PHOTOGRAPHS FROM THE 19th CENTURY:

A Process Identification Guide

William E. Leyshon

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"I have read all of some of the books, and some of almost all of them, and the rest I'll get to, one of these days"...

Bookmark inscription, Prescott Public Library, Prescott, Arizona.

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The FOTOFIND program uses QBSCR screen routines written by Tony Martin.

Preface

This book is a guide to the identification and dating of all the known types of black and white 19th century photographs on all bases. It includes common commercial types as well as rarities and home-made varieties. The aim was to make this a self-sufficient reference for such readers as educators, students, historians, collectors, museums, photographers, antique dealers, and individuals seeking to identify and date family photographs.

The book began as a compilation of identification characteristics of historic photographs from local sources, and the search widened as one reference lead to another. Eventually it became apparent that, while many excellent references exist, no single source listed recognition data for all known types, common and rarities. We hope the book fills this need.

How to use this book

The plan of the book provides several levels of information, varying in depth and technicality. Part One, Chapters One through Thirteen, contains technical and historical information on the processes, with emphasis on recognition of the types of photograph. Part Two, Chapter 14, is a quick reference area that contains five independent sections, including condensed descriptions in Section 3 that are listed according to base materials for quick reference. Section 4 describes an interactive computer program called FOTOFIND, written as a companion to this book. It is intended to be a complete identification database and also a learning tool.

Since not all readers have easy access to comprehensive libraries, multiple references are given to improve the chances of finding more information if needed. It is not possible to provide current information on all available books in print; libraries and booksellers maintain up-to-date listings of this information.

In addition to contemporary references, a number of 19th century works have been listed, such as original references and reprints of classic 19th century books that are excellent sources of unabridged information. To aid in topical research, the bibliography is also listed in broad categories in classified form.

Introduction

Anyone who is interested in the collection, study, and preservation of our photographic heritage is likely to encounter problems in dating and categorizing specimens. For example, are unknown pictures 'collotypes', 'calotypes', or 'kallitypes'? The information may be needed to date them, to determine their market value, or simply to put correct labels on them for display.

The literature on historical photography is voluminous, and it can be a tedious task to sort through chronological descriptions in narrative history books in search of a description that seems to match a picture in question. There are several very useful flow-chart guides, for example Coe & Haworth-Booth [32], Gill [67], Reilly [122] and Rempel [124]. But such references generally do not attempt to include all known types of pictures with details arranged for identification. Taft [140] remarks " Anyone who finds the profusion of types bewildering should at least be grateful to the author for not mentioning all the types that flourished during the first quarter century of photography." Unfortunately a reader may not be grateful to find that the description of a particular picture is one of those omitted for convenience.

The number of major and minor variations produced in only sixty years seems nearly endless, and some simplification in classification is necessary in a manageable identification system. This book attempts to improve on the degree of completeness of many previous histories without becoming encumbered with trivial variations.

Beaumont Newhall has remarked on the nomenclature of early photographs that ... "the list of types is imposing and an industrious researcher could easily turn up fifty or more." This is a fair estimate: this volume includes about one hundred names, but many are synonyms. There has been much confusion over names, definitions, and inventors. The work by Vogt-O'Connor and Pearce-Moses [109, 110] on the development of a thesaurus of photographic terms is a valuable clarification. It has been incorporated in The Art and Architecture Thesaurus, reference [1]. In addition, an interesting history of the nomenclature is found in reference [20].

One question is whether to count processes that were invented, patented, named, and published, but never became commercial realities. For historical reasons they have been included, at the same time noting that museums and collectors are not likely to find specimens. Or will they? Maybe historical accounts overlooked something, and somewhere there is an attic trunk...

The subject of this book is necessarily technological. 19th century inventors made the best use of their contemporary science that they could: some photographic pioneers were physicians, possibly because of their knowledge of chemistry. Numerous college professors and at least one noted astronomer made lasting contributions. And of course there were many self-taught amateurs. But innovation in early photography demanded technical familiarity and discipline, and a book on the subject will not do the reader a favor by side-stepping the fact.

Most of us think we know what a photograph looks like. Be warned, however, to take nothing for granted in nineteenth century photography. Some processes were highly praised because they produced pictures that looked as little like 'photographs' as possible. Why? To please patrons who preferred the artistic appearance of paintings. Others were photomechanical reproductions that "to the untrained eye are indistinguishable from actual photographs". But what is an actual photograph?

Defining a photograph is not without difficulty. Silver content cannot be a criterion; it would eliminate gum bichromate, platinum prints, cyanotypes, uranium prints, and dye images. "Emulsion-coated paper" as a criterion would exclude platinum prints and the salt prints of Fox Talbot. The photomechanical prints of Woodbury were comprised of gelatin on paper and might be considered emulsions. 'Primary images' would exclude multiple prints from such classics as the negatives of Ansel Adams, and other derivatives.

Gernsheim [61] describes photography as implying a permanent picture made by means of a camera. Some would argue that pictures in newspapers fit this limited description. The first permanent image of the Frenchman Nicephore Niepce, discovered by Gernsheim and generally regarded as the oldest surviving photograph, was made by the action of focused rays of light on a coating of bitumen. It was the result of an effort to find a better process for reproducing pictures in ink.

The definition of a photograph used in this book is "a permanent picture made by means of a camera and originally comprised of photosensitive materials on any substrate” which eliminates the medium of printers' ink and photomechanical reproductions. However, a survey of the subject of photomechanical reproduction is included in this book to clarify the recognition of certain types of reproductions that closely resemble photographs, such as Woodburytypes and carbon prints.

Early photographic inventors, starting with Louis J. M. Daguerre, liked the idea of combining their names with the suffix "-type", or else adopting poetic prefixes such as "calo-" (from "kalo", Greek for beautiful). Fox Talbot (*William Henry Fox Talbot is frequently referred to in the literature as 'Fox Talbot'; Fox was an old and distinguished English family name. The cover title of Talbot's book "The Pencil of Nature by H. Fox

Talbot" implies his own preference.) later changed "calotype" to "Talbotype" in his own honor, thereby bequeathing posterity two names for the same process. Calotypes are also often called salt prints, adding to the confusion. Batchen [20] provides some fascinating sidelights on the origins of photographic names.

Webster's Unabridged Dictionary defines "type" as, among other things, "... a figure, image, form, or representation of something to come." The use of the appendage "-type", largely a nineteenth century usage, was thus appropriately applied to photography; one wonders whether "something to come" could presage the latent image concept.

During research on this book, a discouraging amount of disagreement between 'authorities' was encountered. To professional historians this observation will not be a revelation, but to a mere student of history it was dismaying. This is the reason the Bibliography includes a considerable number of historical references. I am under no illusion that discrepancies in dates, process details, and attributions have all been eradicated, but a serious effort was made to do so.

Nineteenth century photography was an arena of promoters, inventions both serendipitous and inspired, ferocious litigation, fleeting fame, imperfectly understood science, and rapid obsolescence. Are we so different today? Early photographers performed heroic feats of endurance to get their pictures, and they sickened and died from toxic chemicals in an age when people legally took opium for tooth ache. Their surviving pictures record humdrum life, great beauty, and momentous history, and surely are worth our best efforts to recognize and conserve this time machine to the past.

Part One

History of the Processes

Chapters 1-13

Chapter 1
Uncoated Paper and Salt Prints

This chapter describes anthotypes, Breyertypes, calotypes, salt prints, catalysotypes, ceroleins, chromatypes, crysotypes, cyanotypes, energiatypes, Feertypes, fluorotypes, kallitypes, platinotypes, Printing Out Papers (POP), and Developing Out Papers (DOP).

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The phenomenon of darkening of silver salts in the presence of light was known in the 1600's. Silver nitrate is soluble in water, while silver chloride is water-insoluble. The chloride occurs in nature as a soft mineral called horn silver, while silver nitrate does not occur naturally.

Since silver nitrate is water soluble and was observed to darken when exposed to light either in solution or dried, it would seem to be the simplest of experiments to dip paper into a solution and make shadow pictures in the sun. This may have been done in the 1700's, but the first documented experiment was performed by Thomas Wedgwood, son of the English potter Josiah Wedgwood, and was reported in 1802 by the chemist Humphrey Davy. Wedgwood and Davy also experimented with silver chloride, called silver muriate, prepared with muriatic (hydrochloric) acid. They observed that silver chloride was considerably more light sensitive than silver nitrate, which we now know to be true. But simple silver nitrate photography was a technological dead end; photography was to encounter many such dead ends in the next century.

Because Wedgwood and Davy failed to solve the problem of fixing the image, all their pictures have faded, and they are not credited with the invention of photography. Their work is remembered as the forerunner of Talbot's success.

calotypes (salt prints): 1841 (patent) to the 1860's.

William Henry Fox Talbot patented the positive/negative salted paper process in 1841 after a public announcement in 1839. He soaked paper in a solution of common salt (sodium chloride), then applied a water solution of silver nitrate, thus achieving a mixed coating of silver nitrate and silver chloride on one side. He fixed the image by again soaking the light-exposed paper in a salt solution. The process produced a printing-out image during exposure, but Talbot also found that the image could be considerably intensified by developing in a mixture of silver nitrate and gallic acid. During the same year Sir John Herschel suggested the use of sodium hyposulfite as a fixer instead of sodium chloride, and "hypo" has remained to this day the basis of photographic fixers.

Talbot gave the name 'calotype' to paper negatives or prints made from them. The term 'salt print' refers to prints that were made by the salt/nitrate process from various negatives including calotype negatives and glass negatives (the latter being superior because of the absence of paper fiber). According to Lassam [89} he later gave the name 'Talbotype' to the calotype process at the urging of friends.

The calotype is described in many historical books; a particularly concise description is found in reference [135] by Stapp. DuBose [45] has an excellent history and process description that gives a perception of the results of process variations, particularly on color. This is discussed in Appendix III on the Fotofind program.

Ceroleine

Calotype paper negatives were translucent, not transparent. When the negatives were printed, the paper fiber was imaged along with the silver image, to the detriment of resolution. As early as 1841 Talbot had applied melted wax to his negatives with a hot iron after they were processed and dried; he included it in one of his patent claims. In 1851 Gustave LeGray demonstrated better results by waxing the paper before it was sensitized and processed. Negatives made by his process were called ceroleines, a more convenient name than "LeGray's Process". Positives made from good paper negatives showed excellent resolution and tonal range, but they were soon superseded by wet-plate glass negatives.

The index of refraction of waxes is closer to that of paper fibers than is the refractive index of air. Therefore if wax fills the spaces between fibers, light scattering by the fibers is significantly reduced. Paper consists of a mixed population of fiber compositions, some of which are not even transparent, so a perfect match cannot be attained. Waxes, too, are complex mixtures, and white wax was recommended over yellow. Towler [108, 178] gives a procedure for separating the cerolein, or white component, from bees' wax.

To achieve best results, wax should wet the fibers and completely displace the air. Application was done with heat in most cases, with care to avoid scorching. The sizing materials used in some papers prevented good penetration and wetting, as did silver salts and processing residues. Talbot's negatives often showed blotchy and uneven light transmission. LeGray's process of waxing before processing was inherently better, provided the most suitable paper and wax was used.

Interesting sidelights on the waxed paper process as practiced by Roger Fenton are given by Hannavy [70], particularly regarding pre-exposure and post-exposure waxing.

Oils were tried, since they penetrate and wet without heat. Unfortunately they tended to soak into storage envelopes and anything else the negatives contacted, necessitating periodic reoiling. The process was messy enough without that.

The quality of the paper base was important because trace impurities caused spots, discoloration, and fading. Individual photographers tried the available artists' and drawing papers and usually settled on a favorite. They could buy presized papers or prepare their own from various recipes.

Reilly [121] has emphasized an important distinction in nomenclature. Salt prints are made by a two-step process: salting and sensitizing. The paper may or may not be coated with an emulsion or binder. Albumen prints are also made by sensitizing a pre-salted paper and therefore technically are salt prints, even though they have an albumen coating, unlike Talbot's earliest prints. Plain salt prints have a surface of exposed paper fibers; albumen prints are always glossy, but paper fibers are visible in the highlights through the transparent albumen because there was no undercoating of white baryta as in later bromide paper.

POP and DOP Processes

Printing-out papers (POP) are those in which the silver image, called photolytic silver, appears spontaneously during light exposure without chemical development (subsequent fixing is still necessary). There is no negative image produced by the POP reaction. The production of photolytic silver under the action of light quanta is related to the simultaneous formation of a latent image, but the exact relationship is not fully understood. Photolytic images must be gold-toned because they are inherently unstable even if fixed in hypo. Photolytic silver is accompanied by the release of an equivalent amount of free halogen gas (chlorine, bromine, or iodine), which may then recombine and reduce the effective rate of darkening. If recombination is prevented or slowed, a faster rate of darkening results; one way of accomplishing this is the inclusion of reducing agents in the emulsion or binder. All silver papers will eventually darken in daylight; POP papers are simply those in which the change is fairly rapid and the tonal range is useful. POP processes, including albumen, dominated 19th century photography.

In developing-out papers (DOP) light exposure produces an invisible latent image requiring chemical development to become visible. The colloidal particles of reduced silver in POP images are very much smaller than the filamentary particles in DOP images. Comparison electron micrographs are presented in Eastman Kodak [47-28], and Reilly [122]; a transmission electron microscope is necessary because individual particles in POP images are too small to see in light microscopes. The small size of these clumped particles is the principal reason for the characteristic reddish color of POP prints, though processing variations and toning alter the color. This is discussed in more detail in Chapters 3 and 11, and in Reilly [123-3]. According to Reilly [122, 6], the largest class of DOP prints from 1840 to 1885 were crayon portraits, which continued to be made into the 20th century (see Appendix II).

These surface characteristics are summarized below because they are important recognition clues for dating:

1. Exposed paper fibers over entire surface:
   - POP salt prints 1841-c1860
   - kallitypes & platinotypes 1870's-c1890's
2. Glossy surface, paper fibers visible:
   - POP albumen c1850-c1890
3. No fibers visible, glossy or matte:
   - POP or DOP, silver chloride or bromide c1890-present

Cyanotypes: 1842 - present

The cyanotype has not been taken seriously by professional photographers because the tonal range is poor and the images are bright blue, an unrealistic color for both portraits and landscapes. On the other hand cyanotype paper is cheap and easy to make and process, and the image has good permanence. However, cyanotypes should not be stored in contact with buffered or alkaline paper, sometimes called non-acidified paper and used in archival applications: such paper will fade cyanotypes. Exposure to light will also fade the images.

Specimens showing family groups and buildings are fairly common, but the greatest use was in copying text and line drawings, as blueprints. It has been in continuous use perhaps longer than any other photographic process.

The original process was discovered in 1842 by the astronomer Sir John Herschel, motivated by a need to copy his scientific calculations before the era of copy machines. Herschel's first process was based on ferric ammonium citrate and potassium cyanide, which produces a blue image where light strikes it. The image is fixed by simply washing in water. A positive print with blue shadows and white highlights is made by printing from a negative. A contact print against a line drawing makes the familiar blueprint with white lines on a blue background. Crawford [38, 163-166] describes the process in detail for home experimenters. Reference C is a valuable source of process information.

Less well known is Henri Pellet's patented (U.S.) process for making direct positives, described in Lietze [84, 65-69]. Poitevin also made direct positives in a violet color (Lietze [92, 75-78]). In both processes line drawings could be made in one step with dark lines on a white background, without reversal.

In all these processes the paper fibers are exposed in all parts of the image. Often the paper was sized with glue or starch to reduce penetration into the surface. Because of toning and process variations the colors were not always bright blue; they may range from blue-black to purple.

Valuable insight into the cyanotype process is in Ref. C by Mike Ware.

Platinotypes, Palladiotypes: 1873 (patent) - 1937

The platinum process is classed as a ferric process related to the cyanotype. William Willis patented platinotypes in 1873 in England. Crawford describes the full working process [38, 76-78, 167-175]. The chemistry is also discussed in Eder [48, 543-546] and in Lietze [92, 79-90]. According to Crawford, platinum paper went off the market in 1937, but there have been revivals, and palladium paper is again commercially available as of this writing. Platinum paper shows a weak image during exposure (POP), but developing is necessary for the final image. Colors range from silver gray (neutral black) to warm brown, depending on processing and toning. Paper fibers are visible throughout the picture, and the image appears embedded in the fiber texture. The image consists of reduced metallic platinum and is more stable than the underlying paper.

A variation, multiple platinum printing, is described briefly by Struss [137].

Palladium is chemically similar to platinum but cheaper and more plentiful and was used both alone and in mixed chemistry. Willis' patent claims the use of salts of palladium, gold, iridium, platinum, and mixtures thereof.

Many writers are lyrical about the unique beauty of platinum prints. It is perhaps the only process whose intrinsic beauty is a useful (though subjective) identifier; Crawford describes it very well [38, 77].

<u>Kallitypes</u>: 1843 - 1890's

The kallitype process is chemically similar to the platinotype process except that the final image contains metallic silver rather than platinum. Kallitypes resemble platinotypes in their beauty, and in fact kallitype paper was marketed commercially as a substitute for the very expensive platinum paper. Unfortunately people expected the substitute to be as resistant to fading as platinum, but the stability of silver does not compare with that of platinum, and kallitypes acquired a bad name. At about the same time the more convenient gelatin silver chloride papers became available and kallitypes fell from favor.

Crawford describes two kallitype processes in detail [38, 177-180]. Pernicano [115] gives a detailed modern recipe. Kallitypes are also described in the 1908 Library of Practical Photography [131], in The Photo [116], and in Eder [48, 543]. The paper surface shows exposed paper fibers throughout. The image becomes visible during exposure (POP) but darkens during development and fixing. Colors ranged from black to brown; there were many home-made process variations.

<u>Non-commercial Types of Uncoated Prints</u>

A non-commercial listing does not mean that there are no surviving specimens. The early days of photography were a do-it-yourself period; amateurs and professionals eagerly tried every process that was published. Some, but not all, inventors tried to license or restrict use of their processes. Robert Hunt of London freely made public three of his processes: the catalysotype, energiatype, and fluorotype, and many publications carried instructions and notes on their application. It would be of interest to find more authenticated specimens of these lesser--known types.

Anthotype: 1842

Sir John Herschel discovered in 1842 that water and alcohol extracts of flower juices coated on paper were light sensitive. Several workers published recipes: Snelling [133, 37-42, 113-116] has considerable detail. Among the list of recommended flowers were the violet, red poppy, and wall flower. The images were "fugitive", and exposures as long as four to five weeks were needed. The light instability of organic dyes was a problem of long standing, and Herschel's early attempt to make a virtue of it is intriguing. Five weeks' exposure time is a little long for practicality, however.

Breyertype: 1839 - ?

An obscure but historically important process invented by Albrecht Breyer of Berlin in 1839. It was a silver chloride facsimile print of text and line drawings made by shining light through the back of sensitive paper placed in contact with a printed page. The print was produced by the light reflected from the page being copied, and was a negative from which positives could be made.

Breyertypes may be recognized by their subject matter of printed text or drawings, either positive or negative, whose color was brownish black with a texture of paper fibers, and with exposed paper fibers over the entire surface. The same subject matter may appear in prints made by the various cyanotype processes described in Lietze [92], but they were colored blue, purple, or other distinctive colors. Other photographic processes were capable of copying text, but they can often be recognized by characteristics such as coatings.

Catalysotype: 1844 - ?

This printing-out process was invented by Dr. Thomas Woods of Ireland in 1854, and improved by Robert Hunt in London. The paper was coated with iron iodide and sensitized with silver nitrate. The name was derived from catalysis, which was thought to explain image formation, probably an erroneous concept.

Chrysotype: 1842 - ?

Another of Sir John Herschel's iron processes of 1842, in which the paper was first coated with ferric ammonium citrate and dried. After exposure it was developed in gold chloride and fixed in potassium iodide. The image consists of reduced metallic gold that is purple in color. It had a limited tonal range and was used mostly for copying line drawings and text, producing a negative of white lines on a purple background. Chemically it is related to the kallitype and cyanotype. Although the paper was not made commercially, the recipe was published and widely used by amateurs.

Chromatype: 1843 - ?

Another of Robert Hunt's processes in 1843. The sensitive material was a mixture of copper sulfate and potassium dichromate, which produced a direct positive image of an orange or lilac color; Eder [48, 553] lists variations. If the process had been more sensitive it might have been successful, because it produced a direct positive in the camera.

Energiatype: 1840 - ? Also called Ferrotype.

This process of Robert Hunt's had considerable vogue, with lengthy articles appearing in books and periodicals. The paper was coated with a mixture of succinic acid and sodium chloride in a gum arabic binder, then sensitized with silver nitrate. After exposure it was developed in iron sulfate (hence the name ferro-type). According to Snelling [133, 111] the same developer works well with other salts of silver.

Feertype: 1889 - ?

An early diazo print, 'Diazo' refers to a class of light sensitive nitrogen-based organic compounds, which can produce a wide range of colors, mostly broad-band colors low in saturation. Feertypes were not commercially successful when Dr. Adolf Feer patented the process in Germany in 1889, but they were the fore-runner of the Ozalid process after World War I that competed with blueprints for copying line drawings. There was no pictorial usage then, though today the process is sometimes used to print on cloth bases, such as tee-shirts.

Fluorotypes: 1844 - ?

Another Robert Hunt process, with little acceptance or documentation. The name was derived from sodium fluoride, which was mixed with potassium bromide; it was developed in iron sulfate.

Summary of Identification of Uncoated Prints

1. All have exposed paper fibers over the entire surfaces, which distinguishes them from matte gelatin and matte collodion prints. Waxed negatives have a translucent gloss.
2. All are faded except perhaps cyanotypes and platinum/palladium prints: look at protected edges under mats or frames. Do not be misled in this observation by ordinary paper yellowing.
3. Many specimens were originally tinted or toned. Existing colors may be unreliable identification clues, except for the blue of cyanotypes, but may still provide useful clues.
4. The unique chemistry of many of these processes can serve as positive identifiers if the appropriate analytical facilities are available: see Chapter 13.

Chapter 2

Coated Printing Paper

This chapter discusses albumen, collodion, and gelatin paper prints, and baryta undercoating.

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The salt prints made from calotype negatives were the first successful paper prints, but several problems prevented widespread international acceptance comparable to that of the Daguerreotype, even though calotypes were often larger and could be reproduced. One problem was the litigious personality of Fox Talbot, who constantly engaged in lawsuits over the use of his patents, attempting to broaden his claims to include all sorts of improvements by himself as well as others. In fairness, many other inventors of the times did the same thing, in some cases hindering the public acceptance of their processes.

