image and probably as a factor contributing to eventual brittleness of the gelatin. In the 1960s, dry mounting was considered to be a wonderful archival mounting method for photographs generally, since it formed a barrier between the back of the photograph and the mount, isolating the photograph from "impurities" which might be migrating from the mount. Consequently, many prints of permanent value were dry mounted, including albumen and even salt prints. Today, we can see the irreparable damage caused by such treatment, especially the very severe

fissuring and cleavages in albumen layers, and the darkening, embrittlement and scorching of salt prints—all effects of the heat required for dry mounting.

Dry mounting should be avoided for prints of permanent value, though it is an acceptable and useful mounting method for copy prints (i.e., institution-generated prints intended to be replaced, made from available archival negatives). If prints of value have been dry mounted to archival mount boards, it is important to treat the board as an integral part of the valuable object—it should be protected from handling damage and dirt, for instance.

A second problem caused by structure is the prints' extreme vulnerability to damage from flexing and bending: even slight bending places the exterior layers under strong tensile and compressive stresses, cracking emulsions and creasing and breaking paper bases. Cracks in emulsions are irreparable and occur frequently; one sees them particularly often at the corners of prints and at the center of the right margin, where the thumbs of generations of right-handed researchers have picked up unsupported prints. The emulsion is usually the most brittle layer in the laminate; one frequently sees severely damaged emulsions, with multiple parallel straight, curved or branching lines of cracking, demonstrating the positions and directions of stresses and shocks. The housings devised for gelatin prints must provide rigid support to prevent bending; prints showing signs of emulsion brittleness such as cracking require particular protection.

Little is known about the optimal hardening of gelatin layers for maximum useful life; the effects of various hardeners over long periods of time is completely unstudied. Yet it seems likely that the embrittlement and cracking of emulsions is as frequent and serious a factor in prints' longevity as image fading. Certainly "underhardened" emulsions stick to other surfaces and swell excessively when wetted; while "overhardened" emulsions probably show increased brittleness. Though I know of no experimental work linking hardening and brittleness, it is reasonable that a relation exists. Formaldehyde, the hardener commonly called for in the restoration literature, has been shown to cause "afterhardening"—that is, the hardness of the treated emulsion continues to increase long after the treatment. Until more is known about the long-term effects of hardeners, their use (particularly the irreversible aldehydes) on irreplaceable prints seems foolish.

In the meantime, lack of a safe hardening system creates an obstacle to the treatment of some gelatin prints, since anytime a thick gelatin emulsion is wetted there is a chance that a swelling problem will result.

Uncontrolled swelling, which results in separation of the emulsion from the support around edges and excessive surface softness, can be predicted only partially by droplet tests. Prints should be wetted gradually with careful inspection, and only cold water treatments should be used. In general, wetting any silver print is a serious treatment with wide-ranging effects and should not be undertaken without specific need. Drying wetted gelatin prints poses its own difficulties since foreign matter—loose paper fibers, dirt particles and so forth—easily adheres to and embeds in the soft, sticky, swollen emulsion, deforming the surface. Gelatin prints must be dried almost completely before any drying/flattening method involving contact or weight can be used. The commonly recommended method of drying prints face down on fiberglass screens causes frequent surface damage; prints should dry face up after water droplets have been carefully wiped from their surfaces. Drying or flattening with heat should be avoided.

Dry gelatin emulsions are soft and easily scratched, and their vulnerability to abrasion varies widely depending on the particular gloss and smoothness of the surface, extent of hardening, and presence of matting agents. Some surface cleaning with erasers is possible on some gelatin prints, but it is very delicate work and should only be done under a microscope with raking light. Some solvent cleaning of the surface is useful, but the solvent must be used so sparingly as not to penetrate, or dissolved material previously confined to the surface will spread through the emulsion. The use of water-based solutions (especially containing ammonia, as has sometimes been recommended) should be avoided for surface cleaning, since emulsions swell and soften so easily with water that dissolved material is more likely to be absorbed into the emulsion than removed.

Gelatin prints need the same rigid support, restraint from curling and surface protection that albumen prints need, but providing it is quite a bit more difficult because of the softening and swelling gelatin emulsions undergo at elevated humidities, and because of their moldability in that state. The use of mylar sleeves and interleavings, ideal for other print types, may cause problems if used over gelatin prints in an environment without humidity control—glossy contact spots, called "ferreotyping," and adhesion to the smooth, water-impermeable plastic surface can occur with the combined conditions of a soft or thick emulsion, elevated humidity and pressure. A variety of packaging modifications, with the mylar window lifted up away from the print surface, can be worked out. Interleaving sheets for matted prints of a smooth, nontarnishing, nonacid tissue paper can be used. When humidity can

be controlled at about 40 percent relative humidity, these difficulties with mylar sleeves disappear.