Another problem was the lack of sharpness caused by printing through the paper fibers in the negative, even though it was alleviated by waxing the negative. In addition, salt prints were soon found to be susceptible to rather rapid fading, which did not afflict Daguerreotypes.

Image sharpness in salt prints was also adversely affected by penetration of silver salts into the fiber structure. If the paper was totally immersed in sensitizing solution, light scattering in the paper caused darkening and ghost images on the back of the print and an unacceptable degree of blurring. For this reason sensitizing was always done by floating the paper on one side only; sizing the paper with starch or glue also helped reduce penetration of chemical solutions in the paper.

To some people the slightly soft appearance of a salt print was pleasing, but then, as now, many people wanted glossy sharpness. Today all printing papers are comprised of several coated layers on flexible bases, most of them on synthetic films or resin-fiber composites rather than on plain paper.

Collodion, albumen, and gelatin, the same materials eventually used on glass, were tried on papers and all three were eventually successful in varying degrees. Printing papers did not have to be as sensitive as negative materials for cameras, nor were keeping qualities as critical. Coatings tended to stick to paper better than glass, and formulations were modified for the two bases.

Albumen: 1848 - 1890's

Experiments with albumen on glass apparently preceded those on paper. In 1847 the Frenchman Niepce de Saint-Victor published a process consisting of albumen on glass, but the sensitivity was low. In 1850 the Frenchman Louis Desire Blanquart Evrard announced his albumen printing-out paper process, which dominated photography for forty years. Printing-out paper is discussed in Chapter 2.

'Albumen' is chicken egg white, and many were the recipes for concocting the most sensitive and best appearing coatings. There were also recipes for using the left-over egg yolks, which according to Newhall totaled an estimated 20 million in one year. Leather tanneries helped by consuming the surplus yolks.

Albumen prints were generally sharp and glossy, in contrast to the soft matte appearance of calotypes. Some matte albumen paper was made by adding starch to the albumen, but glossy predominated. After the mid 1870's albumen paper was given extra gloss by roller-burnishing; microscopic examination can sometimes reveal the faint eggshell texture of non-burnished emulsion and infer its period. The microscope will often reveal cracks and fissures in the coating caused by expansion stresses from the mounting.

Arguments over matte-versus-glossy aroused strong differences of opinion. Albumen paper had a more durable surface than salt prints, an important advantage on the increasingly popular cartes de visite and stereographs. Pre-salted albumen paper was made commercially in rolls up to 33 inches wide, ready for silver nitrate sensitizing by the user. It was variously salted with sodium chloride, ammonium chloride, and potassium chloride or bromide. There were conflicting notions about the efficacy of these materials: sensitivity and keeping qualities were important criteria. But sensitized albumen paper did not retain its sensitivity in storage and had to be sensitized by the user just before exposure.

The albumen solution was coated directly onto the sized paper base. Since baryta undercoating was not used until the mid 1880's, paper fibers are visible through the albumen in the highlights. In the shadows the fibers usually cannot be seen because of image density. Although the fibers can be seen (some magnification may be needed), the fibers are not exposed as they are in the highlights of carbon prints. Examination under a microscope reveals the difference; in an albumen print the top surface of the albumen first comes into focus smooth and glossy, with the fibers under the surface.

Albumen prints were often gold-toned to alleviate the fading problem, producing a characteristic purple-brown color. This is the typical color of surviving 19th century photographs, the majority of which (estimated to be 90%) are albumen prints. They are sometimes called 'sepia' but that is a misnomer and, in fact, a different process. Figure 1a is a black and white reproduction of a typical faded albumen low-contrast print; Figure 1b is a print of the same subject that was gold-toned to a chocolate brown.

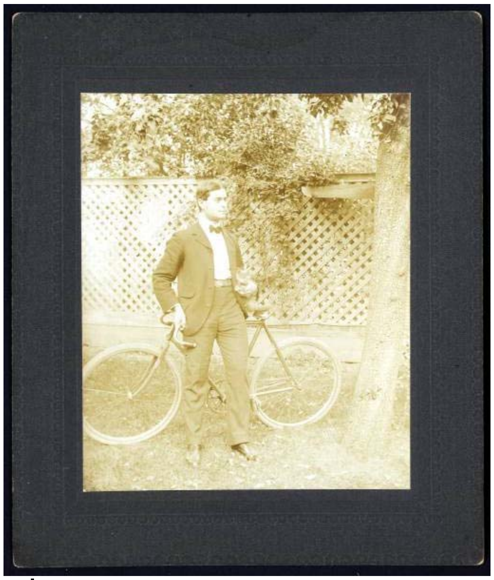
Figure 1a


Figure 1b

Albumen paper was the first photographic paper manufactured on a large scale. Daguerreotypes were too expensive for the mass market, and calotypes were involved in too much litigation. Since the demand for paper was so large, it became commercially feasible to devote some effort to tailoring the quality of the paper base to the peculiar needs of photography. All-rag content was a necessity, and bits of buttons and metal caused glaring defects. Chemical trace impurities caused longer-term problems of spots and fading. Two European firms, one Belgian and one French, eventually emerged as the dominant world-wide suppliers.

Paper stock for albumen prints was made in more than one thickness, but most of it was dense, smooth, thin paper about the thickness of modern twenty-pound computer or copy paper. This is little more than half the thickness of modern single weight photo papers and only one fourth that of double weight. Thin paper was used because it was easier to manipulate during the sensitizing flotation operation. Thin paper was also easier to glue to carte de visite and stereograph cards, which represented the largest market for many years: nearly all albumen prints were mounted.

Reilly's 1980 book [121] is the definitive reference for albumen prints, but descriptions are found in most histories. Bernard [22], Eastman Kodak [47] and [122], George Eastman House (F), and Holme [77] are especially useful because of their full color reproductions.

<u>Collodion Paper</u>: 1867 - 1890's

The first industrial production of collodion-coated paper was in 1867 by J.B. Obernetter in Germany. It was a silver chloride printing-out paper coated by hand until 1889 when machine coating was introduced, incorporating a baryta layer. Both glossy and matte surfaces were made available.

Collodion is a solution of gun cotton in ether and alcohol; it had been used in surgical applications and is very flammable.

It does not react chemically with silver salts as albumen and gelatin do, and was more stable than albumen, but fading is related to trace chemicals (intentional and otherwise) in such complicated ways that no blanket assertion is justified.

The use of collodion in the wet plate glass negative process had a much longer vogue than collodion-coated paper. A good description is found in Wentzel [151, 69-71]; Towler [145] has a very complete review of the processes; also see Newhall [105, 126] and Eder [48, 536].

Collodion papers were gradually phased out by the 1890's as the faster and more convenient gelatin papers became available.

Gelatin Papers: 1879 - present

Gelatin silver papers were made as chlorides, bromides, and chloro-bromides. The differences were in sensitivity and color tone, and in whether they were developing-out (DOP) or printing-out (POP) types.

Peter Mawdsley (England) suggested gelatin silver bromide paper in 1874 but it was not a commercial success. Sir Joseph Swan was more successful in 1879 and gelatin paper began to supplant albumen paper. By 1884 Eastman Kodak had a coating machine in production.

The first POP emulsion paper that produced a visible image without a negative (because it contained excess silver nitrate) was glossy collodion paper, and it enjoyed considerable popularity in the late 1880's. About 1890 Aristo paper was introduced; this also was a Printing Out Paper, and it is still in use as a studio proofing paper. Both POP papers were baryta-undercoated.

Developing-out gelatin silver chloride paper was invented by Eder and Pizzighelli in 1881 in Austria, and was later manufactured as "Alpha" paper.

This was the period of the popular 'gaslight papers', which were fast enough to be exposed under gaslight instead of sunlight (which albumen paper required); they could then be developed and fixed by turning down the gas. They all had baryta subcoats. Gelatin silver-chloride paper was made in both printing-out and developing-out forms. Some other trade names were: Velox, a DOP chloride or chlorobromide; Solio, Ronex, and Seltona were POP chloride proofing papers.

When DOP gaslight papers were first introduced they represented the ultimate in sensitivity, but after the more sensitive bromide papers were introduced, gaslight papers were the slowest ones. Bromide papers became the choice for enlarging as they are today, while the slower chloride papers are generally used for contact printing.

The technology of paper processes changed very rapidly in the 1880's and 1890's as collodion and gelatin supplanted albumen. At the same time silver chloride and bromide in both POP and DOP versions competed, and it is difficult to state a simple time line for dating purposes as 'modern' manufacturing processes began to dominate around the turn of the century. Identifying the competing types of this period by simple inspection is very difficult. The illustrations in Reilly [122] are particularly helpful.

Matte papers

According to Eder, matte-surfaced bromide paper was produced as early as 1879 by using starch in the gelatin. Hubl added starch to albumen paper in 1895, a little late in its history. Another way of diminishing gloss was mechanical stippling. This produced minute indentations in the surface without penetrating it, and can readily be seen under a microscope. The earliest date of its use is unknown at this writing.

Tarnishing

This form of age deterioration is known by different authors as silvering, bronzing, and mirroring. The appearance is that of a metallic sheen of various colors, more prominent in the dark regions of the image, and eventually occurring in most silver images. The sheen can be very pronounced, almost like a mirror except that reflections are not specular.

It is most common in silver gelatin DOP images, but it can occur in other silver images in an organic binder, including nitrate negatives. It does not occur in binderless images such as salt prints and platinotypes. The cause is a change of state of the image silver by a complex process influenced by several factors, with the formation of metallic silver on the top layer. See Reilly [122] for a discussion of the phenomenon. The mechanism may not be identical in all cases, since the incidence of atmospheric sulfur, moisture, and processing residues vary. The effect is so obvious in nearly all glossy DOP images of that period that it can serve as an identifier. World War I - era pictures commonly show the effect.

Figure 2a shows a picture (dated 1905) in diffuse lighting; figure 2b shows the top of the same picture illuminated with light from the camera position; it shows heavy tarnishing. The same effect is apparent if the observer tilts the picture slightly in normal light.

References: Eastman Kodak [47, 15; 74; 132; 134]; Crawford [38, 65].

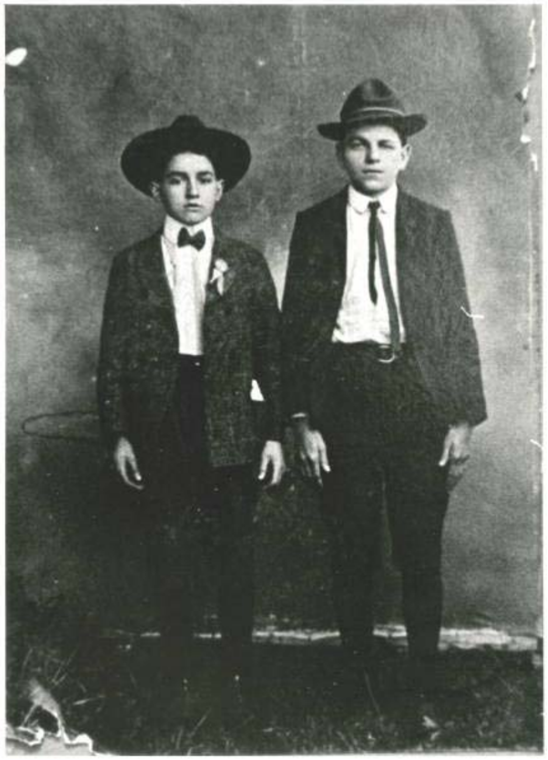

Figure 2a

Figure 2b

<u>Baryta Coating</u>

Baryta is barium sulfate, a white pigment with only a slight yellow tint. Coated on photographic paper under the sensitive layer, it functions as a smooth chemically inert coating that covers paper fibers and brightens highlights. The first description of baryta-coated paper appeared as early as 1826, before photographic applications were envisaged; it was finally patented in Paris in 1881. Manufacture of baryta-coated paper did not become widespread until the mid 1880's with the advent of machine coating. It therefore was not found in calotype or albumen prints; it did appear in machine coated collodion and gelatin papers. Baryta was not hand applied by amateurs, so its presence indicates that the paper was commercially manufactured. Wentzel [151] has many intriguing details of baryta manufacture.

Baryta can be recognized in highlights where it completely hides the paper fiber. Barium can be identified nondestructively by x-ray fluorescence analysis, or destructively by wet chemical analysis.

<u>Emulsion Identification</u>

For identifying the type of emulsion, chemical or physical analysis can be used as discussed in Chapter 13. In most cases it is simpler to apply Rempel's solvent tests [124] to the emulsion. The solvents are distilled water and ethanol (reagent ethyl alcohol). Water swells gelatin but has no immediate effect on collodion or albumen, while alcohol dissolves collodion but does not affect gelatin or albumen. The tests may leave permanent marks and should be performed under a microscope on small marginal zones in non-image parts of the specimen. Reference 124 should be consulted for details.

Chapter 3

Flexible Negatives

This chapter discusses paper-based stripping films, and self-supported films of gelatin, nitrate, acetate, and celluloid.

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There have been many inventions that were conceptually correct but that suffered from early commercial problems caused by materials limitations. Some prominent examples were the pneumatic automobile tire, cylindrical phonograph records, and flexible photographic negatives.

The first negative of any kind was Talbot's paper calotype. Glass plates coated with sensitized collodion soon superseded calotype negatives and dominated photography for three decades. But glass plates were heavy, breakable, expensive, and had to be loaded in the camera one at a time. The fledgling plastics industry was able to mold Daguerreotype cases but not thin transparent flexible films of optical quality capable of resisting photographic chemicals.

Stripping films:

Attempts were made to coat glass plates with collodion or gelatin, then to strip off the coatings and expose them in cameras without the glass. But the films were flimsy to handle, they swelled erratically in solutions, and their light sensitivity was much too low.

The first Kodak camera, No. 1, used stripping film in a round format 2 1/2 inches in diameter. The silver gelatin emulsion was coated on a sub layer of soluble gelatin on a strip of paper base holding 100 frames. After exposure by the customer the camera was returned to Eastman Kodak for processing. The paper was steamed to dissolve the soluble layer, and the emulsion was transferred to clear gelatin for development and printing.

This process was first introduced in 1886 and used in Kodak No. 1 in 1888; it was available until 1891, although Kodak No.2 with a 3 1/2 inch format was introduced in 1889. It was gradually supplanted by the nitrate base; these processes overlapped chronologically.

In order to make the most of the compactness and light weight of stripping films, one more invention was needed, and it appeared right on cue - the spool. Actually it was a complete mechanism with supply and take-up spools and rollers for holding the film flat. Eastman and Walker patented their roll film holder in 1884. Leon Warnerke had patented a roll-film holder in 1875 for gelatin silver bromide emulsions on paper, and Melhuish and Spencer also patented a roll holder for calotypes in 1854, but neither came into general use. Litigation ensued as it did so often in the evolution of photography, but the Eastman-Spencer holder was the right product at the right time. The first Kodaks used rolls of paper negatives, but the paper grain was objectionable just as it had been in calotypes, and Eastman paper negatives were supplanted by stripping films within a year. Stripping films, in turn, lasted about six years until good quality nitrate film appeared.

Surviving specimens of stripping films are relatively fragile and rare; informed recognition and careful handling are necessary if remaining examples are to be saved.

Cellulose Nitrate:

Collodion film base was patented in 1856 but the fabricated product remained poor in quality for the next thirty years. Celluloid, invented in 1869, is a thermoplastic cellulose nitrate, often called guncotton, plasticized with camphor. This formulation, while adequate for billiard balls and shirt collars, was unsuited for optically clear sheets. For a time John Carbutt in Philadelphia made and sold photographic plates cut from solid blocks of celluloid; this heroic process produced unbreakable plates lighter than glass, but still not a roll film.

Manufacturing technology finally caught up with need in 1889 when Eastman chemists patented the first nitrate film. Like celluloid it was basically cellulose nitrate, but with different plasticizers and solvents. In 1892 Samuel Turner invented the familiar black paper backing with numbers visible in a red window. It was marketed by the Boston Camera Company, which George Eastman soon bought and merged. Photography had come a long way in six decades.

The Need for Safety Films:

Collodion, celluloid, and nitrate films are all extremely flammable. Fires from nitrate film in movie projection booths were not uncommon as the movie industry grew. The displaced vaudeville industry had adopted asbestos stage curtains; movies put the hazard at the other end of the theater. Film was obviously flammable, but safety film had not yet been invented, so fires had to be accepted as an unavoidable risk in a new and exciting entertainment medium.

The long-term problem of inevitable spontaneous decomposition of nitrate film in all storage conditions was slower to be recognized. Nitrate film evolves fumes containing nitric acid and various organic decomposition products, ending in total disintegration or fire. The flash point may go as low as 120 degrees Fahrenheit. The rate of decomposition depends on the original formulation, film thickness, and type of roll. Cine film is more hazardous than flat sheets because it is tightly rolled, and the decomposition products cannot escape as rapidly as they form, thus accelerating decomposition.

Students of chemistry may see an apparent contradiction with the usual rule that reaction products on the right side of a chemical equation must be removed for the reaction to proceed. This is true of simple reactions, but nitrate film is inherently unstable (does not reach equilibrium), and deterioration is caused by complex reactions whose products are progressively corrosive.

The most comprehensive and up-to-date discussion of the problem is in the 1985 book by Eastman Kodak [47, 89-93]. A vividly illustrated article by Michael Hager appears in Image [69]. Young [159] also provides a good reference.

Safety film in the form of cellulose acetate first appeared in 1933 in X-ray film, but professional 35mm nitrate film was made as recently as 1951. Dates of consumption of unused stock cannot be ascertained; Eastman Kodak states [47] "any negatives made before 1950 are suspect". The best course of action is to test any negative that does not show the legend "safety film" along the margin.

Several tests are described in reference 47. Safety film will burn, though not as rapidly as the almost explosive combustion of nitrate film. A small clipping of nitrate film sinks in the solvent 1,1,1 trichloroethane (trichloroethylene), while safety film floats. This solvent is obtainable from laboratory suppliers; it is hazardous to breathe. Details of this and other tests can be found in reference 47, and in Rempel [124].

The storage of nitrate negatives is the most serious single hazard in archival management. One long-term solution is to copy the images on modern film and then destroy the nitrate in an approved manner. Freezing is often used as a temporary expedient; its long-term efficacy is debated.

Chronology of Flexible Negatives

The major steps in the evolution of flexible negatives are summarized below. Other individuals published suggestions or otherwise made contributions, and the literature should be consulted for additional details, particularly Gernsheim [61, 405-409] and Eder [48, 485-490].

1855: Frederick Scott Archer patented a collodion stripping film on paper, reinforced with a gutta-percha coating. This appears to be the first flexible transparent negative.

1856-7: variations by Reade, Parkes, and Ferrier, not commercial.

1875: Leon Warnerke produced rolls of chalk-coated stripping paper with collodion or gelatin sensitive layers on a collodion and india rubber substrate. It was made and sold in London for use with his patented roll-film holder.

1882: Alfred Pumphrey manufactured collodion-on-gelatin cut film for plate cameras and the Pumphrey magazine camera.

1883: a commercial stripping film introduced by Georges Balagny in France: sensitive gelatin emulsion on collodion on talc-coated paper for ease of stripping. It was manufactured by the Lumiere brothers who later made the successful Autochrome color film. In 1886 Balagny introduced a sheet film version, comprised of alternate layers of collodion, varnish, and gelatin.

1884: George Eastman patented gelatin silver bromide stripping film on paper; this was manufactured from 1885 to 1889, using the Walker film holder.

1888: John Carbutt of Philadelphia manufactured gelatin dry plates coated on celluloid 0.25 mm thick. They were light and unbreakable, and were made in quantity.

1889: Eastman nitrate film began to supplant stripping film for rolls. Until the early 1900's the film was thin and easily curled.

1892: black paper backing with negative numbers visible through a red window in the camera back, introduced by Samuel Turner of the Boston Camera Co.

<u>Recognition</u>:

Most of the surviving specimens of these types are fragile and yellowed. Their composition can be determined by analytical methods, and possibly by the tests in Rempel [115], but many of the types are sandwiches of different materials such as collodion, gelatin, or rubber. All paper-based negatives and stripping films are of historical interest and can usually be identified by inspection.

Sometimes the image size can be a clue in dating. Following is a list of the standard film sizes, from several sources:

TABLE 1

Film Number	Date Introduced	Date Discontinued	Image Size
101	1895	7/1956	3-1/2 x 3-1/2 inches
102	1895	9/1933	1-1/2 x 2
103	1896	3/1949	3-3/4 x 4-3/4
104	1897	3/1949	4-3/4 x 3-3/4
105	1897	3/1949	2-1/4 x 3-1/4
106	1898	1924	3-1/2 x 3-1/2
107	1898	1924	3-1/4 x 4-1/4
108	1898	10/1929	4-1/4 x 3-1/4
109	1898	1924	4 x 5
110	1898	10/1929	5 x 4
111	1898	N.D.L.	6-1/2 x 4-3/4
112	1898	1924	7 x 5
113	1898	N.D.L.	9 x 12 cm.
114	1898	N.D.L.	12 x 9 cm.
115	1898	3/1949	6-3/4 x 4-3/4
116	1899	4/1984	2-1/2 x 4-1/4
117	1900	3/1949	2-1/4 x 2-1/4
118	1900	8/1961	3-1/4 x 4-1/4
119	1900	7/1940	4-1/4 x 3-1/4
120	1901	-	2-1/4 x 3-1/4
121	1902	11/1941	1-5/8 x 2-1/2
122	1903	4/1971	3-1/4 x 5-1/2
123	1904	3/1949	4 x 5
124	1905	8/1961	3-1/4 x 4-1/4
125	1905	3/1949	3-1/4 x 5-1/2
126	1906	3/1949	4-1/4 x 6-1/2
127	1912	-	1-5/8 x 2-1/2
128	1912	11/1941	1-1/2 x 2-1/4
129	1912	1/1951	1-7/8 x 3
130	1916	8/1961	2-7/8 x 4-7/8
35	1916	1/1933	1-1/4 x 1-3/4
616	1932	5/1984	2-1/2 x 4-1/4
620	1932	-	2-1/4 x 3-1/4
828	1935	2/1985	28 x 40 mm.

N.D.L. = No Domestic Listing, usually for sale outside the U.S.

Some image sizes were duplicated on different spool widths: the first number in the listed dimensions corresponds to the roll width. Examples are numbers 103 and 104. Number 103 had the long dimension of the image in the direction of the roll length, while 104 was on a wider spool with the short side of the image in the direction of the roll. When separated negatives are examined, the separation cuts are usually not as straight as the original roll edges, so the image orientation can often be deduced.

Chapter 4

Gum Bichromate and Carbon Processes

This chapter discusses bichromated gelatin, carbon, carbro, and gum prints, gum platinum, Mariotypes, Ozotypes, Ozobromes, oil and bromoil prints.

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Silver has occupied center stage in photography almost since the beginning, with the successful Daguerreotype and Talbot's calotype, and before that the early experiments of Thomas Wedgwood. But a surprising number of non-silver processes also surfaced, starting with the asphaltum picture of the Frenchman Nicephore Niepce in about 1824. Some of these processes flourished commercially and are still in use in one form or another.

An important group of light sensitive compounds are the chromates: sodium, potassium, ammonium, silver. In 1839 Mongo Ponton (Scotland) discovered that paper soaked in a water solution of potassium dichromate darkened when exposed to sunlight. Fixing was accomplished by simply washing in water. This effect could have produced pictures of a sort, but no practical use seems to have resulted until 1852 when Fox Talbot patented Photoglyphic Drawing, the light sensitivity of gelatin sensitized with potassium dichromate (usually called bichromate in the older literature). This was nearly as momentous a discovery as his paper negative calotypes because he incorporated the separate concept of the halftone screen, which can be observed in any modern newspaper picture; it is discussed in Chapter 5.

When dichromate-sensitized gelatin is exposed to light, it becomes insoluble in water; sections not exposed to light can be washed away in warm water. The gelatin could be dyed various colors when it was initially coated on the base. The thickest areas of gelatin remaining after processing were darkest where the incident light was brightest. Thus the original exposure was a negative; a positive print could be made from any type of negative. John Pouncy (England) produced prints in 1858 incorporating pigments in the gelatin; they were called, not unreasonably, pigment prints, but they had poor tonal range. The chromates had significantly lower light sensitivity than silver compounds.

The reason for poor reproduction of intermediate tones was discovered by Abbe Laborde in a nice bit of clear reasoning, as described by Crawford [38]. When light of intermediate intensity strikes the surface of the gelatin it renders insoluble a thin top layer but does not penetrate further. During warm water washing the unaffected lower layer washes away and takes the top surface with it. Only very heavily exposed areas remained, resulting in excessive contrast. Laborde did not suggest a remedy, but in 1858 J.C. Burnett exposed the paper through the reverse side, which caused exposed regions to adhere to the paper as desired.

However, this was only a partial solution because printing through the paper fibers caused the same texture problem as in the calotype negative. Transparent celluloid was used thirty years later, but a more immediate answer was found in 1864 by Sir Joseph Swan who used glass backing and then transferred the gelatin image to paper.

When carbon black was used as a dye the prints were called carbon prints, and this term came to mean all prints made by transference, not to be confused with carbro prints described below. Sepia or brown were popular as well as black, possibly because they more nearly resembled average flesh tones, or albumen prints. They also resembled silver prints that were gold toned to reduce their rate of fading. Many other pigments were used: the Autotype Company, founded from Swan's patent, at one time listed 55 colors. By using multiple exposures in different pigments Adolph Braun in Alsace made reproductions of famous paintings with great success. Such pictures are not subject to the fading that plagued early silver processes. Accelerated testing as we know it today was not necessary; the time scale for silver fading was short and erratic, as it depended on so many processing and material variables not then understood. But carbon is one of the most stable and unreactive of the chemical elements, and gelatin is also reasonably durable. Some of the pigments in the gelatin were probably organic dyes, and were subject to fading.

The carbon process was cumbersome and carbon prints did not approach albumen prints in popularity. Later, in the 1890's, the process had one of its occasional revivals under the name gum or gum bichromate. Gum bichromate, with gum arabic substituted for gelatin, had been invented by Alphonse Poitevin in the 1850's. Its virtue, besides permanence, was the high degree of artistic latitude permitted by the process through multiple printings, an attraction that continues to this day.

Bichromate prints are always contact prints because of the low light sensitivity; large prints were made from large negatives. Carbon or gum prints can often be recognized by a faint surface relief effect. The gelatin is thickest in the shadows where it has received the greatest light intensity; in the highlights the paper fiber may be all or partially exposed. The shadows therefore tend to be shiny. If there is a sharp shadow against a light background, the difference in thickness can be seen in side illumination with a hand magnifier. Sometimes multiple coats and exposures were used. Woodburytypes also show this relief effect and are often difficult to distinguish from carbon prints.

Carbon prints did not fade, and sometimes for this reason are conspicuous in a mixture of old carbon and silver prints. This evidence is circumstantial, however, since there are some unfaded silver prints, particularly those that were toned. Carbon prints were often imprinted "Permanent" on their mounts, a unique and welcome identifier.

Dichromate-sensitized gelatin is the basis for the modern silk screen process used for many kinds of stencil printing. It has been used for research in color television and in micro-electronic hybrid circuits. It is sufficiently light sensitive to permit enlarging with an intense point-source zirconium arc light. The process has spanned nearly one and a half centuries with considerable success.

References: Crawford [38, 69-75]; Gernsheim [61,338-9]; Harrison, Joan [73, 369-376]; Newhall [105, 60-61]; Bernard [22] and Holme [77] contain color reproductions that are helpful identification aids.

Following are some variations on the bichromate process:

Gum Platinum

This process, introduced in the late 1890's, applied pigmented gum on top of platinum prints and exposed after the platinum was processed. It was noted for special effects such as exposing the two images from different negatives, and using brightly colored pigments in the gum. The technique seems to have evolved from a desire to add deeper blacks to platinum than could otherwise be achieved. Edward Steichen was a well-known practitioner of the technique, examples of which are in Holme [77]. Gum prints could be printed over other prints besides platinum, but gum platinum has acquired a more distinct identity.

Mariotype

This was an image transfer between two bichromated papers, exhibited in 1873 by A. Marion in Paris. It was not viable.

Ozotype

A modification of the Mariotype by Thomas Manly in England in 1898, with no better results. Ozone was fancifully thought to play a role in the process, hence the name.

Ozobrome

Manly continued to work on the contact transfer idea, and in 1905 the ozobrome finally worked; it transferred the image from a gelatin silver bromide print to a bichromated gelatin sheet. The name was changed to "carbro" - a composite of carbon and bromide, by H.F. Farmer in 1919, and was commercialized by the Autotype Company. Its evolution thus extended well into the 20th century, but its origin was the Mariotype. Carbro prints are well described by Crawford [38, 187].

Oil Prints and Bromoil

The Frenchman A.L. Poitevin discovered in 1855 that when greasy printers' ink (as opposed to water suspensions of carbon) was applied to a bichromated gelatin image, the ink adhered only to the light-struck shadow regions. The hardened shadows become hydrophobic: they repel water and are wet by oils and greases. It offered a way to darken the image after exposure rather than adding pigment to the gelatin during coating; the prints were called oil prints. In 1907 it was found by C. W. Piper that gelatin bromide prints also showed this effect, hence the name bromoil.

The above description applies to ink-intensified gelatin prints, but it did not take long to observe that duplicate prints could be made by pressing the inked gelatin to a sheet of plain paper. Thus was born the photomechanical process known as collotype, so named because the printing was done directly from the colloid surface rather than from etched plates. Collotypes are discussed in greater detail in Chapter 5.

Chapter 5

Photomechanical Reproduction

This chapter discusses the mechanics of printing, etched Daguerreotypes, photomechanically-reproduced pictures including collotype and its derivatives, photogravure, Woodburytypes, and some recognition factors.

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There were several mechanical printing processes that produced pictures difficult to distinguish from photographs, the latter as defined in the Preface. Omitted from this chapter are pictures that obviously are not photographic in origin, such as Currier and Ives lithographs, wood cuts, and line engravings. This is usually evident from angles different from camera perspective, hand-executed shading and other artificialities. However, descriptions of the photographic processes that have played some part in their reproduction are included to clarify identification.

The oldest known photograph in existence was made in 1826 by the Frenchman Nicephore Niepce, who was searching for a way to reduce the labor in engraving lithographic stones and plates. This photograph consisted of a pewter plate coated with bitumen of Judea (see Glossary under asphaltum). Niepce discovered that a thin layer of bitumen or asphaltum became insoluble in certain oils after exposure to light. The approximate modern equivalents of his materials are tar and turpentine, but Niepce was lucky in finding materials from the right natural sources that worked. These materials are mixtures of complex organic compounds whose composition varies with their origin, and Niepce's formula depended on bitumen from Judea and oil of lavender. Niepce's nephew recalled that his uncle first used Dippel's oil, a distillate from animal bone.

An all day exposure to light rendered the bitumen insoluble in the highlights; the unexposed tracts could be washed away, uncovering the base metal for acid etching. When the etched plate was inked and then wiped, the etched pits remained filled with ink transferred to paper on contact. This process, called intaglio printing, enabled Niepce to make the first known permanent image from nature, and many historians (not all, of course) have recognized Niepce as the inventor of photography. The act of pointing the way by showing that a thing is possible is the mark of historical greatness in many fields. Technology may be subsequently altered almost beyond recognition, but only after the original insight.

The oldest surviving specimen of Niepce's work is an etched plate from which many inked prints have been made. In 1827 he made a direct positive image by darkening the exposed metal in iodine fumes. This image has been copied and widely published; the original is in the Gernsheim Collection in the Harry Ransom Humanities Research Center at the University of Texas in Austin.

The Mechanics of Printing

Before the advent of photography there were three types of plates used to print illustrations:

1. Relief Plates.

Relief plates had their inked surfaces raised above the white level, like raised movable type. These plates were compatible with type: they could be clamped in a matrix with type and printed on the same page as text. Examples were black-line wood and metal engraving. Good halftones could not be produced; making the plates almost required the skills of a sculptor, since each line to be printed black had to be cut on both sides.

2. Intaglio Plates.

Intaglio plates had their inked surfaces cut below the white level; they were inked with rollers and then wiped clean on the top surfaces. Examples were steel and copper line engraving, enhanced by aquatint. They were not compatible with type, so illustrations had to be bound on separate pages from text.

Photoengraved intaglio plates are widely used in modern times; even our currency was at one time printed with them. One of the early problems was that wiping the excess ink tended to remove ink from large shadow areas. The problem was solved by dusting or owing a solution of resin on the plate and baking to melt the particles of resin. It was called a ground; the grains of resin provided tooth or roughness to hold the ink during wiping. This was the basis of aquatint, a somewhat misleading name since it had nothing to do with color.

Aquatint was sufficiently fundamental to be carried over into photomechanical processes. Resin in solution produced a "dried mud" pattern of connected lines similar to reticulated gelatin. For a more random pattern, resin was applied as a dust in dusting boxes, and fused to the plates by heat. Aquatint predated Talbot's gauze screen and was used to enhance printing quality in many intaglio variations.

Mezzotints, invented in the 1600's, were a variation of intaglio plates with good halftones. The blank metal plate was first roughened in a random pattern by a metal rocker with a serrated surface. Metal in the shadows was then removed by a skilled graver to varying depths.

3. Planar Plates.

Planar plates were the basis of lithography, which used flat porous stones that retained greasy inks and repelled water. It was not directly compatible with type, but type impressions in greasy ink could be used along with a picture impression by using transfer paper. Lithography, which dated from 1796, was in a sense a chemical means of transferring ink from either raised or intaglio plates, or from crayon sketches.

Halftones

Compatibility with type was more important to book publishers than to print makers. Halftone reproduction in printing was a major problem. Raised type, inked on the flat top surfaces, produces printed characters with sharp edges. White is the absence of ink, while gray needs just a little ink, and raised type does not modulate the ink density. Individual picture elements either did or did not transfer ink, so density variations had to be achieved through spatial distribution and depth control. Hand engraving was limited by the minimum dimensions that picture elements could be cut. Wood blocks were easy to carve but wood grain limited them to coarse line drawings (coarse by modern standards; some wood cuts were quite pleasing). Steel or copper engravings could have very fine lines or dots if the graver was skilled and patient. Acid etching could save time in removal of metal, but the resist coating still had to be scribed with skill. All of the available processes produced illustrations that were obviously hand drawn artistic representations. The most skillful attempts at realism could not be mistaken for the photographic accuracy to which we are accustomed.

Composition of Printers' Inks

There are many formulations of printers' inks, but they fall into two categories: water based and oil based. Water based inks are somewhat like modern India drawing ink, made of colloidal carbon in water. They have a thin consistency, dry rapidly, and soak into porous paper. Greasy inks are thick, dry slowly, and can be retained in intaglio plates.

Carbon inks are blacker than most photographic images, which tended to be gray or brownish-black. The colors of silver images depend on the particle size of the reduced silver as well as changes in the binder and base. Carbon (the chemical element) does oxidize, but the rate at room temperature is negligibly small; it is much faster in a fire. At normal temperatures carbon is extremely unreactive with other materials. It does not change color, but it can flake off the paper. Dried India ink on smooth paper may show microscopic dried-mud patterns, depending on the degree of penetration, distinguishing it from most photographic emulsions.

It has been reported that some of Gutenberg’s Bibles in the 1400’s were printed with inks containing compounds of copper and lead. The characters are clear and glossy after five hundred years, while others of the same period that were printed with carbon ink are dull and crumbled. The observed differences in aging can probably be attributed to the properties of the binders and the degree of penetration in the paper.

Woodburytypes were printed with “ink” consisting of a water solution of pigmented gelatin. The pigments could be finely divided solid particles, but the gelatin was a colloid.

Apparently this was the only printing process that used a medium unlike conventional printers' inks.

The Contributions of Photography

At this point the story gets more complicated. Many workers entered the field because photographically enhanced printing techniques had immediate commercial applications, even though Niepce had to struggle for recognition.

Niepce's invention was a labor saver, and his process was used commercially until the early 1850's, when bichromated gelatin was found to have superior sensitivity and ease of use. It was not type compatible, nor did it have good halftones, but it served to initiate efforts by a large number of workers.

Following are descriptions of the principal processes based on photography. The reprinted 1895 book by Denison [44] contains contemporary details of photogravure and other 19th century processes.

Etched Daguerreotypes

A fatal weakness of the Daguerreotype, besides cost, was the lack of a negative. A Daguerreotype could be rephotographed on another Daguerreotype, but this was expensive. Niepce's process produced multiple copies but was not widely used at this time. Daguerreotypes can be acid etched in their normal form, producing a weak intaglio plate (weak meaning that the etching was shallow and the resulting prints were low in contrast). Nitric acid etches the silver shadows, leaving the raised amalgam dots (see Appendix I for photomicrographs of a Daguerreotype surface). The surfaces were not durable, but could be reinforced by copper or gold plating. Only a few hundred prints could be pulled from the average etched Daguerreotype.

Prints were precisely the size of the parent plate (see Chapter 7), and the left-to-right reversal of the Daguerreotype was corrected in the prints.

Historians do not agree on assigning dates and priorities. Inventors often made announcements of a process and then delayed disclosing the details, either hoping to find financial backing or waiting for patent protection. Without details, other workers could not confirm the announced results. Alfred Donne of Paris and Josef Berres of Vienna were the first to show prints from etched Daguerreotypes in 1839 and 1840 respectively. Their results from simple etching were not of high quality.

In 1841 Hippolyte Fizeau of Paris produced good results by a more complicated process. After lightly etching a Daguerreotype he coated it with linseed oil and wiped it like an intaglio plate. Next he electroplated gold onto the plate, which adhered only to the elevated regions, since oil in the depressions prevented gold adherence. After cleaning, the plate was given a deep etch, the gold now acting as an etch resist. He was able to reinforce the halftones with aquatint resin, and obtained quite creditable quality. Some of his prints appeared in a travel book published in 1841, which was a rapid adoption of the new Daguerreotype process. M. Fizeau did not choose to name his pictures "Fizeautypes", although he might have been so justified.

Some references are: Crawford [38, 237-240]; Eder [48, 577-580]; Gernsheim [61, 539-540]; Jussim [85, 49]; Newhall [105, 249]; Taft [140, 412].

<u>Photo Relief Plates</u>

The first successful photographic relief halftone process was patented in 1881 by Frederick Ives. This complex process produced good halftones with type-compatible plates. The images have a readily detected dot pattern that distinguishes them from photographs, but it was a landmark process made possible by photography. The Meisenbach process from about the same era also used a grating to produce relief plates.

Photography even aided one of the oldest relief printing processes, that of wood cuts. Photographic images were printed on wood blocks by the collodion process; the images served to guide the wood carver's perspective, but of course the resulting prints were still line prints.

Photoengraving, which produces type-compatible relief plates, should not be confused with photogravure intaglio plates. The later have superior halftones at the expense of incompatibility with type.

<u>Photogravure</u>

Photogravure, also called 'photo-aquatint', produces intaglio metal plates by acid etching through a photographically exposed etch resist. It is analogous to the hand scribed steel or copper engraved plates, hence the name "photo - grav - ure". It produces excellent halftones by substituting the greater detail and continuous tonal range of photography for the fine lines of hand engraving. Photogravures, dating from about 1879, more closely resemble photographic prints than any other photomechanical reproductions with the possible exception of Woodburytypes. The process is well described in Jussim [85].

Fox Talbot patented the first process in England in 1852, using potassium bichromate sensitized glue on steel plates (bichromate sensitizing is described in Chapter 4). Talbot at first used platinum chloride as the etchant; in 1858 he patented ferric chloride etching, still used today.

To solve the problem of ink removal from the shadows during wiping, Talbot used a black gauze screen between the positive and the bichromated resist to create an etched dot pattern. This was the first use of a halftone screen, the results of which can be seen in any newspaper picture today. Later he used powdered aquatint resin for the same purpose (however, this was not original; aquatint, as previously mentioned, dates back at least to the beginning of the 19th century.) Talbot thus laid the complete foundation for modern photogravure; he called it "photoglyph", having already used "Talbotype" for positive/negative photography. Figure 4 shows two views of a newspaper picture halftone pattern.

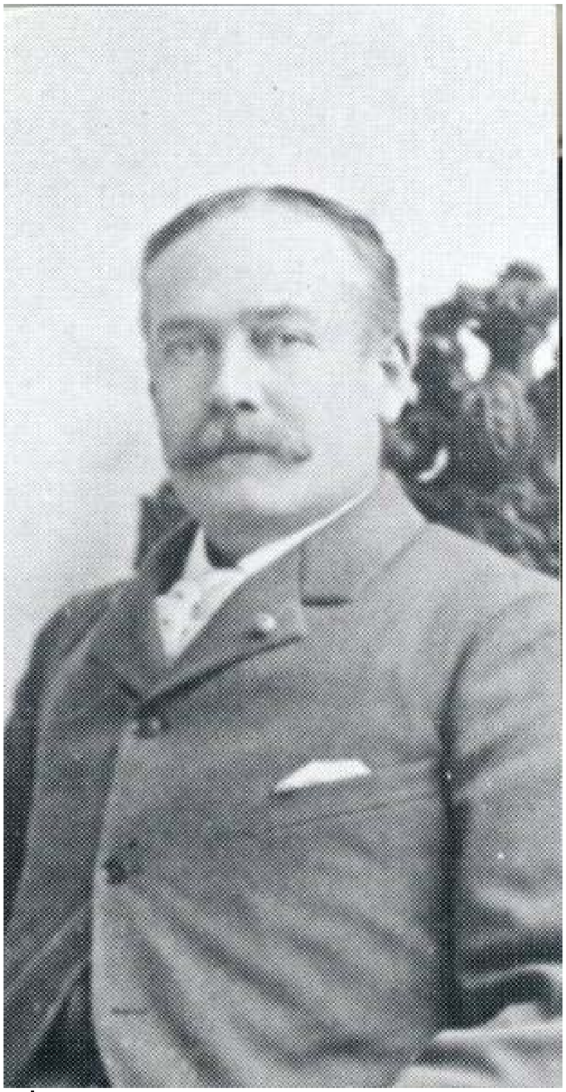

Figure 4

There were many variations. Paul Pretsch of Vienna patented in 1855 a bichromated gelatin-on-glass process based on swelling and reticulation in the shadows. The gelatin was molded in gutta percha and then copper electroplated. Campbell Duncan Dallas adapted this process for his Dallastypes, possibly infringing on Pretsch's patent, yet the name Dallastype has survived instead of Pretsch's. In 1879 Karl Klic of Vienna made copper photogravure plates both with aquatint grain and with a screened grain.

Improvements in photolithography continue to be made, particularly in random dot processes. There are now processes in which the number of dots in a given area depends on the amount of picture detail in that area, resulting in improved resolution.

References: Crawford [38, 243-268]; Dennison [44]; Eder [48, 593- 608]; Gernsheim [61, 544]; Jussim [85, 83; 303]; Newhall [105, 142]; Thomas [142, 94-95]; Welling [150, 85].

Collotypes

Collotypes are inked images on paper and are printed directly from light-exposed bichromated gelatin (a colloid, hence the name "collo-"). The halftones are good to excellent, and some of them can easily be mistaken for original photographs.

Alphonse L. Poetevin (France) patented in 1855 the first collotype process using bichromated gelatin. In zones exposed to light the gelatin hardens and no longer absorbs water; it will absorb a coating of greasy ink for transfer to paper. In nonexposed areas water absorption repels greasy ink. In this respect it is related to lithography, and it used lithographers' ink.

Josef Albert (Germany) improved the process in 1868 and renamed it Albertype, using a glass base. When Albertypes were printed on glazed paper they resembled glossy albumen prints; microscopic examination will show the collotype reticulation pattern. Albertypes were widely used for book illustrations and postcards.

The heliotype, invented in 1869 by Ernest Edwards in England, transferred the gelatin to a more durable metal plate.

The water content of the gelatin in collotypes was an important process variable, resulting in a curious historical sidelight. The process was said to work better in the European climate than in the United States. At that time the American industrial establishment was mostly east of the Mississippi River where the humidity is greater than some European locations. If humidity is detrimental to the process, it probably would have worked well in the arid American southwest, but industrial facilities were lacking there. Whatever the reason, the collotype process is still used in Europe but is practically unknown in the United States. On the other hand, solar enlarging on albumen paper was reported to work better in the United States because of more reliable sunshine. The early literature is filled with advice concerning conditions that appeared to influence the working of processes; sometimes the advice was correct for the wrong reasons. There were many variations of the basic collotype, some of which have been briefly described in Chapter 14, Section 3.