As proteins, gelatin and albumen coatings are vulnerable to mold attack. A storage environment with humidity above 65 percent invites mold growth; because of the possibility of locally trapping excessive moisture in impermeable packages, such as mylar sleeves and encapsulations, their use should be avoided when excessive humidities are possible.

Preservation Problems Relating to the Silver Image

Silver undergoes two major chemical reactions in normal, indoor environments: it oxidizes and it forms silver sulfide, the familiar tarnish layer one removes from silverware. The silver of photographic images occurs in very small particles and bundles of fine filaments, and has an extremely large surface area in relation to its mass, giving it much greater chemical reactivity than bulk silver. While the colloid matrix holding it in position protects the image silver somewhat from materials which oxidize and sulfide it, photographs have a long, consistent history of "fading." Their impermanence has been an enduring worry to photographers since the earliest days of the medium. In 1855 the Photographic Society of London established a committee to study the fading of photographs, which duly reported back to the membership much of what one is told today: that photographs should be very well washed after fixing in thiosulfate, that gold should be used for toning, and that prints should be stored in dry environments if fading is to be avoided.[10] Until rather recently, an invariable claim of each new photographic printing process has been that it was "absolutely permanent."[11] The products of all of these processes have faded, of course, to widely varying degrees; the degree of fading or other deterioration appears to depend on a very large number of individual and process-related variables, most of which cannot be determined, today, by archivists and conservators looking at the aged, faded prints in collections.

The deterioration of the silver image has been seriously studied, using modern techniques, for only one type of photographic material—microfilm. In the early 1960s it was discovered that a large proportion of microfilms (which had then been in archival use for only about thirty years) had formed spots of several distinct types in the outer layers of the reeled film. The problem was studied in the research laboratories of the film manufacturers and at the National Bureau of Standards, and the published results of these studies offer almost the only reliable information on the deterioration mechanisms of silver in photographic images.

After the spots had been carefully examined and characterized and had been reproduced under a wide variety of conditions, it was decided that they had been caused by the oxidation and reduction of image silver at preferred sites, and that the oxidizing and reducing agent had probably been a peroxide formed by the cardboard containers the films had been stored in, under conditions of elevated humidity. Migration of image silver while in an oxidized state was an important factor in spot formation: the distribution of silver in the spots showed either that silver had migrated from positions in the normal grain structure through the gelatin matrix, to form a changed, thickened grain structure with different optical properties (recrystallization), or to form new, colloidal-sized silver particles giving orange and red color effects; or that silver had migrated to the surface of the gelatin, where it formed a reflective surface "mirror."[12] Silver sulfide formation did not appear to be an important causative factor. The spots were reproduced under laboratory conditions by exposing film to peroxides generated by a wide variety of common materials such as deteriorating paper (including the original microfilm cartons), rosin, turpentine, some oils, and hydrogen peroxide itself,[13] as well as by storage in an oxygen atmosphere, and incubation in normal air at raised humidities and temperatures. Hydrogen sulfide, ammonia and sulfur dioxide, common in polluted air, promoted the attack of atmospheric oxygen on silver images; and ozone and its derivatives, including the nitric oxides it generates in smog, paint fumes, some plastics, and bleached wood, were all cited as oxidants and sources of oxidants commonly present in archive storage areas and likely causes of spot formation.[14]

Oxidation of silver photographic images has a distinct appearance: when test strips of silver print papers are exposed to hydrogen peroxide vapors in a closed jar, the first effect observed is a shift in the hue of the image toward yellow, seen in areas of minimum silver density (highlights). As the image oxidizes further, spots form in middle silver density areas (midtones) where the reaction occurs unevenly, and the highlights fade to pale yellow tones. Then midtones fade evenly and shadow areas show color changes toward red tones, spot formation and finally uniform fading, leaving the image in pale gradations of yellow and brown. This is true of albumen and salt prints as well as gelatin prints. Using similarly prepared sets of prints, gelatin prints show early hue shifts first, salt prints complete fading first, gelatin prints complete fading last, and albumen prints are intermediate. Heavily gold-toned prints gain a pink hue in highlight areas and fade much less than lightly gold-toned or untoned prints. When removed from the test atmosphere,

the oxidized prints show very noticeable light sensitivity, darkening considerably with light exposure.