References: Crawford [38, 269-280]; Eder [48, 553; 594; 617-621]; Gernsheim [61, 540; 547-549]; Jussim [85, 72]; Newhall [105, 251]; Thomas [142, 96]; Welling [150, 85].

Woodburytypes:

Walter Woodbury (England) patented his process in 1864; it was in worldwide commercial production until the 1890's (according to Jussim the French name was photoglyptie.) It was the only continuous tone photomechanical process, and prints were available in brown, red, green, blue, and other combinations; brown was commonest. The prints have a superlative halftone, excellent sharpness, no screen pattern, and a beautiful liquid depth. Of all photomechanical processes, Woodburytypes are the most likely to be mistaken for high quality original photographs. Their fatal disadvantage was that they were not type-compatible.

The process used bichromated gelatin on a reinforcing layer of collodion on glass; it was exposed through the collodion after being stripped from the glass. Hot water washed away the unexposed sections in proportion to the degree of exposure, which gave a relief pattern to the gelatin.

To this point the treatment was similar to that of other workers in bichromated gelatin, but his printing process was unique. The gelatin relief was pressed against a lead plate in a hydraulic press. Gelatin behaves like an incompressible fluid, and the soft lead received an accurate intaglio impression. For ink, Woodbury used a heated water solution of pigmented gelatin in the lead mold and transferred it to paper in a smaller printing press. Excess gelatin was squeezed out at the sides, and Woodburytypes had to be edge trimmed. Conventional intaglio ink printing removes the excess ink by wiping before the paper is applied, as described previously, making possible clean margins.

Woodburytypes closely resemble toned silver bromide prints and especially carbon prints. All three types, if bound in a book, will be alone on their pages. There is a convenient identification clue: carbon prints were usually labeled "Permanent", while Woodburytypes were labeled "Woodburytype". Such straightforwardness is salutary, but there were exceptions. Sometimes the legend was on another page, which is lost if the print is no longer in the original binding.

According to Crawford, the largest Woodburytype was 10 x 14 inches, though 7 x 9 inches or smaller was more common; the size of the hydraulic press was the limitation. Woodburytypes were always edge trimmed, and are more likely than carbon prints to show visible raised edges at light/dark boundaries under grazing illumination. A characteristic flaw in Woodburytypes is the presence of tiny dark specks in the highlights, caused by particles of dried gelatin carried over. Woodburytypes were usually a rich brown color, but the gelatin could receive any common pigment. Woodbury later introduced the stannotype, which was made with tinfoil instead of lead plates to eliminate the need for expensive hydraulic presses. The stannotype process was not a commercial success because of competing photographic processes, and the prints are not distinctive unless labelled.

References: Crawford [38, 270; 285-289]; Eder [48, 587-589]; Gernsheim [61, 340-342]; Jussim [85, 57]; Newhall [105, 251]; Thomas [142, 96]; Welling [150, 85].

<u>Distinction Between Pattern and Grain</u>

Prints made by photogravure and collotype can be recognized by their fine-structure. There are three basic patterns visible under low power magnification:

1. Geometrical dot structure characteristic of halftones. It may be cross-hatched, diamond, square, or round dots.

2. Collotypes show random connected lines in a worm-like or

wrinkled pattern caused by reticulated gelatin.

3. The random particle pattern of aquatint and photogravure, a process that dates to about 1800 and was used to enhance many printing processes.

Woodburytypes and carbon/gum bichromate prints have no patterns, but there is confusion in some historical literature regarding grain. At least two sources refer to Daguerreotypes and Woodburytypes as "grainless", which is in error. It should have been said that they are lacking in visible texture.

We live in a grainy world. A television receiver tuned to a distant transmitter displays what we call snow; in radio it is static. Applied generally to electronic communications, it is more accurately described by the signal-to-noise ratio. There is always grain present in photographs, comprised of image elements at discrete nucleation sites. Daguerreotypes were regarded as grainless in comparison with calotypes that had a paper fiber texture. The true nature of Daguerreotype grain is shown in the scanning electron micrographs in Appendix I.

The patterns in gravure and collotypes are reliable descriptors. When the pattern is geometrical it is unambiguous. Collotype reticulation pattern is also distinctive, but it may require microscopic examination to identify. Aquatint resembles photographic grain; both are random but aquatint particles are larger. Photographic grain is visible to the unaided eye in magnification or enlargements. Matte surfaces were often produced on silver bromide gelatin paper by mechanical stippling. It can be identified microscopically by the regular pattern of sharp-pointed indentations in the emulsion that do not cut through the emulsion.

Chapter 6

Glass Bases

This Chapter discusses Archertypes, lantern slides, crystoleums, sphereotypes, and types of flat glass used in early photography, plus a description of "weeping glass".

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Negatives on glass

Talbot's negative-positive calotype paper process was clearly a conceptual improvement over the Daguerreotype because it permitted multiple reproductions, but the texture of the paper fibers limited the sharpness of the finished picture. LeGray's wax impregnation of the negative helped reduce this texture, but still the paper was translucent, where complete transparency was wanted. Satisfactory transparent flexible films were not made until late in the 19th century, but glass was available much earlier in virtually any desired size. In 1858 John Kibble in Scotland made plates 36x44 inches in size. A camera named "The Mammoth" was built in Chicago in 1900 that used plates 4 1/2 by 8 feet; the loaded plate holder weighed 500 pounds according to Gernsheim.

The trouble was that glass could not simply be coated with a water solution of silver nitrate: it rubbed off when dry. Paper, on the other hand, retained silver nitrate when it was soaked in a solution, and the nitrate could then be converted to the more sensitive and water-insoluble chloride. The resulting image had an embedded appearance that today helps to identify the process.

A multitude of inventors experimented with coatings and binders on glass. A good coating had to be sufficiently durable to stick without peeling while going through various chemical baths; it had to be permanently transparent; and it had to be chemically compatible with the light sensitive ingredients. The most successful coatings turned out to be gelatin, collodion, and albumen (egg white). The first use of glass in quantity for photography was for the wet plate collodion process invented by Archer in 1854.

Rempel [124] discusses tests for identifying various coatings, and his work should be consulted for details. The tests are destructive but can be performed on very small regions under a microscope. Essentially they depend on the fact that water swells gelatin but not collodion, while ethyl alcohol dissolves collodion but not gelatin. Albumen is unaffected by either solvent. Infrared spectrophotometry is a non-destructive but more expensive analytical process that is quite reliable.

After the apparent solution of the adherence problem it soon became apparent that these coatings had more subtle shortcomings: low and erratic sensitivity to light continued to be a persistent difficulty. The Archertype, or wet plate collodion process, was far more sensitive than early dry albumen or gelatin emulsions, but it was clumsy. The sensitivity was so fleeting that the plates had to be exposed and processed within no more than ten minutes after coating, literally wet. One theory was that dried collodion prevented diffusion of processing chemicals to the silver. However, tintypes used dry collodion emulsion with no processing difficulty, so the problem was complex. The wet plate process survived for more than two decades because it took that long for a dry plate to be invented that approached or surpassed the sensitivity of wet collodion.

Besides George Eastman, other inventors were at work on the dry plate problem. Eder (48) describes a number of these experiments. Dry plates began to be marketed by various inventors in the 1870's; Eastman's plates appeared about 1880. An interesting sidelight on this work is that twin brothers in Maine, Frelan and Francis Stanley, manufactured successful dry plates until Eastman bought them out. They used the money to start an automobile company, making the Stanley Steamer.

A great amount of trial and error was expended to find a preservative that would slow the drying and prolong the sensitivity of collodion negatives. Some of the experimental preservatives that were concocted were more ingenuous than ingenious, as Gernsheim has recounted (61, 324): he called it "the culinary period of photography." Preservatives included caramel, camphor, coffee, gin and water, ginger wine, glycerine, honey, Iceland moss, lager beer, laudanum, liquorice, malt, magnesium nitrate, milk, morphine, morphine nitrate, nux vomica, raisin syrup, raspberry syrup, salicine, sherry, sugar, tannin, tea, tobacco (several brands), treacle, vinegar, whey, wormwood, and zinc nitrate. Whiskey was not listed in any of the four references that were consulted, an unexpected and mystifying absence. Perhaps it went into the photographer instead of the coating mixture.

Serendipity had its place, too. It is now known that some of these organic mixtures have the property of promoting the formation of organometallic complexes and colloids, with results that conceivably did benefit the photographic process. It is worth reflecting that a century from now some of our own efforts might fare no better in history's judgment.

In recent years some workers have reported on their use of modern analytical methods to investigate the composition of historic pictures for dating purposes (see the Bibliography of modern scientific studies.) Infrared and ultraviolet spectrophotometry and x-ray fluorescence are useful non-destructive analytical techniques, but interpretation of results can encounter formidable problems when the above list of "preservatives" is considered.

Collodion-based sensitive layers were used in three applications:

1) Glass negatives, described above as Archertypes.

2) Collodion-coated paper, late in the 19th century.

3) Tintypes.

The sensitivity-stability problem existed mainly in connection with glass negatives. Collodion-coated paper could easily be given whatever exposure was needed in the darkroom. Tintypes were less affected than Archertypes for reasons that are discussed in Chapter 7, basically having to do with the superior speed of short focal length lenses.

Generally speaking, photographic plates and papers were coated on only one side, with the exception of very early salt prints. Coating both sides by dipping was easy, but it not only doubled material costs, it also produced out-of-register ghost images from the back side. Coating machines were put into production in the latter part of the 19th century, and manufactured dry plates (mostly gelatin silver bromide) can be recognized by their uniformity in thickness compared with the hand-coated product. Collodion plates were hand-coated by the user at the time of use, and film thickness often varied at the edges because of uneven drainage, and the fact that collodion would not adhere to as-cut edges (scored and broken). The edges of collodion plates were therefore usually roughened or polished, which also reduced handling injuries. They were often salvaged and reused several times to save cost. Plate thickness was not standardized, but they were considerably thicker than the dry plates introduced in the 1880's, which usually had as-cut edges.

Hand coated plates often contained blisters and occluded dirt particles; at the factory such defective plates were (usually) discarded. Sometimes the glass showed faint markings caused by the factory practice of marking lot numbers with soap; the alkaline soap slightly etched the glass, preventing collodion adherence, and the marks could only be removed by abrasive polishing. There were probably more flaws in the collodion coating on average than in the glass.

Visual Appearance of Emulsions

As Gill [67] and Rempel [124] have described, observation of reflected and transmitted light from images on glass can often differentiate between the emulsion types. Collodion is creamy or milky by reflection and a neutral black by transmission.
Gelatin-silver images are neutral black by both transmitted and reflected light. Woodburytypes are usually brown in transmitted light and dark by reflection. Carbon transfer prints were pigmented with many colors, which show by transmission.
Hand-tinted colors can cause confusion, but some areas were fortunately left clear, so the basic appearance of the medium can

be observed.

Albumen on glass was tried as early as 1847 but because of low sensitivity it was seldom used commercially for negatives in spite of its popularity for paper prints. It was used on glass as positives in several forms, described below. It has a creamy appearance by reflected light, black and white by transmitted light.

Positives on glass

Glass was a natural base for lantern slides, which had already found some vogue with hand-painted images. The Langenheim brothers of Philadelphia patented photographic albumen glass lantern slides in 1850 under the name Hyalotype. They are brown by transmitted light, milky by reflected light, and survivors are somewhat rare. Woodburytype, carbon, and collodion transparencies were also made for lantern slides. They are difficult to distinguish visually from each other. Woodburytypes and carbon positives, like Hyalotypes, are usually brown, but they have a dark reflection rather than milky.

Collodion negatives on glass were the basis for ambrotypes, as discussed in Chapter 7. Collodion positives were sometimes printed on opal glass, also known as milk glass by some collectors and dealers. Opal glass contains colloidal crystallites, usually sodium or lithium fluorides, that scatter light and produce a pleasing translucent white color. Opal glass superficially resembles ivory, but collodion portraits were not made by the same process as ivorytypes or Eburneums (see Chapter 9). Collodion portraits on opal glass were often vignetted, framed, and tinted. It bears repeating that collodion prints on opal glass are not "opal ambrotypes", as we have seen at least one specimen mislabeled. They are positive collodion prints on a white glass, whereas ambrotypes are negative collodion prints on clear glass against a black backing.

Crystoleum

The crystoleum was representative of several types of decorative pictures on glass. An albumen print was glued to the inner side of a slightly curved glass, and the paper was removed by soaking, leaving the transparent albumen image on the glass. The image was tinted with oil colors and sealed with wax. A second curved glass was tinted with broad expanses of color and mounted behind the image; the two glasses were bound together with a separator to give a three dimensional effect. Details of the process are given in Cassell's [84, 154-5].

The sphereotype, patented by Albert Bisbee in 1856, was made somewhat similarly on the bottom of curved paperweights. The spherical glass acted as a magnifier. Other similar processes were the diaphanotype, the ectograph, and the opalotype (see Chapter 14, Section 3, for references). Some were transfer processes, others direct printing, and their classification is somewhat arbitrary. See also Chapter 7 for further information on variations of ambrotypes, and Chapter 9 for information on transferotypes.

Notes on the History of Flat Glass

19th century photography was one of a growing number of new industries that demanded better raw materials. Photography soon exerted sufficient commercial leverage to bring about improvements in paper making (see Chapter 1). Better and cheaper glass was also needed with the advent of Archer's wet collodion process in 1854.

Good quality flat glass was difficult to make in the nineteenth century. "Good quality" means flat parallel surfaces, uniform thickness, smooth grainless surfaces, neutral coloration, freedom from pits, stones, bubbles, and striae; and all at the lowest cost, naturally.

In the nineteenth century there were two principal glass compositions: lead and lime glass. Both were used in photography; lead glass was heavier and more expensive, but because of its early availability as plate glass, it was used for wet plates. Later in the century it was phased out in favor of lime glass, which had been made as early as 1864. The quality gradually improved so that it could be used for window glass without grinding.

The commonest chemical impurity in the glass was iron, producing a green color that did not bother negative processes but caused unpleasant effects in glass positives. Only 500 parts per million of iron will give window glass a green color that can be seen through the edges (optical glass is permitted only 10 PPM or less). Lead glass is dark in edge viewing, while lime glass commonly shows a green tint.

A booklet from the Corning Museum Of Glass, reference I-12, states "At the beginning of the 20th century, there was no way to mass-produce flat glass". Several methods of making flat glass were in use in the 19th century, each with its own peculiarities:

1. Cast glass:

One of the oldest ways of making flat glass was to cast molten glass and then roll to thickness on flat iron tables (molten glass does not stick to iron or carbon except at red heat, so these materials are used for tools.) The bottom surface was always optically spoiled by contact with the casting surface, and ripples and striae were common. Grinding and polishing the contact surface made a good product ("plate" glass) for windows and mirrors, but it was expensive and reserved for those who could afford it. There is a diamond-polished mirror on display in President James Monroe's home from early in the 19th century.

Steam power was used for grinding plate glass as early as 1789. The surfaces were seldom as brilliant (grainless) as fire polished surfaces because of the particle size of polishing media, and body flaws were common, especially in larger sizes. Grinding the two sides was done separately until 1937 when a twin grinder was developed in England that ground both sides simultaneously.

2. Blown cylinder glass:

This method consisted of blowing as long a cylinder of molten glass as possible; after cooling, the ends were cut off and the cylinder was scribed lengthwise. When reheated in a furnace, the cylinder opened and sagged flat on a table. Only the inner surface remained fire polished; the outer surface was somewhat deteriorated by contact with the table, but not as seriously as table-cast glass. A specimen of an uncut cylinder, about eight feet long, is on display at the Corning Museum Of Glass, Corning, New York.

This process was not mechanized until early in the 20th century. The product was wavy but tolerably good for windows: the Crystal Palace, built in England in 1851, used 300,000 panes of cylinder-blown glass four feet long. At first it did not make a very good negative photographic base without grinding, but selected pieces were occasionally used because it was cheaper than ground and polished glass. Apparently the quality improved in the 1870's, in time for the gelatin dry plate.

3. Disc glass:

This was an old process consisting of blowing a glob of glass into a sphere, opening the end, and spinning rapidly while molten. Centrifugal force could form a disc as large as a meter in diameter, which even today is a tricky manual operation. It was not suitable for photography without grinding because cut pieces did not have parallel surfaces, and the surfaces were marked with concentric ridges. It was used for small windows such as leaded diamond panes, where the defects were less apparent and even attractive.

The thick center from which the disc formed during rotation was called the "crown". Crown glass was scrap and was used for lens-making when big enough pieces could be found that were not too bad in quality. Crown and flint glasses were used together in compound lenses to correct some lens aberrations. Flint glass contained lead oxide, while crown glass did not, and the refractive indices and optical dispersion of the two glasses were substantially different. Lens formulas increasingly made use of these properties in compound lenses to meet the demand for better photographic sharpness.

According to Archer [2], crown glass was sometimes flattened by melting to produce sheet glass, actually a form of casting with its characteristic defects on one side.

Two other kinds of glass have had some photographic use as light diffusers. One is commonly called "ground glass", used as viewing screens in view cameras. It is usually made by sand blasting or fluoride etching. The other is "opal" glass, and is used as a light diffuser in enlargers and other light sources. It consists of a thin layer of opal glass fused to a base of clear glass. The opal layer is thinner than a solid piece of opal glass and therefore has less light loss, while the clear glass provides strength for the thin layer. Neither of these two types appear to have been used as photographic image bases. However, solid opal glass was sometimes used as a substrate, as mentioned above. The composition of opal glasses is discussed in Scholes (A - 326).

Modern flat glass is made by several methods: grinding and polishing cast glass, continuous vertical drawing of sheets, and floating on molten tin; the latter currently dominates the window-glass industry. The quality is so good that grinding is not necessary for most applications.

There are also many specialized methods to meet modern requirements. One example is the very thin, optically perfect sheet glass used for screens in laptop computers such as the one on which I am typing these words. Reference I-22 describes the fusion draw process used for this type of sheet glass.

Wet Plates and Dry Plates

When Archer invented the wet plate collodion negative in 1851, the best available glass was polished plate glass. It was usually lead glass; later in the century, lime glass supplanted lead glass because it was cheaper and lighter. By this time lime glass was universally used for ordinary window glass.

I have not found reliable information on the sources of glass for gelatin silver dry plates, so the following remarks are speculative. In the context of the technology, the most likely source was soda lime cylinder glass, selected for uniform thickness within lots, and minimum waviness. It seems unlikely that it was ground and polished because of cost and industrial capacity; the fact that the plates had as-cut edges argues for cost constraints even in early days of factory production. Slight variations in thickness would probably have been tolerated at a time when attention was concentrated on the sensitivity question.

Weeping Glass

This is a term that has been given [Ref 152] to destructive deterioration of glass under certain storage conditions. It is irreversible and may completely ruin glass photographic plates, even in archival storage. The explanation is necessarily technical, but understanding may help save some valuable plates.

It manifests itself as a sticky wet coating on the glass surface (not the emulsion side) in an apparently dry room. The coating may remain wet in room environment. If the glass is washed in clean water and dried, the coating will be gone but the glass will appear frosted or etched. A photographic plate will be hazy, and a good clear print cannot be obtained from it, nor can the original clarity be restored by chemical treatment.

It can occur in archival storage if the environment undergoes a temporary excursion of high humidity, such as might happen if the air conditioning fails, or a sprinkler system nearby is energized, or the roof leaks. The restoration of normal conditions may not save the day if the damage has been done, and once started, it can continue to progress under benign storage. The combination of circumstances causing the condition are fortunately rather uncommon, but it can occur in climate-controlled archival storage that is usually considered safe. This writer has seen it happen.

The chemistry of the problem is well described in Scholes [A-408]. Werner [152] has a similar discussion. Glass can be attacked by water but most glasses are not water soluble. If a thin film of water is allowed to condense on glass and remain, hydrogen ions diffuse into the glass, displacing sodium ions. This sodium diffuses into the water, forming a solution of sodium hydroxide. If the body of water is small (such as a thin film of condensate), the sodium hydroxide may become quite concentrated with a high pH. Such an alkaline solution rapidly etches the glass, destroying the Si-O bonds, and does not readily evaporate to dryness at room temperature. It feels wet and "soapy" to the touch, and the etching is progressive and irreversible. A concentrated electrolyte of this kind has a reduced vapor pressure and low evaporation rate at room temperature, so its drying rate is much reduced.

The buildup of a concentrated solution of sodium hydroxide requires a thin undisturbed film of water. The time scale depends on temperature and film thickness, but damage can occur in a few hours. Etching is more likely to take place on the reverse side of photographic plates rather than the emulsion side, although water swells gelatin emulsion and affects its optical properties.

Soda lime glass is particularly susceptible, which was used for gelatin dry plate negatives rather than the heavier and more expensive lead glass. Of course, glass photographic plates can withstand darkroom chemical processing with no observable change. Glass is a durable and ubiquitous material, evidenced by long service in windows and other objects. But window glass may exhibit faint cloudiness after many years of weathering, and other glass objects stored in a damp environment can deteriorate. Antique glass vessels often show interior cloudiness; it is sometimes mistaken for calcium deposits. Acetic acid will remove calcium deposits but it has no effect on water-damaged glass.

The conditions conducive to the formation of a film of condensed water on archival photographic glass plates are fortunately uncommon. But this writer has seen storage racks in two modern museum archives draped with sheet plastic because of roof leaks, for periods of days or weeks. When a water problem is present, archivists may be more concerned about the threat to paper artifacts than to glass plates, because glass is considered to be "waterproof". Archival storage is usually thought to be safe and secure, but eternal vigilance is necessary to avoid false security.

Chapter 7

Daguerreotypes, Ambrotypes, and Tintypes

This chapter discusses Daguerreotypes, tintypes, ambrotypes, and ambrotype derivatives Hallotypes, Diaphanotypes, sphereotypes, and alabastrines.

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Specimens of Daguerreotypes, ambrotypes, and tintypes are sometimes mistaken for each other in similar decorative cases. Daguerreotypes and ambrotypes were always cased; only tintypes were both cased and uncased. When cased, tintypes resemble ambrotypes on cursory inspection. The normally rather obvious differences in the three types are often obscured by deterioration and by original process variations. Unlike paper photographs, however, these three types did not fade. It took many years to recognize and control impurities in paper and gelatin, and in processing chemicals.

Daguerreotypes

The literature on Daguerreotypes is phenomenal in physical volume and in the vitality of modern research. Virtually all photographic history books contain accounts of the invention and worldwide acceptance of the process from about 1840 to the mid 1860's. The calotype made only minor inroads in its popularity, even though the calotype negative permitted duplication, while the Daguerreotype had to be rephotographed or etched and ink-printed. The wet collodion and tintype processes finally superseded the Daguerreotype, but it left a rich legacy of some of the earliest historical photographic images.

Besides the standard history books, Gernsheim [61], Barger [8], and Newhall [104] have separate histories of the Daguerreotype, based on historical and cultural factors. The process has been revived in recent years, notably by Irving Pobboravsky of the Rochester Institute of Technology, with beautiful results. Romer [126] estimates that there are or have been several dozen modern practitioners of the art.

The Daguerreotype has been studied more extensively by modern analytical methods then any other historical photographic process. Most of the results to date are listed in the bibliography under Modern Scientific Studies. The definitive work has been reported by M. Susan Barger and her collaborators [references 7 through 18]. In particular, Barger and White, reference 15, is a work of major significance, not only regarding the Daguerreotype but also parallel branches of photography in that period. Other work is by Pobboravsky [118 and [119], Swan et al [138], and Jacobson & Leyshon [80]. A scientific model is described by Barger [8 and 12]. Modern scientific interest in the process is aroused by its embodiment of thin film physics and optics. It is the only completely inorganic chemical photographic system with no emulsion, which makes it an interesting model for photosensitive research.

Daguerreotypes are probably the easiest of the three cased types to identify because the polished silver exhibits specular reflection. This means that they are silver mirrors in which the viewer can see a true image reflected, not just a metallic sheen. The appearance depends critically on the viewing angle.

The nature of the Daguerreotype image is shown in scanning electron micrographs in Appendix I. Highlights in the image contain a high density of light - scattering amalgam particles, so that some incident light has a good probability of reaching the viewer's eye. Shadows have fewer such particles, so incident light is efficiently reflected away from the eye unless the viewing angle is very close to ninety degrees. In the latter case, the viewer will see his or her own image.

The polished silver is a property unique to Daguerreotypes and a valuable aid to recognition, but there are two problems. First, the silver is subject to tarnishing, especially around the edges as shown in Figure 5. Second, all Daguerreotypes have protective glass over the picture, and reflections from the glass can be mistaken for reflections from the silver. This may confuse identification because all ambrotypes and some tintypes were also glass covered.

Figure 5

Daguerreotypes were made in standard sizes (not all authorities agree on these sizes):

Table 2

Whole plate	6-1/2 x 8-1/2 inches
Half plate	4-1/4 x 5-1/2
Quarter plate	3-1/4 x 4-1/4
Sixth plate	2-3/4 x 3-1/4
Ninth plate	2 x 2-1/2
Sixteenth plate	1-3/8 x 1-5/8

In addition, there was a "double whole plate", also called Mammouth or Imperial plate, 10 1/2 x 13 1/2 inches. This was the largest Daguerreotype size ever made, and a few were made about 1850. According to Condax [35] no camera capable of holding these plates is known to exist today.

Most Daguerreotypists bought whole plates and cut them to desired sizes, using much ingenuity to minimize waste. Rough cut edges and corners are common, concealed in the cases. Blank plates were supplied to the trade, mostly from French and American sources, and were made by two processes: (1) electroplated silver on copper, and (2) cladding.

Cladding was discovered about 1742 by Thomas Boulsover. It is a process of fusion bonding by alloying a bar of silver against a bar of copper and running them together through a rolling mill under great pressure. The process is described in Bisbee [23]. The silver thickness of clad plates was one-fortieth to one-sixtieth of the copper thickness; the number 40 was often stamped in one corner of whole plates. Clad plates were used for the earlier Daguerreotypes, while electroplated plates were later used by some Daguerreotypists.

Electroplating was patented in 1840 and put into practical use about 1844; it depended on the availability of electric current. 'Galvanic' batteries were used as a power source, and electroplated plates were called 'galvanized' (modern usage of the term refers to hot-zinc dipping). Pobboravsky [119, 42] states that French electroplated Daguerreotype plates were made as early as 1851, with an embossed hallmark of the process.

The microstructure of the silver surface is different in the two processes. Rolling generates minute longitudinal marks, while electroplating produces a more porous grain structure which can be seen microscopically. Fusion bonding also produces some alloying of the copper in the silver, which varied with process parameters. In principle it should be possible to trace the source of a plate by analysis of these characteristics. Both processes are common metallurgical operations today.

The sensitized plates were exposed directly in the camera, generating a reversed image (see Chapter 11), but not quite all Daguerreotypes are reversed. Some are rephotographed copies, so that shop signs, for example, read normally. Others were made by photographing through a 45 degree prism mounted in front of the camera lens, or from a mirror. Both of these techniques produced a normal picture but were not often used because they were too much trouble and expense. People were so entranced with the novelty of fixed images that it didn't really matter if portraits were reversed.

There have been several published processes in the past few years for removing tarnish from Daguerreotypes. It is strongly recommended that none of them be used without first reviewing the most recent techniques: see the comments in Chapter 12 and Appendix I. Cosmetic reasons are not sufficient to justify the risk of irreversible loss of image information.

Ambrotypes

Ambrotypes were more popular in America, appearing from 1854 until about 1865; their European name was amphitype. They are collodion negatives (not positives) on glass, sandwiched against dark background materials in a case. They appear as positives for the following reason. When any transparent silver based negative is viewed from either side, a small amount of light is reflected back to the viewer from the shadows; essentially no light is reflected from the highlights. This is difficult to verify in a brightly lighted room because so much light comes through the negative, but it can be seen in a darkened room with the illumination coming from behind the viewer. If a matte black surface is placed behind the negative, it will prevent any light from coming back to the viewer from the clear regions, transforming them into shadows. Light will still be reflected from the darkened areas of the negative and they become highlights relative to the clear areas. Thus the negative now appears as a positive, though not very bright or contrasty by modern standards. Daguerreotypes were usually not very contrasty either, so ambrotypes became competitive, especially since they were cheaper.

Ambrotypes often look like they were made on a dark and stormy night. Efforts were made to improve the contrast; exposure and development techniques were optimized, and tinting helped to relieve the dullness. Different kinds of background were used; japanned black cardboard, velvet, black varnished metal, and black varnish applied directly to the collodion negative. Towler [108, 138] lists four varnish formulations that could be applied to either side of the glass negative. If it was applied to the collodion side the picture was not reversed to the viewer but it was duller than if the glass on the side opposite the collodion was varnished. Most ambrotypes are reversed as a tradeoff for a slightly brighter appearance.

Varnish on the glass is often blistered after a century and a quarter; in such cases the picture appears hideous and apparently worthless, but there is hope of restoration. The picture can be restored by removing the old lacquer; this is a task for a skilled restorer who knows which solvent will remove the varnish and not the collodion picture. Black paper (acid-free archival quality) will then restore the picture if the collodion image is intact. Sometimes just placing black paper against the blistered varnish will improve the appearance, but it is not a proper restoration and it may abrade the collodion if that is the side that was varnished. Neither Daguerreotypes nor tintypes show this particular form of deterioration, so blistering is at least an aid to identification. Figure 6 shows an the component parts of an ambrotype that is backed with a piece of black lacquered iron with formed raised edges to prevent close contact with the glass. The collodion surface can thus face the backing without abrasion damage, and the picture is not reversed. This backing has survived without deterioration. The image photographed on a white background can be seen to be a negative.

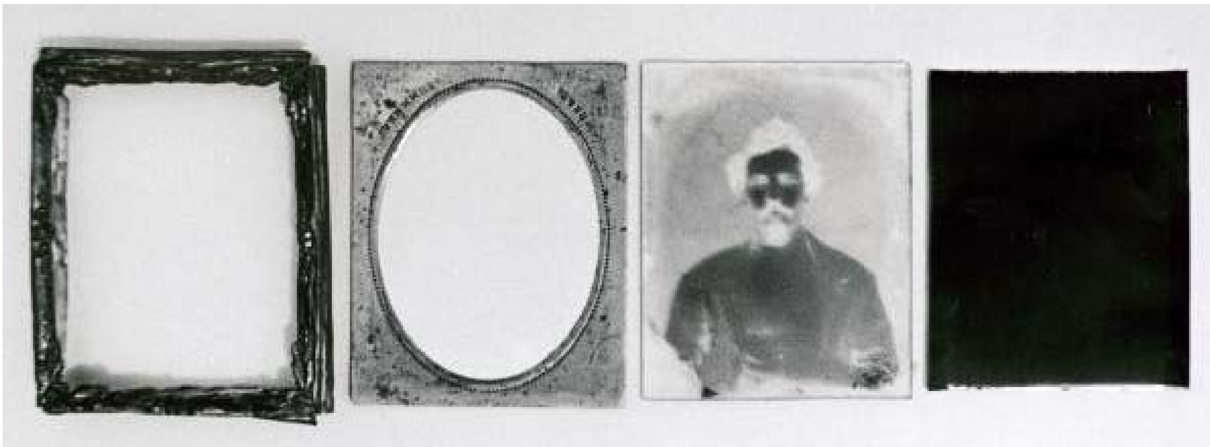

Figure 6

Ambrotypes that are backed with deteriorated cardboard or velvet are restorable by simply replacing the old backing with black archival paper (not waxed). Ambrotypes were made in sizes corresponding to Daguerreotypes with which they competed, so they could be mounted in the same cases.

<u>Hallotypes</u>

The Hallotype was a derivative of the ambrotype process, invented and patented in 1856-1867 by John Bishop Hall of New York.

There were many minor variations, but essentially Hallotypes consisted of two ambrotype transparencies bound together in registry with colored backgrounds. Stereo effects were produced by separating the two transparencies, with many backgrounds including mirrors.

Other variations were:

1) The 'Diaphanotype', an ambrotype cemented to various colored or painted glass backings.
2) The 'sphereotype', a vignetted ambrotype in register with a duplicate transparency similar to the Hallotype.
3) The 'alabastrine' bleached the highlights in the front image with colored backings; some used opal glass.

So many variations emerged that the patent rights dissolved in a sea of complexity. A good account of these fascinating processes is found in the Marders' paper [94].

Tintypes

Daguerreotypes and Ambrotypes were fragile, both requiring glass protection and confining their viewing to the home environment. Both were expensive, the Ambrotype less so because of its cheaper materials. Talbot's salt prints were not as fragile, being on paper, but Talbot's habit of suing everybody restricted public acceptance (salt prints also had an early fading problem). The invention that broke the price barrier and opened photography to widespread dissemination was what we call the tintype. It was invented near Cincinnati Ohio by Professor Hamilton L. Smith in 1854 (some references incorrectly call him Hannibal Smith; see Estabrooke [51] for the correct spelling and the text of his patent).

The collodion containing silver halide compounds was coated directly on thin japanned iron (see below). The following discussion of image formation, described by Estabrooke [45], may help to explain the wide variation in contrast observed in present-day specimens.

The unexposed emulsion had a "creamy-white" appearance, obscuring the dark japanned metal, unlike the clear collodion coating on Archertype glass plates. Development of the latent image in an iron sulfate solution produced a deposit of metallic silver in areas that received the most light during exposure, and these areas received an additional deposit of precipitated silver from the solution. Fixing in potassium cyanide dissolved unexposed silver halide, revealing the dark underlying color of the japanned iron. Thus highlights in the subject were represented by heavy silver deposits, and shadows were the dark japanned iron showing through the thin or absent silver. The result was a positive image whose contrast depended greatly upon processing variations. Too much development produced a light-colored washed-out picture, while too much fixing caused an excessively dark picture. Of course lighting conditions during exposure also had a significant effect.

Archertypes that used collodion emulsion had a severe problem with sensitivity stability, described in Chapter 6, but this is seldom mentioned in connection with tintypes that also used collodion emulsion. The literature appears not to explicitly address this comparison, but one reason may be as follows: most tintypes were exposed in cameras that were designed for the small format of tintypes, about 1" x 1/2", whereas Archertypes were often 5" x 7" or larger. Lens speed, related to light-gathering power, is the lens focal length divided by the diagonal dimension of the picture. A rule of thumb is that the diameter of the lens should be equal to the diagonal of the picture. The effective result was that pictures small in size, which characterized most tintypes, received more light per unit area than large negatives such as Archertypes. It was easier and cheaper to grind a lens of short focal length to cover the small tintypes than a long lens for an Archertype. The dry collodion coating, lower in intrinsic sensitivity than Archertpe wet collodion, was thus sufficiently sensitive to be useful for the tintype.

This may have been a reason for the upper limits to the sizes of tintypes and Daguerreotypes (about 5 x 7 inches), though it is not expressly described in this manner in the literature.

Figure 7a shows a tintype with poor tonal range and dark whites; figure 7b shows how much better an appearance proper processing could achieve.

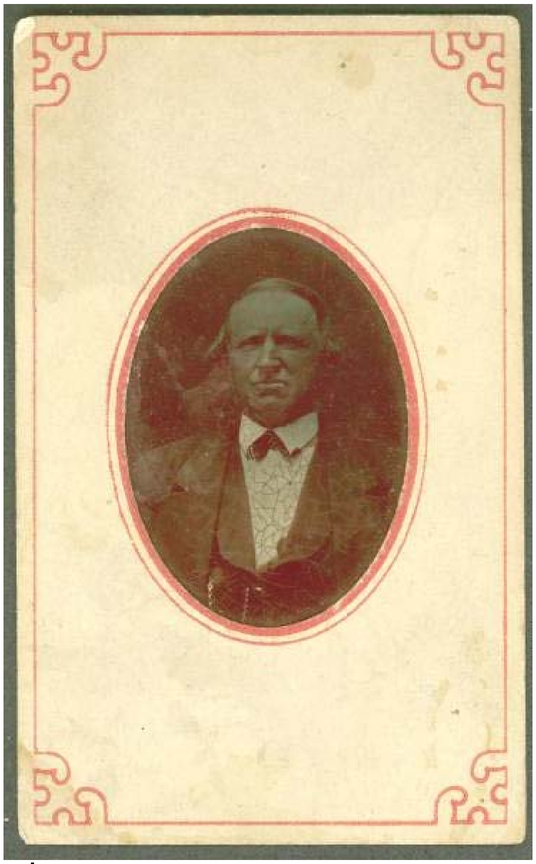

Figure 7a

Figure 7b

Note that in paper processes, shadows (not highlights) are rendered by heavy silver deposits in the negative, and positive prints are produced in a second step from negatives. Highlights in paper prints derive their color from the underlying paper stock.

Some tintypes are very dark overall while other specimens have surprisingly good contrast with an almost white background that is independent of viewing angle. Crawford [38, 43] mentions that a grayish white background could be created by adding mercuric chloride or nitric acid to the developer. Neither Eder nor Towler mention this process, but there are striking variations in the contrast range of different specimens, for which we have been unable to establish a date correlation. The tricks used by individual practitioners often interfere with hopes of finding a convenient historical progression for dating.

Tintype plates, like Daguerreotypes, were exposed directly in the camera and therefore were reversed, but again there are exceptions. In addition to copying, and the use of prisms or mirrors, the collodion image could be transferred to another metal plate. The resulting picture was called, naturally, a transferotype and was re-reversed, or normal. Further, the final metal base did not have to be japanned iron and the magnet test fails if it is, for example, copper or brass. These exceptions are relatively uncommon (we have no frequency data), but the serious historian should be aware of the possibilities.

Estabrooke's book [51] contains inserted 'non-reversed' tintypes "made by the identical processes offered in this book", but he fails to describe the 'non-reversal' process. However, he describes the 'copy stand' in his darkroom and it can be inferred that it was used. If he had used a prism at the camera lens (see Chapter 11), one would have expected him to mention it in his detailed description of his 'glass room', or studio.

The collodion surface of tintypes often shows fine crazing or cracking, which distinguishes them from ambrotypes. Remarkably, many tintypes show no trace of rust in spite of bends and scratches. At one time it was fashionable to adorn tombstones with tintypes, and a few have survived a century of outdoor exposure.

Tintypes were made in many sizes with little standardization. The largest was 6-1/2 x 8-1/2 inches. The base material was cheap and many tintypes are very roughcut and irregular. Some were mounted in Daguerreotype or ambrotype cases; they can usually be identified with a small magnet. Tintypes were often glued on small paper mounts or mounted as cartes-de-visite. The tiny Gem tintypes (1 x 1 3/8 inch - see Figure 8) were sometimes mounted in stamped brass frames that resembled Daguerreotype frames; these frames were then crimped on cardboard mounts. But the majority of tintypes were simply unmounted; in this form they could be mailed easily and cheaply, making them popular during the Civil War.

Figure 8

Many tintypes are rather grubby in appearance, as Crawford aptly describes them, and art critics universally turned up their noses. Aesthetically they were no match for the elegant platinotype. But they are durable and unfaded after more than a century, and today they remain a plentiful legacy of the appearance of Civil War soldiers, celebrities, period clothing, and architecture.

Direct Positives

Daguerreotypes and tintypes were direct positives and were commercially very successful, even though they lacked an intermediate negative for reproduction. Many inventors strove for the simplicity of single step positive processes and there were some successes. But why does a light-struck area of the sensitive surface appear light after processing in spite of the earliest observations that silver salts darken when exposed to light?

In both tintypes and Daguerreotypes, the light from highlights in the subject produces a chemical change in the sensitive surface. In the Daguerreotype, nucleation centers in the highlights are converted to dense concentrations of mercury-silver amalgam particles. These particles scatter more reflected light to the viewing eye than does the surrounding area with no particles, resulting in a "positive" image. In the tintype there are no amalgam particles, but the reduced silver particles in the highlights are more reflective than the dark backing without silver particles exposed in the shadows. Both processes relied upon the difference between reflectivity from the highlights and from the shadows: there was a better chance of light reaching the viewer from the highlights than from the shadows.

Neither process worked on white paper, and both processes were marginal in their contrast control compared with modern processes.

Japanning

A description of japanning is in order, since it is rarely described in photographic histories. Perry [111, 18] has a useful description. Essentially it consists of baked lacquer, usually applied in multiple layers to sheet iron, and baked between each coat. The composition of early lacquers was sometimes a trade secret, but Estabrooke's formula is simply asphaltum (tar) in linseed oil. Tar is available from many sources in nature, with variations in impurities, and japanning quality was no doubt correspondingly variable. In Europe japanning dated to the early 17th century, and in the East much earlier. The original motivation was decoration, but it also formed a very durable and rust-resistant coating that compares favorably with some of our modern polymers.

Collodion images were sometimes printed or transferred (these were two separate processes) on to japanned cardboard or leather. In these cases the finish was air dried black varnish; Towler [145, 150] has a simple recipe. True japanning requires high temperature baking cycles that could not be used on flammable materials, but many black varnishes or lacquers acquired the generic term of japanning. For restoration purposes it is not safe to assume resistance to any particular solvent.

Japanned lacquer was produced in various colors besides black; only the "chocolate" plate, patented in 1870, became as popular as the black, and there are many surviving brown specimens. The brown color was thought to be more lifelike; the same thinking may have accounted for the popularity of sepia paper prints. But gold or sepia toning was widely used on paper prints to combat fading, so public acceptance of brown may have been a factor. Tintypes and ambrotypes did not fade unless they were grossly underfixed or washed, whereas paper prints suffered chronically from fading problems for many years.

Tintype Nomenclature

Tintypes, the name most often used today, were also called Ferrotypes, Melainotypes, Melanotypes, Melaneotypes, Ferrographs, Adamanteans, Adamantines, and several other trade names (see Estabrooke, [51]. These names reflect minor trade differences, but they are all collodion-silver images on japanned iron. The evolution of the many trade names is complicated and illustrates the problems of assigning a single identity to what now appears to us a single process. The following account is largely paraphrased from Estabrooke's 1872 book [51].

Smith's invention is usually dated as 1854, but the date of publication of his patent is February 19, 1856. Smith called it the Melainotype, and Estabrooke says it was based on a French invention of a black enamelled plate "for photographic purposes" called the Melanotype plate. Apparently Smith's contribution was to coat the Melanotype plate with collodion containing a solution of silver salts.

Peter Neff bought Smith's Melainotype patent in 1856 (Eder says 1857) and continued manufacture for several years. At about the same time (1856) Mr. V. M. Griswold of Peekskill New York introduced his Ferrotype plates in defiance of Smith's (now Neff's) patent. By this time the market was a free-for-all of competing processes and tradenames, and one writer, in disgust, referred to the various processes as 'hum-bug-otypes'. This same writer favored the Melaneotype (sic), adding a new name to the confusion. Some other tradenames were Adamantean, Phoenix, Vernix, Eureka, Excelsior, Union, Star Ferrotype - all collodion silver on japanned iron. Finally in 1870 the Phoenix Plate Company introduced the "chocolate" plate which was a sensation, short lived because the advent of chlorobromide paper was imminent. Estabrooke remarks that "...in those times every unimportant change was called a new process."

Mr. Griswold issued a rather plaintive statement concerning the many trade names:

"Many other names have been given to similar plates, such as Adamantine, Diamond, Eureka, Union, Vernis, Star Ferrotype, Excelsior, and others, among which the most senseless and meaningless is 'Tintype'. Not a particle of tin, in any shape, is used in making or preparing the plates, or in making the pictures, or has any connection with them anywhere, unless it be, perhaps, the 'tin' which goes into the happy operator's pocket after the successful completion of his work. None of these names, however, have been considered so apt and appropriate as Ferrotype, and it will, doubtless, be generally accepted as long as the pictures are known." Alas, Mr. Griswold, for your optimism.

Chapter 8

Cases, Mounts, and Cartes de Visite

This chapter also describes cartes-de-visite, cabinet cards, crayon prints, and US Revenue stamps.

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Daguerreotypes were always enclosed in hinged cases with glass protecting the fragile surface; ambrotypes were glass-covered if their emulsion side faced front. These pictures were expensive for the times, and handsome packaging was justified. Louis Daguerre adopted the cases for his new pictures from artists of the period who painted miniatures. It was a natural evolution, and the cases were good protection for the glass-bound pictures. The earliest cases were made of tooled leather on wood frames; cost reduction soon produced embossed and lacquered paper. Cases molded of a mixture of shellac, sawdust, and pigments, called Union cases, were actually the first products of the infant molded plastics industry, appearing in 1854.