Outside the controlled atmosphere of the dessicator jar, oxidation rarely occurs without some sulfiding, and takes place much more slowly, less uniformly and less completely. One sees the characteristic shift in image hue toward yellow in the highlight areas first, as well as density losses. In badly oxidized prints, the highlights will have faded to pale yellow tones and the midtones will have a grainy, mottled appearance, giving a two-color effect—gray or brown grains against a light yellow background, or vice versa. This pattern is typical of salt, albumen, collodion, and gelatin prints. A further, very conspicuous symptom is the formation of a surface layer of silver, a silver mirror, which is most obvious in the deepest shadow areas where the largest amount of silver is located. Mirror formation is most pronounced in gelatin prints where the conditions of elevated humidity which commonly promote oxidation also swell the gelatin matrix, aiding silver migration. It occurs in albumen prints also, but only to a small extent in salt prints, and only if the print paper is heavily sized. Oxidation damages typically occur much more strongly at the edges of prints, which are exposed to increased flow of moist, polluted air by most storage systems. Strong fading, yellowing and mirror formation, which are sharply limited to edges, are frequently seen in tightly closing albums of albumen prints; if the pages of such an album are warped, forming a gap of air along one edge, the prints will be found to have increased oxidation damage in the gap area.

To minimize oxidation of silver in photographic collections, the conditions specified in the American National Standard PH5.4-1970 for the storage of archival microfilm should be duplicated as closely as possible.[15] The relative humidity should not exceed 40 percent—this is the most important single condition. For general photographic collections, a small range just under 40 percent is desirable, since the brittleness of the colloid layers and paper bases of prints increases with lowered humidity; the importance of providing rigid support for prints becomes correspondingly greater. The temperature should not exceed 70°F and should be even. The air should be filtered against oxidants and pollutants. Wooden cabinets and frames should be replaced with metal ones. Deteriorating paper and cardboard storage materials should be replaced with clean, buffered, "archival" papers. Sometimes the most deteriorated papers in a collection will be the mounts of albumen prints, for which a satisfactory remounting method has yet to be developed; these mounts should never be stacked on top of other prints—a barrier of

mylar or some other material should always be present as an interleaving.

The transformation of the silver image to silver sulfide is the second major deterioration process. Silver sulfide is one of the most insoluble and stable of the silver salts, forming readily whenever oxidized silver contacts a source of sulfide. It is therefore closely connected with silver oxidation in photographic images. Silver sulfide concentration typically increases along edges of prints where oxidation has occurred, and surface mirrors are usually composed of mixed silver and silver sulfide. Because of its ease of formation and stability, as well as the widespread availability of sulfides in polluted air, silver sulfide is the natural end product of a variety of image deterioration processes.

To minimize sulfiding in photographic collections, oxidation must be minimized and the availability of sources of active sulfur must be reduced. Storage and matting materials containing active sulfur must be rigorously avoided. This requirement is more difficult than it appears, since, in general, the manufacturers of archival storage materials have not concerned themselves with the requirements of photographic materials. It should be understood that the word *archival* as applied to storage materials means only "nonacid"—it does not imply freedom from peroxide sources or active sulfur sources, though these are probably more critical requirements for the storage of photographic materials than is neutral pH. Peroxide-forming materials may perhaps be avoided by using paper from an adequately clean pulp—most archival papers should satisfy that requirement. But the presence of active sulfur must be tested for, using a silver tarnishing test such as that described by Collings and Young.[16] Surprising number of archival materials contain active sulfur, including some art papers, interleaving sheets, polyvinyl acetate emulsion adhesives, and Japanese hinging and repair papers. In my own tests, Permalife bond paper, unmodified cooked starch paste, Elvace 1874 PVA adhesive, the heavy, gray buffered Hollinger paper used for negative envelopes, and most nonacid rag museum boards have given negative results; but such a small amount of sulfur causes such large visual effects that its presence as a contaminant rather than a constituent must be considered. Probably each lot of material ordered should be tested before use.

Unfortunately, a major source of active sulfur for sulfide formation is frequently contained in photographs themselves. Thiosulfate, the silver complexer used as "fixer" since the early days of photography, itself forms a layer of silver sulfide on the silver image particles, either during fixation or immediately thereafter. Residual thiosulfate, left

behind in the print after washing, will continue to react with image silver, forming silver sulfide until either the thiosulfate or the silver is exhausted. This is certainly as true for albumen and salt prints as for gelatin prints, but because of the thickness and retentiveness of gelatin paper layers and the formulation of fixing solutions, thiosulfate retention is, in practical terms, a problem primarily of gelatin prints.