Some tintypes were also mounted in cases, especially during the chronological overlapping of Daguerreotypes and collodion. Tintypes were completely different from the types they displaced: they were much cheaper and less fragile, and did not have to be protected in velvet-lined cases. For these reasons relatively few of the surviving cases contain tintypes as originally sold. Of course it is possible for tintypes to have been inserted in salvaged cases at any later date including the present. It would be tempting to define these cases as reliable descriptors of Daguerreotypes and ambrotypes, but what one person can case, another can uncase, so to speak. Helmut Gernsheim has told the story (PhotoHistory V Symposium 29 October 1982, International Museum of Photography at George Eastman House, Rochester, New York.) of seeing American soldiers in France after World War II buying bushel baskets (literally) of Daguerreotypes, discarding the contents, and inserting their own snapshots in the salvaged cases for the folks back home. Such specimens would represent rather obvious anomalies if they ever find their way into the antique markets.

Since these cases can be taken apart, it is likely that this has happened before and will happen again. Sometimes they are described by dealers as having locks of hair inside, or the name of the subject and date. The prospect of finding valuables inside almost guarantees that there are few unopened cases by now. Some dealers like to demonstrate to prospective buyers how easily their cases come apart, as if that were a virtue.

Sometimes missing parts such as lids are replaced from other cases in an effort to create a more marketable assembly. This is probably enough to say about the integrity of cases as identifiers of the pictures they contain.

Dating cases

Welling [149, 18-25] has a number of illustrations and discussion; see also Welling [150, 40-41]. Newhall [104, 127- 1-33] has a useful discussion but few illustrations. Most general histories mention cases in passing. Taft [140, 160] has an interesting sidelight on cases for daguerreotypes, ambrotypes, and tintypes.

References G, K, and L contain detailed information on cases. Mace (Ref D) also is informative.

Cabinet Cards and Cartes-de-Visite

The carte-de-visite, or photographic calling card, was patented in 1854 by the Frenchman Adolphe-Eugene Disderi. Cartes, cabinet cards, and about fifteen similar card mounts probably represent the largest body of surviving 19th century photographs. The numbers manufactured worldwide were in the tens of billions. Portraits were commonest, but view cards were also popular. The definitive reference is Darrah [40] from whom we quote: "... with experience, about 95% of the cartes issued between 1860 and 1885 can be dated with reliability of plus or minus one year". Dating is based on decorative imprints, photographers' logos, and evolution in the paper characteristics. Their importance as a time scale is thus very significant.

Some sizes, in inches, are summarized below:

Table 3

	Image	Card	Dates
Cartes	2-1/8 x 3-1/2	2-1/2 x 4	1861, rare after 1905
Cabinet	4 x 5-1/2	4-1/2 x 6-1/2	1866
Victoria	3 x 4-1/2	4-1/2 x 6-1/2	c 1870 - 1876
Trilby		1-15/16 x 2-13/16	
Promenade		3-3/4 x 7	
Boudoir		5 x 8-1/2	

Processes

Most were gold-toned albumen paper made from wet collodion glass negatives, but cartes were also made from gelatin-silver and collodion prints, and from collotypes and Woodburytypes. A few of the early ones were salt prints from collodion negatives, but this type of paper was less durable than the glossy albumen. In the 1890's bromide paper began to be used; the color was gray to black instead of the characteristic rose brown or faded yellow of albumen.

Woodburytype cartes were popular in England from about 1875-1882. They were rare in the United States in carte form. Other types were permanent chromotypes or Lambertypes, made by the Swan carbon-transfer process, or the Autotype Company. They had a glazed finish, were usually identified on the mount, and were made about 1876 - 1883. "Mezzotints", so labeled, were merely soft focus prints. Cameos, made about 1868, were albumen prints embossed on a form that gave them a convex shape (see Fig. 3). Cartes-de-visite and cabinet cards sometimes bear trademarks that appear to be representative of the process but are not always literally true.

Tinting of cartes had a short vogue in the United States from about 1860 - 1865. It was more common in Europe and Asia. Crayon portraits were made by a process used mostly for enlargements, and are discussed below and in Appendix II.

Darrah [40, 194-196] and Gilbert [65, 91; 107] have very useful summaries of dating information. Pilling [117] and Welling [149, 65; 71] have also discussed dating.

Crayon Prints

Many cabinet cards bear advertising on the backs relating to "crayon prints", but curiously there are few references to details of the technique. Cassell's encyclopedia [84] describes crayons as "small pencils of pipeclay, kaolin, or chalk incorporated with various mineral or metallic pigments, etc.... In process work, lithographic crayons, consisting of a mixture of wax, shellac, soap, and lampblack ..." Lithographic crayons are therefore somewhat like our modern crayons, but they were used in processing rather than in the final prints. The conclusion from this is that crayon prints were hand tinted with what we would call colored chalk. Water colors were also frequently used for tinting. Darrah [40, 191] mentions crayon prints and tinting; further details are found in our study in Appendix II.

Revenue Stamps

All photographs were required to carry United States Revenue stamps on the back (Fuller, [57]) from August 1864 to August 1866, which is a reliable reference for those two years if there is no sign of tampering. A few photographs have handwritten names and dates on the back, but sadly these are uncommon. It has been estimated that less than ten percent of surviving nineteenth century photographs are dated, or the subjects identified.

Chapter 9

Transferotypes and Miscellaneous Bases

This chapter discusses atrephographs, diazotypes, Eburneums, enamelines, ivorytypes, and transferotypes.

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The technique of moving an image from one substrate to another was widely practised, for a variety of reasons. Photographers explored every money-making possibility of getting ahead of their competitors, but there was also a fascination with the flexible creativity of the new art. In addition to readily available commercial plates and papers for routine work, there were many "do-it-yourself" recipes for light sensitive emulsions that could directly print pictures on almost any surface.

Transferotype

This name does not refer to a process associated with any particular individual. Transferotype paper consisted of gelatin silver bromide on top of a layer of water soluble (unhardened) gelatin. After processing the exposed image, it was pressed against another substrate while still wet. The application of hot water to the back of the picture melted the soluble gelatin so that the paper could be peeled off. The gelatin image was reversed if viewed from the back, and was nearly transparent, permitting hand tinting and special effects. Transfers were made to many bases, such as wood, metal, colored glass, ivory, leather, and fabrics. Metals were usually iron, copper, or brass; aluminum was not a commercial product until the Hall process was invented in 1886.

Transfers were also made by peeling the emulsion and placing it face up on a second substrate. Care was required to avoid wrinkles and air bubbles, but it did not reverse the image. Contact transfer, as mentioned, reverses the image, and this was sometimes one reason for doing it.

Silver bromide paper was first manufactured on a large scale by Swan (England) in 1879, but transfers were made long before that date with collodion, bichromated gelatin, and albumen emulsions. Workers attempting to make flexible negatives and stripping films tried various combinations of gelatin, collodion, albumen, and rubber (see chapter 3). There is no general recognition guide except analysis. If the top layer is collodion, the reflected appearance is milky, while gelatin is dark.

Emulsions on Other Substrates

Sensitized collodion syrup and bichromated gelatin could be poured on almost any surface that could withstand processing and that did not dissolve in the emulsion. Even then, substrates such as cardboard, leather, and fabrics could be varnished or "japanned". The latter was a generic term; real "japanning" required baking, which of course could not be done on temperature-sensitive or flammable materials.

If the surface was flat, a simple contact exposure was made, while projection enlargements could be made on curved surfaces. The reprint of the 1864 edition of Towler [145, 150-151] has detailed recipes. The same variety of substrate materials mentioned above for transferotypes could be coated with liquid emulsions. Some of the processes that were successful enough to be dignified by name are described below:

<u>Atrephograph</u>

This name was applied to several processes. Cardboard and leather were coated with collodion and bichromated gelatin on top of japan varnish. Images were also applied to the same bases by transfer processes.

<u>Diazotypes</u>

There is a large class of organic compounds that are listed under the prefixes "azo" and "diazo" in organic chemistry references, having in common a nitrogen atom in each molecular arrangement. This class of compounds was discovered in Germany in 1860 and was very extensively studied as the basis for making dyes. Some of the compounds are light sensitive, and this property was utilized by Adolf Feer in his 1889 patent. Feertypes were not commercially important, but many workers experimented with them, and they are the basis for the important "Ozalid" process for copying large industrial line drawings. Diazo compounds can be made in many colors, usually low in color saturation, and have been applied largely to paper and fabric bases.

<u>Eburneum</u>

This process was invented in 1865 by J. M. Burgess. A collodion emulsion was applied to a waxed glass plate. After exposure and processing, the surface was coated with a mixture of gelatin and zinc oxide. The collodion was then peeled off the waxed glass and remounted with the back side out. The white zinc oxide pigment on the former front surface simulated an ivory backing. The process reversed the image, but the original negative could be reversed for the exposure.

<u>Ivorytype</u>

Miniature portraits on ivory had been painted by artists for many years, but they were expensive. In 1855 J. E. Mayall (England) patented a cheaper process. He made tinted collodion or albumen portraits on artificial ivory (the newly invented celluloid), and called them "ivorytypes".

Ivorytypes were also made by adhering paper prints to glass, usually with the image side against the glass, either by waxing or by applying them wet from processing. Wax made the paper translucent, and tinting made a lifelike effect against a white background. Welling [149, 136] illustrates a double print ivorytype with two tinted translucent paper prints, each on separate glass backings and bound in register.

The name "ivorytype" seems to have been a generic name applied to pictures that looked as though they were on ivory. Ivorytypes were sometimes called imitation Eburneums, which in turn were imitation ivory pictures. In spite of detracting descriptions, many of the pictures were quite pleasing as well as photographically faithful.

Microscopic examination can detect fibers in paper-based ivorytypes, compared with the fiberless collodion. It may be possible to see zinc oxide grains in Eburneum pictures.

Ivorytypes are described in Cassell's [84, 313], Gernsheim [61, 344], and Welling [149, 136].

Enamelines and Fired Images

The art of firing decorated ceramics is perhaps 10,000 years old. The concept of firing photographic images on inorganic substrates seems to have originated in 1854 with the Frenchmen Bulot and Cattin whose English patent covered transferred and fired collodion pictures. Thereafter many photographic processes were applied to and fired on glass, porcelain, and enameled metal. It is difficult to generalize on appearances because of the wide variety of materials and techniques. Untinted photographs contained silver, chromium, platinum, or iron, along with carbon from organic binders. These chemical elements dissolved in the ceramic bodies, and the resulting colors depended on the element, the ceramic, and on whether the firing atmosphere was oxidizing or reducing. In addition, ceramic pigments were often applied as dyes and tints on top of the photographic image. Most ceramic pictures were miniature portraits, but Gernsheim mentions Joubert's efforts in England to make stained glass windows as large as 17 1/2 by 24 inches.

Microscopic examination can distinguish between fired images and coated emulsion prints. Enamelled metal was usually copper. Burbank [28, 165-189] gives detailed recipes for several processes. Other descriptions are found in Eder [48, 566-568], Gernsheim [61, 342-344], and Towler [145, 308-309].

Chapter 10

The Colors of Black and White Photographs

This chapter also discusses tinting and age deterioration.

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Heterogeneous collections of old photographs appear to be colored predominantly brown, either from intentional processing or from the ravages of age.

Photographs that are not colored by a three-color photographic process (as opposed to hand tinting) are customarily called black and white, even though they may be tinted or gold-toned or other colors. But anyone who has spent much time searching through assorted old photographs in antique markets is likely to wonder if there ever were any actual black and whites. The common survivors seem to be mostly brown or yellow in varying shades. Some of the reasons for these colors are:

Original images were sepia or gold toned.
Original images were tinted.
Original paper was tinted.
Binder was dyed
Original images were pigmented (e.g. gum bichromate).
Particle size differences in the image from processing variations
Residues of processing chemicals
Faded images.
Stained images.
Yellowed paper.
Aging changes in the binder (e.g. gelatin).

Evidence of deterioration can be a revealing clue to the process by which photographs were made. A comprehensive discussion of deterioration mechanisms is given by Reilly [122].

It was recognized in the middle of the nineteenth century that fading of photographic images on paper was a serious problem. There were many reasons: individual processing variations, chemicals were impure and not standardized, and paper quality was not uniform until Eastman Kodak perfected paper based on wood pulp in 1926. For forty-five years the dominant printing paper was albumen paper with an emulsion coating made of egg whites.

Considering the sulfur in eggs and the well-known affinity of silver for sulfur, it is perhaps surprising that any of them have survived. Toning with gold or selenium was commonly used to stabilize images. The effect also somewhat resembled skin tones, but there was no uniformity, since the resulting tint depended on the chemistry of the emulsion as well as the toner. This is true today: the tones may be sepia, brown, warm black, or blue black. If color is used as a recognition aid, these variations can create many problems, yet there are experienced persons who can identify pictures at a glance. This should be amended to read "sometimes". The bulk of surviving 19th century prints are either albumen prints or early silver bromide gelatin prints, so with a little practice a good average is possible.

Color Measurements

It would be very useful to be able to characterize the colors of 19th century photographs in a quantitative system that would provide reliable descriptors. The necessary technology has been available for some years, and apparently all that is lacking for feasibility studies is funding and interest. There are two requirements:

1. The availability of standard specimen photographs representative of each process in its original condition, or as well-preserved as possible.
2. Readily available measurement equipment.

The present advanced state of color photography has made precise color measurements commonplace, but the required equipment is not cheap or simple. A rigorous method of color measurement is the determination of the spectral energy distribution of white light reflected from a specimen mounted in an integrating sphere. The inner surface of the sphere is coated with pure white magnesium oxide, and the illumination is from a standard lamp. The integrated reflected light is analyzed with a prism or diffraction grating, and the results mathematically converted to tristimulus coordinates. The technique is widely used in manufacturing industries such as paints, fabrics, fluorescent lamps, and dyes. In principle there is no technical reason for not applying the method to historical photographs.

Pilling [117] mentions the use of Munsell color chips to characterize the colors of cabinet card mounts. The Munsell Color System is a subjective color matching system that under controlled conditions can give reproducible numbers to three components of color. These are "hue", the dominant color; "chroma", the degree of saturation; and "luminance", the reflected brightness. A photograph consists of mixed shadows and highlights, and different values of chroma and luminance will be obtained from different regions of the picture. One solution is to integrate, or average, the reflected light as mentioned above. Another is to standardize on matching either the densest shadows or the clearest highlights, resulting in numbers that could be referenced by other workers. It would be a more objective and reproducible system of descriptors than the use of arbitrary terms such as "faded yellow", for example.

The Munsell System is discussed in Hunt [78, 71; 122]. The American Society for Testing and Materials (1916 Race Street, Philadelphia, Pennsylvania 19103), publishes a "Standard Method of Specifying Color by the Munsell System", No.D 1535-68 or later revision. ASTM Standards may be on file in engineering college libraries. The Munsell System of visual color standards is manufactured by Macbeth Division of Kollmorgen Instruments Corporation, 405 Little Britain Road, New Windsor, New York 12553.

Visual Appearance of 19th Century Pictures

In the absence of a quantitative measurement scheme, a practical way to identify unknown specimens is to compare them to published pictures. The best single reference for paper prints is Reilly [122], Eastman Kodak publication G-25, 1986. Bernard [22], Coe & Haworth-Booth [32], Eastman [47], and Holme [77] also contain high quality color reproductions of some 19th century prints that give a good idea of their present appearance, provided viewing is done in daylight.

Museums and galleries usually have subdued lighting to prevent fading, often by reduced-voltage incandescent lamps whose light is reddish. A case in point was a prominent exhibition at the George Eastman House, of carbon, albumen, and Woodburytypes, all of which showed remarkably similar rose-brown coloration under protective dim incandescent lighting. It is an inevitable compromise between protective but distortive lighting, and total inaccessibility to viewing. On the other hand, this writer has seen original irreplaceable photographs from the Civil War period exhibited six inches from a forty watt fluorescent lamp. They were nearly completely gone. Ignorance is a terrible thing.

The fading of color photographs has been intensively studied in recent years, and some of the techniques are relevant to black and white photographs. A significant study (Presented at the International Symposium: The Stability and Preservation of Photographic Images, 1982, The Public Archives of Canada, Ottawa, Canada, sponsored by the Society of Photographic Scientists and Engineers.) was described by Sergio Burgie in 1982. The paper was entitled "Fading of Dyes Used for Tinting Unsensitized Albumen Paper".

His results, which unfortunately have not been published elsewhere, were presented in color slides. The work was based on a selection of nearly unfaded albumen prints in the collections of the International Museum of Photography at George Eastman House. The availability of these standards was crucial to the study.

In this case the extent of age changes was surmised by examining margins that were covered by frames or mounts. This study did not make use of quantitative color measurements. No comprehensive references that treat the problem of identification of 19th century photographs by quantitative color measurements were found during research for this volume.

The Art of Tinting

Enthusiasm for Daguerreotypes and calotypes did not submerge the desire for colored pictures. If scientific ingenuity could accomplish a marvel such as fixing images from nature, surely the achievement of color pictures would be just around the corner. It proved to be a long corner, but in the meantime artist's colors were at hand. As Rothery [128] remarked in 1905, "Color photography is, as yet, in the clouds and the brush and palette must still be used." There was a flood of articles on how to color with oils, chalk, and water colors; some typical ones were by Delery [43; 27], Rothery [129], and Nicholson [106]. A detailed account of tinting lantern slides is found in Burbank [28, 148-159], who writes the following inimitable hint:

"...the cleanest and most useful dabber is supplied to most persons by nature, one that is not likely to wear out or get mislaid, namely, the finger end. Nothing can exceed the evenness of tint which a practised hand can produce by lightly tapping the paint on the glass he is working on, which gradually renders the color even and smooth.

The finger to be selected is that which has the smoothest skin; generally, the third finger of the right hand is the best. The skin has always a kind of furrowed surface, and some artists, hence, rub the end of the finger lightly on a piece of smooth sand-paper, by which some of the roughness is removed. This cure of the furrows is very temporary; nature, in a day or two, indignant at this treatment of the cuticle, will retort by growing a skin thicker and rougher than at first, so it is better for beginners to use their dabbers as they find them."

Historical research sometimes rewards us with such whimsies. It seems a curious oversight that the Reverend Burbank did not use the term "fingerprint" in his 1891 book. The fingerprint had been used for identification as early as 1858 by Sir William J. Herschel.

A common form of tinting or retouching was found in crayon prints, which are discussed in Chapter 8 and in Appendix II.

Chapter 11

Historical Enlargements and Image Reversal

It is unfortunate that many people, including some writers, have the misconception that photographic enlarging is an advanced technology that appeared late on the scene. Several writers were under the impression that in the early days of photography enlargements weren't possible, so if you wanted an 8x10 print you needed a negative of the same size.

Not so. Enlargers have existed from the beginnings of photography. Sir John Herschel described his in 1839; it even had a lens corrected for spherical aberration. That same year Talbot patented an enlarger for his calotypes. Draper enlarged Daguerreotypes with a copy camera in Massachusetts during the winter of 1839-1840. By 1857 full-figure portraits six feet tall were being made and Woodward's solar enlarger was in widespread use.

It is true that most early photographers preferred large plate cameras. William Henry Jackson is famous for hauling a 20x24 inch glass-plate camera across the western mountains of the United States on muleback in 1875 and making superb contact prints. Possibly a lighter and smaller camera would have enabled Jackson to take even more breathtaking pictures. On the occasion of his ninetieth birthday in the middle 1930's Jackson was presented with a Leica 35mm camera. He remarked (National Geographic, Vol 175m No. 2, February 1989, p230.) "If I'd had one of these on the Hayden Survey, I'd have made many more pictures and lived longer." Yet Ansel Adams often used the 8 x 10 inch format for many of his classic pictures. Adams had a choice that Jackson did not. The transition from Jackson's 90 pound camera to the one pound miniature in less than a lifetime gives talent a wider scope but does not substitute for it.

Enlarger Light Sources

Enlargers cost money and not all photographers felt they were a business necessity. Exposures were lengthy before the days of fast bromide paper, and light sources were a problem. Inventors tried every kind of artificial light: candles, lamps burning kerosene, whale oil, coal gas, and acetylene; battery powered carbon arc lights; hydrogen-oxygen limelight. The latter consisted of a cylinder of lime (calcium carbonate), heated in a gas or hydrogen-oxygen flame. It produced a brilliant white light much superior to the yellow light of kerosene. It was first used for general illumination in 1826, and in 1841 to illuminate subjects for calotypes. Some photographers used acetylene thirty years after Edison invented the electric lamp in 1879, either because their places of business were not electrified, or simply because they thought the results were better. Also, early incandescent light bulb filaments were too large to be placed at the focus of a parabolic reflector to produce a parallel beam.

The sun was the cheapest light when it was shining. New York was much better than Boston for solar work; England was terrible, and much of the European continent was not much better. Exposures of forty five minutes for albumen paper were common, and because of the changing direction of the sun, enlargers or mirrors had to be adjusted every five minutes for uniform exposure. Fires were common, too, since the enlarger lens could act as a burning glass if it was not carefully focused and aimed. Sometimes clockwork was used to keep the enlarger pointed correctly, like an astronomical telescope, but apprentices were cheaper.

The quality of early enlargements was generally inferior to most modern results because of grain and lens aberrations, but sometimes these qualities were an aid in impressionistic work. Enlarged portraits, however, were best viewed at a distance. The history of enlarging is well documented. Ostroff's paper [108] is quite comprehensive; good descriptions can also be found in Eder [48], Gernsheim [61], Gilbert [65], Newhall [105], and Taft [140].

Image Reversal

The property of camera lenses that produces a reversed image is basically simple but often misunderstood. Many writers assume that what they term 'left-to-right reversal' is self evident to readers. But why 'left-to-right': why not 'top-to-bottom?' Users of 35mm reflex cameras see a normal non-reversed image and their final prints come out the same way. Why? The users of view cameras and studio cameras are constantly aware that the images on their focusing screens are upside down; are their lenses somehow inferior to 35mm camera lenses? These questions are relevant to collectors because nineteenth century photographs may be negatives, negative/positives, direct positives, transfers, copies, or reversed by mirrors or prisms.

Camera lenses translate each picture element in a scene from its original position with reference to the center axis of the lens to a corresponding position on the focal plane on the opposite side of the axis. The lens acts as a crossover point for light rays from the scene.

Consider the focal plane to be occupied by transparent film (or the ground glass of a view camera), and view it from the position of the person taking the picture. The image is reversed both left-to-right and top-to-bottom. All this observer has to do is to stand on his or her head and everything looks normal (except possibly the photographer). Users of view cameras seldom do this in public, but there is an occasional temptation to do so. Lenses are symmetrical about their optical axes, so turning the camera upside down is no help.

If the transparent film is developed and fixed, we simply turn it right side up and call it a negative, as Fox Talbot did and thereby became immortalized. A 'negative' should really be called a 'negative transparency' to distinguish it from positive transparencies, or lantern slides. Printing a positive from a negative cancels lens reversal if it is done emulsion-to-emulsion.