The problem of thiosulfate removal divides into two subproblems. The first is thiosulfate closely associated with silver: thiosulfate dissolves silver salts in the fixing bath by forming three successive complexes with silver ions. The first complex is relatively insoluble; the second and third have increased solubilities, allowing these complexes to diffuse away through the gelatin and to be removed by washing, but they can only form when plenty of excess thiosulfate is present. If a print is fixed in a less-than-fresh thiosulfate bath, much of the first insoluble complex will remain in the print, where it will eventually break down to silver sulfide. This complex is distributed throughout the image, the amount depending largely on the exhaustion of the fixing bath, and the silver it contains is unrelated to the image; when it breaks down it is seen as the yellowing of highlights and margins—areas where little or no silver should be present. This problem is easily prevented in the processing of new prints by using a succession of two or even three fixing baths and replacing them methodically. The problem can be cured in previously processed prints if they are properly fixed and washed before significant breakdown has occurred; once silver sulfide has formed, no amount of fixing and washing is useful.

The second problem is thiosulfate ion which has not been removed by washing. Thiosulfate is strongly retained by the gelatin of the emulsion and baryta layers as well as the paper base—the more so as it is usually present with an alum hardener in an acid solution—and it is extremely resistant to washing out. This thiosulfate breaks down through a series of polythionates to form silver sulfide as it contacts oxidized image silver, causing visually apparent fading and yellowing of the image. A print which retains thiosulfate will typically fade in highlights and midtones, but the clear highlights and margins will retain their whiteness. This problem, also, is not difficult to prevent in processing, if one accepts that specific procedures must be followed (wash times of at least one an hour, in a washer of efficient design, using water of 70-75°F, after proper fixing procedures—minimum-length, fresh, multiple baths with plenty of agitation—and the use of a "washing aid"—a salt solution which helps remove thiosulfate by ion exchange; Kodak Hypo-Clearing Agent is the commonest example).

The problem can also be corrected for older prints by careful rewashing procedures, though no older prints should be expected to withstand the efficient but rough washing methods used for new prints; much gentler methods must be devised. The treatment must be done before a significant amount of the image has been converted to silver sulfide.

How can prints which contain unreacted residual silver-thiosulfate complex or thiosulfate be identified so that they can be treated? There are only two possible tests applicable to prints which have not been recently processed; they are old, qualitative spot tests, one for residual silver (the silver-thiosulfate complex) and one for residual thiosulfate. These tests are recommended throughout the photographic conservation/restoration literature and in generations of Kodak guides to black-and-white processing methods, as "Kodak Residual Silver Test Solution ST-1" and "Kodak Hypo Test Solution HT-2."[17] Unfortunately, there are major problems in their use. They can only rarely be used for prints of any value since they are stain tests—the stain each forms is unremovable silver sulfide, identical to the naturally occurring material which the tests are intended to estimate. (The residual silver test, composed of sodium sulfide, provides free sulfide to react with any silver ions present; the residual hypo test, an acidified silver nitrate solution, provides free silver to react with any thiosulfate, thionate or sulfide ions present.) One is directed to apply the test solution to a margin or highlight area of a print since a white area is needed to see and evaluate the stain adequately. Few older prints retain their margins; many do not even have clear highlight areas in the pictorial space. Moreover, the test droplet cannot be too small, since plenty of solution must be available to diffuse through the emulsion to get repeatable results. Whatever the result of the test, one is obliged to wash the print very well after testing since the test solutions introduce materials that must be completely removed if the print is to have acceptable storage stability: silver nitrate forms purple and black stains with light exposure, while sodium sulfide is one of the worst possible contaminants of silver images. There are problems with the accuracy of the test as well. For example, the residual thiosulfate test is necessarily applied to highlights, but much more thiosulfate is retained in areas of high silver concentration—shadows. Margins may be expected to be significantly better fixed and washed than the centers of prints, since most processing/washing systems pass more solution over edges than centers of prints. Moreover, nonuniform fading from local variations in residual chemicals is often seen in older prints and may be considered characteristic of very inadequate fixing and washing methods: it is impossible to

be certain that test results in one area will hold true for other areas of a print. The effect of retention of silver and thiosulfate by the baryta layer and paper is not assessed by the spot tests, but is known to be a large factor in the stability of prints. Finally, though the tests are routinely recommended in the photographic restoration literature for application to older prints, no attempt has been made to interpret the test results for older print materials: what, for instance, constitutes an acceptable stain level for the residual silver test? Clearly a correlation between test results on specific types of materials and behavior in accelerated aging tests is needed before one can move with any certainty from test results to treatment recommendations.

One area of exception, where the residual silver test is adequate and needed, is the identification of prints which have been processed by stabilization, a fast-access processing method which chemically stabilizes nonimage silver salts against light reduction, instead of removing them. A stabilized print gives a dark stain with even a very small droplet of sodium sulfide reagent. Such a print should be refixed and thoroughly washed before being added to a print collection, and any materials it was packaged in should be discarded. Please note that both the sodium sulfide and the silver nitrate reagent solutions are unstable and must be mixed fresh for use; a deteriorated sodium sulfide solution will give a false negative test result—a solution more than a week old should be tested against a print known to have been processed by stabilization.

Can one make useful judgments about residual chemicals based on a visual examination of prints? This is possible only to the very unsatisfactory extent that once the residual materials break down, forming silver sulfide, their effect becomes visible. But one cannot tell whether a process has gone to completion or whether one which shows no symptoms will occur in the future. The rate at which residual chemistry breaks down to silver sulfide, producing visible results, is largely controlled by humidity, increasing greatly with increased humidity—as one would expect; increased humidity increases the mobility of thiosulfate and thionates in the swollen emulsion, promotes the oxidation of the silver image and the migration of oxidized silver, and results in increased formation of silver sulfide. (Newly acquired gelatin prints for which humidity conditions are likely to have increased should probably be inspected with particular care and frequency.)

My own experience has been largely with nineteenth- and early twentieth-century fine art photographs, where the application of staining, contaminating or destructive tests is impossible. I have come to regard a certain amount of fading, yellowing and mirror formation as

normal among older photographs; particularly in albumen prints, such conditions seem usual and generally stable (i.e., not progressing perceptibly). With a few notable exceptions, the photographers whose prints are found in fine art collections were extremely competent workers whose toning, fixing and washing methods were excellent; indeed, many were the processing experts and manual-writers of their day. In the absence of accurate, usable tests, with the current undeveloped state of photographic conservation knowledge and practice, and given the importance of the individual prints as art and history objects and as evidence of process and technology, it has seemed absurd to undertake treatments of no proven need or benefit for a particular print, which may alter the state or distribution of image silver and obstruct the efficacy of future treatments. Refixing a print, for example, with much oxidized but not sulfided image silver (and such prints are not uncommon, their condition indicated by a slight tendency of the image to print out as the print is being examined), would have the effect of removing oxidized silver from the image, losing the possibility of reducing it back to its proper state by a treatment to be devised in the future. Present treatments are so undeveloped that it seems foolish to utilize any that would tend to obstruct future possibilities.

The situation may be different in other types of collections: local history collections, for instance, may consist primarily of recent silver-gelatin prints which have come from sources notorious for "quick-and-dirty" processing—newspaper archives, for example—and which have small individual values as original objects. In such a collection it might be reasonable to "reprocess" much of the collection, if one could know that the treatment was necessary and effective. (Again, however, the first step is control of the environment—lower humidity will decrease sulfiding of poorly processed prints as well as oxidation of all prints.) The photographic restoration literature directs one to reprocess prints by refixing, treating in a washing aid (a salt solution, usually buffered sodium sulfite—Kodak Hypo-Clearing Agent, for example), treating in a hypo-eliminating solution (a hydrogen peroxide and ammonia bath which functions by oxidizing thiosulfate to sulfate), and washing, exactly as though the prints were new prints being "archivally" processed.[18]

To obtain some indication of the extent of residual chemistry in a "worst possible case" collection, and the effectiveness of corrective treatments, I recently tested sixty silver-gelatin snapshots processed by photofinishers, all dated and evenly divided among the 1920s, 1930s and 1940s. They were chosen to represent a range of materials and condi-

tions. All had clear margins on which the ST-1 and HT-2 tests were performed.

Few of the prints showed the presence of residual silver: though the test solution caused varying slight stains on all prints (the solution always causes some stain—the test is called positive if the stain is darker than "a barely visible cream tint"[19]), after the prints had been washed (to remove colored components of the stain other than insoluble silver sulfide) and dried, no stain at all could be seen on thirty-six of the prints, a barely perceptible stain was present on seventeen, and seven showed easily visible light yellow stains. When strips of the positive-testing prints were fixed, hypo-cleared and washed, and then retested, no perceptible stain was formed. In this group of prints, aged forty to sixty years, the presence of residual silver from the silver-thiosulfate complex was slight, and could have caused significant staining in only seven prints. It is likely that the complex had already broken down fairly completely in most of the prints. Refixing was effective in reducing the response of those prints which had formed test stains.