Light can be transmitted from either side: if it comes from the emulsion side, the projected image is reversed, as anyone knows who has given a lecture and found the lantern slide captions reversed on the screen. The emulsion side has to be away from the light source to avoid reversal of the projected image; that is, emulsion-to-screen.

Most photographic processors are careful to adhere to the printing rule (either for enlarging or contact printing): always print emulsion-to-emulsion. But who knows how many times the rule has been violated, either accidentally or intentionally for esthetic effect? All we can do is to be aware of the basic characteristics of the various nineteenth century processes and to be on the lookout for helpful clues.

Binoculars contain internal prisms, and single-lens reflex cameras contain both prisms and mirrors, to restore the viewfinder image to normal orientation. Reflex camera prisms turn out to require five sides, hence the name 'pentaprism.' The reason for five sides is not obvious: interested readers can find ray diagrams in books on geometrical optics, elementary physics, and even camera advertisements. View cameras could have pentaprisms, too, but they would be prohibitively large and heavy.

The human eye and television cameras also reverse the image. Television cameras contain electronic circuits that restore normal perspective; Mother Nature uses neural circuitry in the brain for inversion in lieu of pentaprisms or electronics.

Mirror reversal is a different phenomenon from lens reversal. It can be demonstrated without a darkroom. Just look at yourself in a mirror and put your right hand on your right cheek. The image of your hand is in the right side of the mirror as you face it, but on the left cheek of your image in the mirror. Standing on your head does not put your hand image back on the image of your right cheek. Flat mirrors do not form optical crossovers as lense do: mirrors work on the principle that the angle of incidence of light rays equals the angle of reflection. Of course it is possible to photograph an image in a mirror, and some very pleasing pictures have been published.

The reason that mirror reversal causes left-to-right but not top-to-bottom reversal has been the subject of a number of articles with varying degrees of clarity. Martin Gardner's book <u>The New Ambidextrous Universe</u> [58] has an excellent description, somewhat longer than Richard Feynman ("No Ordinary Genius, The Illustrated Richard Feynman", Edited by Christopher Sykes; W. W. Norton & Company, 500 5th Avenue, NY NY 10110, 1994, pages 36-38.) who explains it as essentially front-to-back reversal. There is even semantic confusion about the meaning of reversal. Interested readers who enjoy a good puzzle will find considerable food for thought in these two intriguing essays.

Lens reversal is more relevant to many kinds of pictures including the ones that are often described as reversed, such as Daguerreotypes, ambrotypes, and tintypes. These comments apply only to first generation pictures. Copies and enlargements of original Daguerreotypes and tintypes <u>made by the respective</u>

<u>original processes</u> (not a transparency process) will be re-reversed, or right side round. The third generation will again be reversed, and so on. Presumably surviving specimens become increasingly rare at this point, but one never knows unless the provenance is certain. See Chapter 7 for a discussion of the 'non-reversed' tintypes bound into Estabrooke's 1872 book.

Copies and enlargements of ambrotypes that were made as ambrotypes may or may not be reversed because, being transparent, they could be flipped over during copying. Of course resolution and picture quality suffer with each succeeding generation. This should be apparent in those rare examples when specimens are available for side-by-side comparison.

Reversing prisms were sometimes used in front of the lenses of Daguerreotype and other studio cameras; the prisms usually had their hypotenuse sides silvered. There is no way to deduce from the picture whether this was done unless there is a reference object such as lettering or architecture. It is therefore incorrect to make the sweeping statement that all Daguerreotypes were reversed, even though most of them were.

The effect of reversal is obvious in the case of subjects containing lettering or well-known landmarks and architecture. To collectors the presence or absence of reversal may be an important clue to the identification of a process, a date, or a photographer. But what about portraits: does it really matter which way the subject faced?

There is a famous and intriguing example of this question. It is the matter of the rather prominent wart on Abraham Lincoln's right cheek. If his portrait is printed from a reversed negative the wart will have changed sides; that is, it will be on the other cheek, not just on the other side of the picture. There are many pictures of Lincoln still preserved, and they were made by three processes: tintypes, Daguerreotypes, and collodion glass negatives. The first two produce reversed pictures (unless they were copied or taken through a prism or mirror) but collodion plates can be printed either way.

In Taft's book <u>Photography and the American Scene</u> there is a frontal portrait of Lincoln that shows the wart on his right cheek and no wart on the left cheek. The caption states that "the print was made from the original negative... by Alexander Gardner." On page 243 another portrait shows the same thing, also from a negative. But in Beaumont Newhall's <u>The Daguerreotype in America</u> there is a Daguerreotype portrait of Lincoln (Plate 104) that shows the wart on his left cheek - the expected effect of Daguerrian reversal. This may seem trivial, but to serious students of history such minutia may be clues to important questions of subject and process identification.

<u>Chapter 12</u>

Copying and Restoration

(This chapter was written in collaboration with R. Gilliam Rudd)

*****

Copying valuable old photographs in a collection should have a high priority, to obtain more stable reproductions before the originals deteriorate further. It is beyond the scope of this book to cover copying in detail. However, some useful techniques are touched on that are especially applicable to stained or faded pictures.

As to the choice of film sizes most suitable for copying, it can be said without question that the best size is the largest practicable a budget will allow. The 35mm film format with a good camera and a lens designed specifically for copying, along with the recently introduced films such as Kodak Technical Pan, can indeed yield copies of excellent quality from originals that vary widely in quality. The copy film needs to have extremely fine grain and a wide contrast range. However, it is more difficult to avoid scratches and surface dust in 35mm negatives in roll format than in flat sheet film.

4x5 sheet film is probably the most widely used size because with reasonable care the negatives can be individually filed and printed repeatedly without damage to the surface. Moreover, it is available in a range of contrasts and color sensitivities.

Deterioration with age in old photographs takes several forms, and more than one form may occur in a single photograph. Chemical treatment and physical retouching are sometimes effective but they do require considerable skill and may be destructive or irreversible. Restoration, therefore, should first be practised on a copy. Copying is a passive procedure resulting in no damage to the original.

Paper prints commonly exhibit the following types of damage:

- Type 1. Color changes in the image or in the paper support, sometimes becoming brownish or yellow.
- Type 2. Staining, appearing as an irregularly-shaped area of color, the color depending on the cause.
- Type 3. Fading of the image.
- Type 4. Tarnishing of the darker portions of the image, resulting in near specular surface reflections.
- Type 5. Surface abrasion and tears.

The recommended copying techniques for these conditions are as follows:

Type 1. Use high-contrast film such as Kodak Contrast Process Ortho 4154. following the manufacturer's development recommendations to modulate contrast as needed.

Type 2. Stains that are a different color than the image may be reduced or eliminated by copying with a filter close to the stain color. If the color of the stain is nearly the same as that of the image, it will be fundamentally difficult to separate the two. If there are perceptible color differences, separation may be possible through selection of adjacent filters in a close series such as the Kodak Wratten filters. It may also help to use a panchromatic film instead of an orthochromatic film.

Type 3. Treat like type 1, plus a filter complementary to the image color. For example, if the image is brownish or yellow, use a deep blue filter such as Wratten 49.

Type 4. The degree of tarnish sheen can be reduced during copying by altering the angle of illumination, or with polarizing filters, or both. A polarizing filter should be used over both the light source and the copy lens, with polarizing axes adjusted for optimum effect. However, this technique should be used only if the sheen significantly obscures detail in the original, since the resulting copy is not a faithful reproduction of the original. Glass-covered Daguerreotypes and ambrotypes can be copied with polarizers to reduce glass reflections without dismantling the cases, since such reflections often do obstruct details. However, the images in these two types are very sensitive to viewing angle and illuminating angle, and a careful balance is needed in the copying conditions.

Type 5. Techniques recommended are: diffuse illumination, crossed polarizers, physical repair, and retouching copy prints.

Processing

All processing should be done in accordance with currently accepted archival procedures. In recent years more effective materials and processes for improved archival life have been published in the technical literature and in symposia. Accelerated testing methods for evaluating these procedures have gradually evolved, with encouraging correlations. But the technology is advancing rapidly, and it is important to keep abreast of currently accepted practices.

Following are some useful references for further reading:
Ref. 36, Conrad
Ref. 46, Eastman Kodak

Ref. 59, Gassan
Ref. 76, Hendriks
Ref. 122, Reilly
Ref. 130, Rudd

Chapter 13

Microscopy and Analysis

This chapter includes description of a camera set-up for closeup copying.

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The identification of several of the attributes of photographs requires close examination under appropriate illumination and with some degree of magnification. Following are some suggested methods:

1) A hand magnifier and a pencil flashlight.

Hand magnifiers are available from magnifications of about 4x to 20x. At lower magnifications the best illumination for faithful color rendition is daylight. The higher powers require more light, and because the working distance becomes quite short, the light needs to be tightly focused. Grazing angle lighting is useful in revealing layers such as in Woodburytypes and carbon prints. Transmitted light can reveal paper fibers in the highlight regions of unmounted salt prints and albumen prints such as tissue stereos.

2) Close-focusing cameras

A camera equipped for macrophotography and mounted on a copy stand can be a useful inspection tool as well as a recorder. Many 35mm reflex cameras can be equipped with bellows focusing attachments or with combinations of extension tubes. Some asymmetrical lenses can be reversed with a mounting adapter to give more magnification. The mounting stand should be rigid and free of vibration, particularly for copying, because movement of the mirror mechanism in reflex cameras during exposure can blur the picture.

The following home-made setup has proven useful to this writer in many cases:

A 35mm reflex camera with automatic exposure control was equipped with 75 mm of extension tubes and a reversed 25 mm f1.9 Kodak Cine Ektar lens (from a 16mm movie camera), mounted on an enlarger column with laboratory clamps. The specimens are laid on a laboratory scissors jack for focusing, and illuminated with microscope lights. Automatic exposure control makes it easy to take record shots. This combination gives a magnification of 6x with excellent definition over the field.

Illumination can be with microscope lights or miniature halogen lamps, being careful not to expose the specimen to excessive time-intensity levels. It should be remembered that old photographs are subject to fading, and that the damage is cumulative. Many archival organizations do not permit copying of original photographs on office copiers for this reason.

3) Binocular inspection microscopes.

These are designed for good working distances at magnifications up to about 90x. They are mounted on swing arms that can reach the center of large photographs, and some can mount cameras for permanent records. They are useful general purpose laboratory tools.

4) Biological microscopes.

It is seldom that magnification up to several hundred is needed, but it is available with biological microscopes at the expense of very shallow depth of field. It is possible to focus down through the paper fibers into the embedded image of salt prints. Biological microscopes are usually mounted on rigid C-frames, which prevent access to centers of photographs as large as cabinet cards. The optical heads can often be transferred to other mounts for large area examination.

Chemical and Physical Analysis

Some of the attributes listed in Section 1 of Chapter 14 can be identified by inspection, and this will often suffice. When inspection leaves doubts, and when the value of the unknown picture is high (historically or monetarily), there is a good probability that modern analytical methods can find the answer. Two case studies are discussed in Appendix I and II. The discussion below is a resume of available techniques.

The photosensitive material and the binder are the attributes most likely to require analysis for identification.

1. Binder Identification

The solvent tests described by Rempel [124] have already been mentioned in Chapter 2. They are simple to perform, but they are destructive; this disadvantage can be minimized by limiting the test to a small area outside the actual image. Infrared spectrophotometry is capable of identifying any of the organic binders nondestructively. The difficulty is in adapting the instrument to a specimen the size of a photograph, since cutting off a corner may be even less acceptable than the solvent tests.

2. Identification of Photosensitive Material

The compositions of most surviving 19th century photosensitive materials except diazo dyes were based on metals. Classical wet chemistry can identify the metals, but only destructively. It can be done on microscopic zones by the use of colorometric spot tests such as those given in Feigel [52].

One of the most useful non-destructive analytical methods that is applicable to specimens the size of photographs is x-ray fluorescence analysis. There are several types of instrumentation, depending on the means of excitation. Basically they depend on exciting the specimen to emit its characteristic x-ray spectrum, then analyzing the wavelength or energy distribution of the spectrum.

Scanning Electron Microscopy

The x-ray spectrum can be excited by bombarding the specimen with electrons whose energy is a few kilovolts. Scanning electron microscopes (SEM) generate their magnified images by electron bombardment, with the emission of both secondary electrons and x-rays from the specimen. The secondary electrons are used to form the topographical images; the by-product x-rays can be analyzed to give the composition. This kind of analysis has to be done in a vacuum, an environment that may damage photographs except all-metal Daguerreotype plates. Specimen size that can be accommodated in electron microscopes is limited to a few inches. Appendix I describes a scanning electron microscope analysis of a Daguerreotype.

Radiation-Excited X-ray Analysis

Of more general use is the x-ray fluorescence technique, whose application to the analysis of photographic emulsions and papers was reported in 1983 by Enyeart et at [50]. Excitation is by gamma radiation from radioisotopes or by X-rays from vacuum tubes. The analysis has been shown not to damage photographs or to leave any residual induced radioactivity in the specimens. It is safe, portable, non-destructive, and can be used on any size specimen. It will detect any of the sensitizing elements in photographs except organic dyes. It cannot distinguish between gelatin, collodion, and albumen except indirectly by their impurity content. For example, albumen contains detectable sulfur, and collodion may contain a variety of preservatives as mentioned in Chapter 7. The instrumentation is widely used in forensic and medical analysis as well as numerous industrial applications; it has figured prominently in the authentication of many art objects.

Cost and Availability

Scanning electron microscopes, X-ray fluorescence, infrared and ultraviolet spectrophotometers are beyond the reach of most individuals for their capital cost as well as for the necessary professional operators. But there are thousands of such instruments in industrial and college laboratories, and in consulting scientific laboratories where analyses can be performed for a reasonable fee. There have even been instances where graduate students or friends have been persuaded to donate a noon hour or weekend for the analysis of a specimen of historical interest.

The purpose of this discussion is to call attention to the existence of appropriate analytical technology to archivists and advanced collectors. For additional information, college libraries have textbooks on the above-mentioned instruments, and the technical periodicals listed in Chapter 12 regularly contain relevant research papers.

Part Two

Quick Reference

Chapter 14

Chapter 14
Section 1
Descriptors and Attributes

Nineteenth century photographs share these attributes, individually and in combination:

1. Picture Base:
   - Brass
   - Ceramic
   - Copper
   - Fabric
   - Glass
   - Iron
   - Ivory
   - Leather
   - Paper
   - Silver-plated copper
   - Stone
   - Transparent plastic
   - Wood

2. Photosensitive Material:
   - Chromium
   - Diazo
   - Iron
   - Palladium
   - Platinum
   - Silver
   - Uranium

3. Image Type:
   - Coated-glossy
   - Coated-matte
   - Negative
   - Not coated
   - Opaque
   - Positive
   - Tinted
   - Toned
   - Translucent
   - Transparent

4. Binder:
   - Albumen
   - Collodion
   - Gelatin
   - Gum arabic
   - None

5. Mounting:
   - Case, various materials
   - Cardboard
   - Glass
   - Metal

Some of these characteristics are easy to identify by casual inspection while others require chemical or physical analysis, or close comparison with known standard pictures. In this book there are two levels of examination on which identification can be based:

1. Visual examination, requiring only adequate light, a pocket scale, and good close vision, possibly aided with a hand magnifier. Observations made in this manner are subjective and the conclusions will always be "possible" rather than "certain".
2. Analysis, utilizing microscopy and any appropriate laboratory analytical equipment, including both non-destructive and destructive tests, when the need for added confidence justifies the effort.

Chapter 14

Section 2

Process Names: Synonyms and Variations

Nineteenth century photographic nomenclature contains a certain amount of confusion and lack of uniformity, reflecting the historical situation. Some of the type names merely represent minor variations of a single fundamental process, yet it is desirable to recognize such historical details for dating clues and identification. The plethora of names makes organizing and searching cumbersome, particularly in simplified flow charts. The worst aspect of this dilemma is that too much simplification will lead to loss of recognition of occasional rare and significant specimens.

The five sections of this chapter address this problem by offering several levels of identification guidance, from visual examination to an interactive computer program. The first step in developing these guides was to make as complete a list as practicable of the historical names in the literature, along with alternate names or minor variants. Obviously consistent naming is crucial to classification and retrieval. Attempting completeness is a lengthy undertaking. This compilation based on historical names was begun some years before recent archival work based on neologisms (process-descriptive names) was published. The solution of difficult identification problems can be significantly aided by consulting the Getty Art & Architecture Thesaurus (reference 1).

Representative key names were then chosen for each process to be carried through the identification procedures. Names for which alternates have been found are so listed. Not all anomalies could be eliminated; some photographic processes were applied to different bases with the same name. The FOTOFIND computer program is advantageous in such cases, for simplified flow charts can get very tangled. Capitalization is generally retained for types derived from inventors' names or trade names. This practise is not universal: for example, 'Daguerreotype' is not always capitalized in the literature. Another example: the names ferrotype and Ferrotype, differing only in the capitalization, refer to two different processes [Eder 46 p326], and are frequently confused in the literature, especially at the start of sentences.

Key Names

1. Paper, uncoated overall: Chapter 1
   - amphitype
   - anthotype (alt. amylotype)
   - Breyertype (alt. Playertype)
   - calotype (alt. Talbotype, salt print)
   - catalysotype
   - catatype
   - ceroleine (alt. LeGray process)
   - chromatype
   - chrysotype (alt. chripotype)
   - cyanotype
   - energiatype (alt. ferrotype)
   - Feertype (alt. diazotype)
   - fluorotype
   - kallitype (alt. argentotype)
   - palladiotype
   - platinotype

2. Coated paper: Chapters 2, 4
   - albumen
   - aristo (alt. Aristotype, Simpsontype)
   - cameo
   - carbon (alt. anthrakotype, Autotype, chromotype, gum bichromate, hydrotype, Lambertype, Mariotype)
   - carbro (alt. ozobrome, ozotype, Mariotype)
   - Charbon Velour
   - crystallotype (probable syn. chrystollotype)
   - gaslight(alt.Velox,Solio,Azo,Aristo)
   - Gaudinotype
   - gum bichromate
   - gum platinum
   - melanograph (alt. atrograph)
   - metotype
   - photoglyphic (alt. gum print)
   - transferotype
   - Wothlytype (alt. uranium print)

3. Glass: Chapters 6, 7
   - ambrotype(alt.Relievo,Hallotype)
   - amphitype
   - Archertype (alt. collodiotype, wet collodion plate)
   - contretype
   - crystoleum (alt. Crystal photo)
   - diaphanotype (alt. hallotype, hellenotype)
   - diapositive
   - eburneum
   - ectograph
   - Gaudinotype
   - Hallotype: (alt. hellenotype; also see ambrotype)

Hyalotype
ivorytype
opalotype
sphereotype

4. Metal: Chapters 7, 9
Daguerreotype
electrotype
enamaline
tintype (alt. ferrotype, Gem, melainotype)
tithnotype

5. Photomechanical: Chapter 5
Autotype (alt. carbon, collotype)
aquatint
chalkotype

collotype (also Albertype, artotype, Autotype, bromoil, Dallastype, heliotype, Levytype, Paynetype, phototype, photoglyphic)
Leggotype
Meisenbach
Photogravure
Plumbeotype
Woodburytype (alt. photoglyptic, stannotype)

6. Miscellaneous bases: Chapter 3, 9.
atrephograph
diazotype (alt. Feertype)
Eburneum
nitrate film
pannotype (alt. linotype, linograph)
safety film (alt. gelatin, acetate)
Stanhope
transferotype

Alphabetical Process Name Index

Albertype: type of collotype.
albumen
ambrotype: alt. Relievo, Hallotype
amphitype
amylotype: alt. anthotype.
anthotype: alt. amylotype
anthrakotype: type of carbon.
aquatint
Archertype: alt. collodiotype, wet plate collodion
argentotype: alt. kallitype.
Aristo: alt. aristotype
artotype: type of collotype.
atrephograph
atrograph: alt. melanograph.
Autotype: type of collotype and carbon.

Breyertype: alt. Playertype
bromoil: type of collotype

calotype: alt. Talbotype, salt print
cameo: type of carte-de-visite
carbon: alt. anthrakotype, Autotype, chromotype, gum bichromate, hydrotype, Lambertype, Mariotype
carbro: alt. ozobrome, ozotype, Mariotype
catalysotype
catatype
ceroleine: alt. LeGray process
chalkotype
Charbon Velour
chripotype: alt. chrysotype
chromatype
chromotype: type of carbon
chrysotype: alt. chripotype
chrystollotype: possible synonym of crystallotype
collodiotype: alt. Archertype, wet plate collodion
collotype: alt. Albertype, artotype, Autotype, bromoil, Dallastype, heliotype, Levytype, Paynetype, phototype,, photoglyphic
contretype
crystallotype: see chrystollotype
crystoleum: alt. Crystal photo
cyanotype

Daguerreotype
Dallastype
diaphanotype: alt. hallotype, hellenotype
diapositive
diazotype: synonym of Feertype

Eburneum
ectograph
electrotype
enamaline
energiatype: alt. ferrotype

Feertype: alt. diazotype
Ferrotype: alt. energiatype
ferrotype: alt. tintype
fluorotype

gaslight: alt. Velox, Solio, Azo, Aristo
Gaudinotype
Gem: type of tintype
gum bichromate; alt. carbon
gum platinum

hallotype: alt. diaphanotype, ambrotype
heliotype: type of collotype
hellenotype: alt. diaphanotype
Hyalotype
hydrotype: type of carbon

ivorytype

kallitype: alt. argentotype

Lambertype: type of carbon
LeGray: alt. ceroleine
Leggotype
Levytype: type of collotype
linograph: alt. pannotype
linotype: alt. pannotype

Mariotype: type of carbon, carbro
Meisenbach
melainotype: alt. tintype
melanograph: alt. atrograph
metotype
nitrate film

opalotype
ozobrome: type of carbro
ozotype: type of carbro

palladiotype
pannotype: alt. linotype, linograph
Paynetype: type of collotype
phototype: type of collotype
photoglyphic: type of collotype
photoglyptic: alt. Woodburytype

photogravure
platinotype
Playertype: alt. Breyertype
Plumbeotype

Relievo: type of ambrotype

salt print: alt. calotype
safety film: alt. gelatin, acetate
sphereotype
Stanhope
stannotype: type of Woodburytype
Simpsontype: alt. aristotype

Talbotype: alt. calotype
tintype: alt. Ferrotype, Gem, melainotype
tithnotype
transferotype

uranium; alt. Wothlytype

wet plate: alt. Archertype, collodiotype
Woodburytype
Wothlytype: alt. uranium print

Some name similarities requiring caution:
Autotype, artotype
calotype, collotype, kallitype
carbon, carbro
chromatype, chromotype
chrysotype, chrystollotype, crystallotype
ferrotype, Ferrotype, Feertype
hallotype, heliotype, hellenotype
melainotype, melanograph
opaline, opalotype
photoglyptic, photoglyphic

Chapter 14

Section 3

Condensed Descriptions and References

Note: The term "not commercial" in the following descriptions refers to experimental processes that did not reach the market, even though they may have been patented, reported in the literature, or publicly exhibited. Authenticated specimens are in several cases uncommon, but some were widely reported and used.