In contrast, nearly all the prints showed significant amounts of residual thiosulfate to be present (90 percent), and some prints stained very deeply (patch #3 and higher on the Kodak Hypo Estimator[20]). Strips of the prints were given various treatments and retested: washing alone was very effective in reducing the response of prints to the test (bringing subsequent tests to below patch #1 on the Hypo Estimator). Hypo-clearing and washing was about as effective as washing alone. Refixing, hypo-clearing and washing was slightly more effective than washing alone for most prints, but for some prints the stain was increased (i.e., new hypo had been introduced and retained). Refixing, hypo-clearing, hypo-eliminating, and washing was consistently the most effective at reducing the stain level (though the actual difference in stains was slight), but hypo-elimination also appeared to bleach the image noticeably in highlight areas of many prints, and swelled the gelatin as well, promoting some "frilling" (separation of the emulsion from the base at the edges) and physical damage. All washes in this experiment were done by changing the water every five minutes for an hour, draining the prints completely between baths, and agitating the trays gently. The fixing solution was a plain hypo bath of 100 grams sodium thiosulfate (pentahydrate) per liter of solution, divided into two successive baths. The hypo-clearing and hypo-eliminating baths were the standard solutions.

These results may provide some indication that refixing may be less necessary than assumed, and washing more effective than hoped. But it

is only a first step—clearly some work is needed to modify the procedure for older prints, maximizing the benefits and minimizing the damages of the treatment, as well as improving the testing methods, before reprocessing—the simplest of the silver treatments—can be considered recommendable for application to collections.

Some types of treatment *are* presently appropriate—emergency treatments, for instance. A gelatin print which is yellowing and fading before one's eyes probably should be refixed and thoroughly washed. (But it should also be stored at lower humidity; and salt prints and all experimental prints are another matter—here, dark, low-humidity storage, expert advice, and perhaps second opinions are in order.) An albumen print severely endangered by its mount, which is perhaps badly torn, should be removed from that mount (and given a temporary protective package or mat). There are certainly many treatments needed immediately, as well as some treatments not likely to be soon improved, such as mending tears, removing tape residues and cleaning surfaces. But it is certainly far too early for institutions to undertake massive or routine treatments of their photographic collections.

In the foregoing discussion of treatments, I have been considering treatment options per se; I have not considered who should perform them. In my own work, I see the results of much ill-conceived, damaging treatment, performed primarily by photographers (who have been the traditional "restorers" of photographs) and framers, but increasingly by paper conservators as well. Because of the chemical and structural complexity of the materials and the new and therefore experimental nature of the field (that there exists no established set of "good" treatments which one can draw on as needed), treatments should be very conservative and should be left to people who are equipped to understand the chemical and physical consequences of the treatments, as well as experienced in the treatment of photographs. Especially complete records of treatments should be kept.

Photographic materials are the products of a far more complex technology than are most types of successfully preserved art and record materials; it is only reasonable that a more complex technology is needed to study them and to develop and evaluate conservation processes for their care. It seems unlikely that the field can improve in the depth of understanding of problems and the development of appropriate treatments beyond an initial "easy" stage unless major scientific aid can be found. Therefore, an additional essential line of action for archivists and curators in the conscientious care of their collections—along with environmental control and proper preparation of the collec-

tion for handling—might be the very strong encouragement of conservation research facilities, such as that at the Library of Congress, to include the problems of photographic materials in their present programs of investigation.

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11. The current situation is not an improvement: manufacturers make no claims for permanence any longer, even for their microfilms; and the public is so naïve or unconcerned with permanence that portrait and wedding photographers routinely use color negative-positive materials, the least stable of all photographic materials, to produce what were once assumed to be permanent family records. In the last few months, a color dye film material has been introduced for making black-and-white negatives, and the author of a magazine review concludes that "there are strong reasons for suspecting that a chromogenic b&w negative [the color dye negative] will probably last very nearly as long as its silver cousins." (Bob Schwalberg. "Revolution in Black-and-White." *Popular Photogra-*

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19. *Preservation of Photographs,* p. 16.

20. The Kodak Hypo Estimator is a set of four color patches for rough estimation of the adequacy of washing in a variety of new materials, when used with the HT-2 reagent.