Uncoated paper

amphitype
Not commercial.
1844 - Sir John Herschel: positive or negative on paper; brown image that quickly faded. Also European name for ambrotypes. See listing under same name in Glass section.
References: Eder [48, 339]; Gernsheim [61, 169]; Gilbert [65, 151]; Snelling [133, 116-120].

anthotype
(also amylotype)
Not commercial.
1842 - Sir John Herschel, England.
Sensitive material - flower juice extracts. Exposure time 4 to 5 weeks. Impractical process, but consider its implications in fading of vegetable dyes used for tinting various types (see Delery [43]; Nicholson [106]; Rothery [128]).
References: Crawford [38, 67]; Gernsheim [61, 169]; Gilbert [65, 151]; Snelling [133, 37-42, 113-116].

Breyertype
(also Playertype)
1839 Albrecht Breyer, Belgium.
Negative facsimile of text (white letters on brownish-black background). A contact process: no camera or lens used. Sensitive material: silver chloride. Rare.
References: Eder [48, 336]; Gilbert [65, 164].

calotype
(also Talbotype, salt print).

Patented 1841 by William Henry Fox Talbot. In use to about 1860. Sensitive material: silver nitrate, often toned. First commercial positive/negative process. Matte fiber printing-out paper. Some fairly standard sizes: 4-3/4 x 6-1/2, 6-1/2 x 8 1/2, 8-1/2 x 10-1/2, 9 x 11, 9-1/2 x 11-1/2, 12 x 16 inches.
Colors - yellowish brown, rose, purplish, variable fading.
References: Crawford [38, 22]; Eder [48, 316]; Gernsheim [61, 80; 162]; Gilbert [65, 152]; Jammes [82]; Lassam [80]; Thomas [142, 56]; Welling [150, 91]; many other histories of photography.

<u>catalysotype</u>
Not commercial.
1844 - Dr. Thomas Wood (Ireland).
Sensitive material - iron iodide and silver nitrate; image appearance after period of dark storage, the delay attributed to catalysis.
References: Eder [48, 326]; Gernsheim [61, 169]; Gilbert [65, 153].

<u>catatype</u>
Also katatype; 1901, W. Ostwald, Germany.
An image transfer process utilizing paper soaked in hydrogen peroxide and placed in contact with a silver or platinum print. Gilbert describes it as "obscure".
References: Cassell's [84, 94]; Gilbert [65, 165].

<u>Ceroleine</u>
(also LeGray process).
1851 - Gustave LeGray, France.
Waxed paper negative, a modification of Talbot's calotype. The purpose was to improve light transmission through the paper and reduce the pattern of paper fiber during positive printing. Cerolein is a white constituent of beeswax.
References: Crawford [38, 38]; Gilbert [65, 155]; Newhall [105, 50]; Towler [145, 178].

<u>chromatype</u>
Not commercial (low sensitivity).
1843 Robert Hunt.
Sensitive material: copper sulphate and potassium bichromate. Direct positive. Colors - orange, lilac.
References: Eder [48, 553]; Gernsheim [61, 169]; Gilbert [65, 153].

<u>chrysotype</u>
(also chripotype).
Not commercial.
1842, Sir John Herschel.
Sensitive material: ferric salts developed with gold or silver chloride; basis for later commercial kallitype.
Color - purple.

References: Crawford [38-68]; Gernsheim [61-169]; Gilbert [65-154]; Lietze [92, 53]; Towler [145, 273].

<u>cyanotype</u>
Color - blue and white; the familiar blueprint, still used.
1842 - Sir John Herschel: positive print from a negative: blue image with white highlights. A print from a positive line drawing produced white lines on a blue background.
1881 - Henri Pellet (patent), positive print from a positive: blue lines on white background from positive line drawing.
Good image permanence, limited tonal range. Paper was usually sized to reduce penetration of image into the paper.
Sensitive material: iron salts, several processes: see Lietze[32]
References: Burbank [28, 17-24]; Crawford [38, 163]; Eder [48, 562]; Gilbert [65-154]; Lietze [92, 53;64]; Towler [145, 273]; Welling [150, 300].

<u>energiatype</u>
(also ferrotype).
Not commercial.
1844 - Robert Hunt.
Gum arabic salt print sensitized with silver nitrate, developed in ferrous sulphate.
References: Eder [48-326]; Gernsheim [61-169]; Gilbert [65-154]; Snelling [133, 111].

<u>Feertype</u>
(also diazotype).
1889 Dr. Adolph Feer, Germany.
Not commercial in original form, but forerunner of commercial Ozalid copy process.
Sensitive material - based on aniline dyes; various colors.
References: Eder [48, 550]; Gilbert [65, 154].

<u>fluorotype</u>
Not commercial.
1844 - Robert Hunt, England.
Variation of energiatype using sodium fluoride.
References: Eder [48, 326]; Gernsheim [61, 169]; Gilbert [65, 154].

<u>Hallotype</u>
Also hellenotype; see Chapter 8
Variation of ambrotype.
Reference: Marder [94]

<u>kallitype</u>
(also argentotype) 1843 - Sir John Herschel, England.
1889 - Dr. W.W.J. Nichol, England. Sensitive materials - silver and ferric salts with variations. Usually brown to reddish brown; appearance sometimes resembled platinotypes, but with fading

problems. Often coated and processed by amateurs, until it was superseded by platinum and gaslight papers. Colors - brown, black, sepia, purple; matte fiber surface.
References: Cassell's [84, 314-316]; Crawford [38, 177]; Eder [48, 543]; Gilbert [65, 155]; Jansen [83]; Schriever & Cummings [131, 285].
See also Appendix II.

<u>palladiotype</u>
1870's; some vogue after World War I because of platinum scarcity. Appearance similar to platinotypes; palladium salts were cheaper than platinum and were sometimes used together in mixed chemistry. References: Eder [48, 544]; Gilbert [65, 155].

<u>platinotype</u>
Patented 1873 by William Willis, England, who formed the Platinotype Company 1879; sepia version patented 1878.
Colors: neutral black, silver-gray; warm brown was less common. Toning was not needed to improve permanence as it was in silver prints. Very long tonal range, seldom faded. Embedded image, matte fiber surface. Often regarded as the most beautiful black and white process.
References: Crawford [38, 76]; Eder [48, 544]; Gernsheim [61, 345]; Gilbert [65, 156]; Lietze [92, 79]; Newhall [105, 142]; Welling [149, 83]; Welling [150, 258; 273]; The Photo [115].

<u>Coated paper</u>

<u>albumen</u>
Invented 1850 by Louis Blanquart-Evrard, France; in use until the 1890’s.
The most widely used paper for forty years, consequently high survival rate among 19th century photographs. A silver printing out paper. Size - to 30 inches wide.
Appearance: tinted, toned, faded; rose-brown, purple, yellow. Many specimens have a distinctive and almost unique faded yellow color. Some have dyed albumen, several colors but blue and pink were common. Very long tonal range. Thin dense paper, usually glued to a decorative mount. Entire surface usually glossy, rarely matte; according to Reilly (definitive reference 121-132), print surfaces made after about 1870 were glossier ('burnished') than those made earlier. Surface may have fine eggshell texture and minute hairline cracks. No baryta undercoat was used as it was with collodion and gelatin papers; therefore paper fibers can be seen in the highlights of albumen paper. Edges usually were hand trimmed and are often slightly crooked.
References: Crawford [38, 45]; Eastman Kodak [47, 32;33]; Eder [48, 339]; Gernsheim [61, 195; 401]; Gilbert [65, 151;157]; Lietze [92, 29]; Reilly [121]; Towler [145, 194]; Welling [150, 79]; Delery [42, 154]; Newhall [105]; Reilly et al [123].

Aristo paper 1880's
Trade name Aristotype or Aristotypie J. B. Obernetter, Germany; commercial usage 1867 - present (used for studio proofing). Printing-out paper; silver chloride or bromide in collodion or gelatin with excess silver nitrate; later versions with baryta undercoat to conceal paper fibers. Silver chloride in gelatin was also available as developing-out paper under trade names such as Velox. Color warm red, brown or purplish, or glossy chocolate brown resembling albumen; appearance and color differed depending on developers and toners, leading to confusion in identification. Collodion POP (Printing-Out Papers) coexisted with gelatin POP; see Chapter 2 for further information.
Ref. Newhall [105]; matte - Crawford [38]; Welling [150]. In matte form it resembled platinotypes. Commonly found as cabinet cards and cartes-de-visite.
References: Cassell's [84, 39]; Crawford [38, 63]; Eastman Kodak [47, 34]; Eder [48, 448; 536]; Gernsheim [61, 399]; Newhall [105, 126]; Welling [149, 81]; Welling [150, 351].

Cameo 1860-1880.
A variation of the carte-de-visite with a convex surface resembling a cameo medallion. Sometimes the effect was produced with cotton padding under the print. Figure 3a shows the front of a simple embossed cameo in side lighting; figure 3b is the reverse side. The emulsion is badly fissured because of the forming process, which only shows in grazing illumination.
The image is 2" x 3".
Reference: Cassell's [84, 82].


Figure 3a

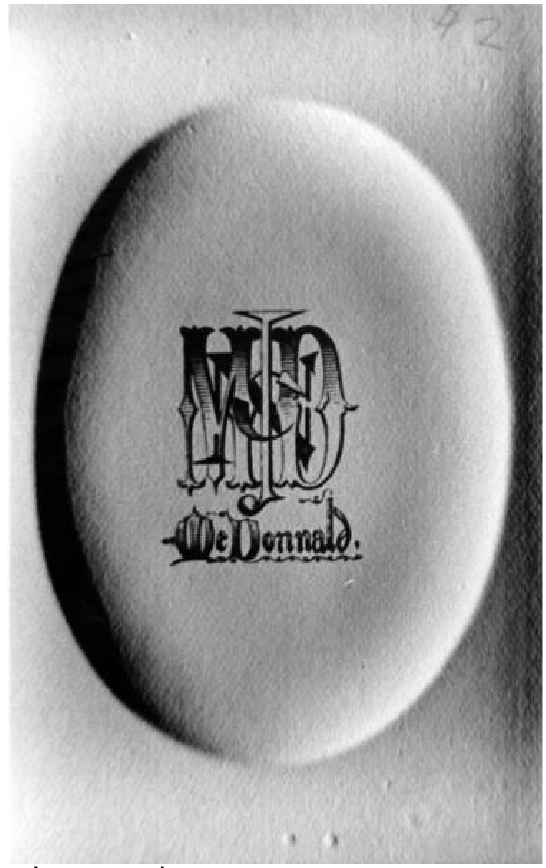
Figure 3b

<u>carbon</u>
(also anthrakotype, chromotype, gum bichromate, hydrotype, Lambertype, Mariotype, trade name Autotype). Early inventors included Mongo Ponton, Scotland, 1839; W.H.F. Talbot, England 1852; Alphonse Poitevin, France 1855, Sir Joseph Swan, England 1864. The process utilizes gelatin sensitized with potassium bichromate and developed in warm water (see Chapter 5), with many variations. Poitevin added carbon dust as a pigment, but it had poor tonal range until Swan developed the transfer technique; the term "carbon" usually is applied to transfer prints. "Carbon tissue" has been commercially available for this technique from about 1864 until the present; tissue made by the Autotype Co. was available in more than fifty colors. Lambertype is a carbon transfer to an enamelled surface; chromotype is the same process contact printed. Bichromated gelatin is also the basis of collotype ink printing and the manufacture of etched gravure plates, leading to confusion in process descriptions. Some processes are still in use today. Appearance: not faded; long tonal range after 1864; many colors, with brown predominating; no grain or dot pattern; glossy or matte; highlights show paper fiber; occasional wrinkles from the transfer process. If mounted,

the imprint "Permanent" may be present on the bottom of the mount.

References: Cassell's [84, 31]; Crawford [38, 69]; Eder [48, 561]; Gernsheim [61, 338]; Gilbert [65, 152; 162]; Lietze [92, 77; 111]; owler [145, 277 - 283]; Welling [149, 83]; Welling [150, 189; 245].

<u>carbro</u>
(also ozobrome, ozotype, Mariotype).
Inventors: A. Marion 1873; Thomas Manly: ozotype 1899; ozobrome 1905. Marketed by Autotype Company 1919. A transfer between a carbon print and a silver bromide-gelatin print. The process is well described in Crawford [38-187], and some of the characteristic faults of transfer processes can help in identification; see Chapter 4. Pigmented as were carbon prints.
References: Crawford [38, 187]; Eder [48, 561]; Gilbert [65, 15]; Newhall [105, 276].

<u>Charbon Velour</u>
1893 - Victor Artigue, 1900 - Theodore Henri Fresson, France. Pigmented gelatin, sensitized with potassium bichromate and developed in an abrasive mixture of warm water and sawdust; sold as Artigue Paper. Appearance similar to other gum prints in many colors; according to Newhall [105-147] some workers' prints resemble water colors.
References: Crawford [38, 87]; Eder [48, 560]; Newhall [105, 147]; Holme [77, 214].

<u>crayon prints</u>
Many cabinet cards and cartes-de-visite carried advertisements for crayon prints on their reverse sides. Crayons were basically colored chalk or pastels used to tint matte-surfaced prints. Lithographic crayons were wax or grease based and were used mostly in litho processing; they were not used in the final print.
Reference: Cassell's [84, 152]; Darrah [40, 191-192]; Barhydt [19]. See also Appendix II.

<u>crystallotype</u>
Patented 1850 - John A. Whipple, United States.
Salt prints made from albumen glass negatives containing honey. Color - brown. Whipple was primarily a daguerreotypist but is credited with helping popularize paper printing in the United States.
Cassell's lists "chrystollotype", attributed to a secret process of Whipple; it may be a name variation of crystallotype. Whipple apparently made albumen glass negatives and albumen paper positives (Welling 150, 91-93).
References: Cassell's [84, 108]; Taft [140, 120; 417]; Welling [149, 105]; Welling [150, 72; 98].

<u>gaslight paper</u>

1893 - Some tradenames were Velox, Solio, Azo.
Gelatin silver chloride developing-out paper. Less sensitive than bromide papers, it could be exposed under artifical light from a gas Welsbach mantle, and then developed under the same light by turning down the gas. The shadows characteristically show a reflective tarnished or bronzed appearance (Eastman Kodak calls it "silvering"). For details see Chapter 2 and Reilly [122]. This effect also occurs in other silver-based emulsions, including silver-gelatin glass plates, but it is usually more pronounced in developing-out papers.
References: Crawford [38-65]; Eastman Kodak [47, 54; 30, 28;34]; Gilbert 65, 9]; Welling [149, 81].

Gaudinotype
1853 - Marc Antoine Gaudin, France: See also Gaudinotypes in the section Glass Bases.
Paper negative, early collodion or gelatin emulsions.
Reference: Gilbert [65, 154].

gum bichromate
1894 - a variation of the earlier carbon process, it allowed easy manipulation of density and pigmentation for artistic effects. See also gum platinum.
Appearance: sometimes printed in multiple layers to increase image density; the structure may be seen under a microscope. Glossy shadows, paper fibers in highlights. Many colors (see Crawford 38, 202). May have brush marks to resemble paintings. Referenc-es: Crawford [38, 74; 88; 199]; Eder [48, 561 - 566]; Gernsheim [61, 463]; Gilbert [65, 154]; Newhall [105, 147]; Scopick [132]; Towler [145, 187]; Welling [150, 386].

gum platinum
Gum print on top of a platinotype. This unlikely combination was introduced in 1898 to give the processor more manipulative control over contrast and tone. Some good examples are reproduced in Holme [77]; Edward Steichen was a leading practitioner. Appearance: glossy shadows, matte fiber highlights similar to carbon prints; misregistration between the multiple layers may sometimes be seen microscopically; may have some raised-relief edges due to the thickness of the gum.
References: Crawford [38, 88]; Eder [48, 561]; Gilbert [65, 154]; Holme [77, 214].

hydrotype
(also carbon)
Patented 1889 - A. H. Cros, France.
Dyed bichromated gelatin on paper and glass, leading to later color processes such as pinatype.
References: Eder [48, 649 (glass)]; Gilbert [65, 162 (paper)].

melanograph

(also atrograph)
1853, Dr. Langdell, Philadelphia; A.A. Martin, France. 1854; G.M. Campbell, England, 1854.
Collodion print on black paper sensitized with silver nitrate; a combination, like the ambrotype, not noted for its brilliance.
References: Gernsheim [61, 237]; Gilbert [65, 152].

Metotype
Paper coated with gold, silver, copper, or bronze metal powders, with a printing-out emulsion on top. The effect was that of an image on metal. Uncommon.
Reference: Cassell's [84, 356].

ozobrome (also carbro)
1905 - Thomas Manly, England.
Carbon prints made from gelatin silver bromide prints by contact transfer; replaced the ozotype.
References: Cassell's [84, 386]; Crawford [38,188]; Eder [48, 562]; Gernsheim [61, 464].

ozotype
(also Mariotype, carbro)
1899 - Thomas Manly
Bichromated gelatin paper transfer, a variation of the carbro process. Did not require light for exposure of the final print.
References: Cassell's [84, 387]; Crawford [38, 188]; Eder [48, 562]; Gernsheim [61, 464].

Simpsontype
1864, George Simpson, England.
Silver chloride collodion fore-runner of aristo paper in the 1880's.
References: Cassell's [84, 494]; Eder [48, 536]; Welling [150, 224].

Transferotype
The original transferotype was silver bromide emulsion on top of a soluble gelatin release layer on paper. After exposure and development, the bromide layer was placed against the desired base material and hot water applied to the paper backing, which melted the gelatin and allowed the paper to be peeled off. As with other transfer processes, the image was reversed. Later bichromated gelatin and collodion images were transferred to many different base materials.
References: Cassell's [84, 546]; Eder [48, 566]; Gilbert [65, 158; 166]; Towler [145, 150; 305].

Wothlytype
Not commercial. 1864 - J. Wothly, Belgium
Uranium and silver salts in collodion. Also made without collodion, simply called uranium prints, without gloss.

References: Gernsheim [61, 344]; Gilbert [65, 156]; Lietze [92 121]; Towler [145, 273].

Glass

ambrotype
(also relievo)
Patented 1854 - James Cutting, United States; made until about 1865.
Collodion negative on glass with a black backing which causes the image to look like a positive. See "amphitype" for a discussion of predecessors. Ambrotypes were cased like Daguerreotypes and some tintypes which they resemble. See Chapter 7.
The "relievo" (1857) is an ambrotype in which the background was scraped off the collodion; the remaining image was then backed with a light-colored cardboard spaced behind the plane of the image so that a three-dimensional stacked effect or relief was created. Relatively uncommon (Gernsheim 61, 237; Cassell’s 84, 457).
References: Crawford [38, 43]; Gernsheim [61, 199; 236]; Newhall [105, 63]; Towler [145, 128]; Welling [149, 5]; Welling [150, 111]; Newhall [105].

amphitype
1851 - W.H.F. Talbot: albumen on glass. 1856 - Blanquart-Evrard: albumen on glass that could be viewed as either a positive or a negative, similar to later ambrotypes. 1840's - Sir John Herschel positive or negative on paper. The name "amphitype" was used in Europe for the ambrotype; otherwise none of these processes became commercial, except as forerunners.
Reference: Eder [48, 339].

Archertype
(also collodion wet plate, collodiotype). 1851 - described by Frederick Scott Archer; disputed by Cutting and LeGray. The basis for collodion negatives on glass, ambrotypes, paper prints, lantern slides. Superseded by gelatin on glass in the 1870’s, and on paper by albumen. Wet-plate collodion negatives
can often be recognized by unevenly coated edges and other hand-coating blemishes. This was a characteristic of most early coated-glass processes; uneven edges on paper prints could be trimmed while glass could not.
References: Crawford [38, 42]; Eder [48, 346]; Gernsheim [61, 197]; Gilbert [65, 130; 159]; Newhall [105, 59]; Taft [140, 118]; Towler [145, 144]; Welling [150, 126].

contretype
Glass negative, gelatin sensitized with bichromate and dyed with carbon (India ink).

Reference: Gilbert [65, 162].

crystoleum
1850's (also Crystal photograph)
Albumen paper print sealed to the convex inner surface of a cover glass, tinted and waxed, backed with white paper.
Reference: Cassell's [84, 154] (details of process); Gilbert [65 158; 165]; Coe & Haworth-Booth [32, 14]; Gill [67]

diaphanotype
1856 (also hallotype, hellenotype). Resembled crystoleums; used hallotype or hellenotype (1857) process of mounting a tinted transparency over a positive on glass or paper; microscopic examination may show the multiple image. See Chapter 7.
References: Cassell's [84, 181; 292]; Gilbert [65, 158].

diapositive
Transparent positives used to make enlarged negatives for contact printing; collodion or albumen.
Reference: Eder [48, 443]; Gernsheim [61, 313].

ectograph
Patented 1850's - William Campbell, United States. Flat wetplate collodion negative sandwiched to wet-plate positive, waxed and tinted.
Reference: Gilbert [65, 158].

Gaudinotype
1861 - Alexis Gaudin, France: Collodion or gelatin emulsions on glass plates.
References: Eder [48, 376]; Gernsheim [61, 324; 327].

Hyalotype
Patented 1850 - Langenheim Brothers, Philadelphia.
Albumen lantern slides (positives). Color - brown.
References: Eder [48, 340]; Gernsheim [61, 195]; Gilbert [65, 159]; Taft [140, 117]; Welling [150, 72; 78].

ivorytype 1855.
Tinted salt print, collodion or albumen image waxed to glass and bound with white backing; resembles the later Eburneum process.
References: Cassell's [84, 313]; Gernsheim [61, 344]; Welling [149, 113]; Welling [150, 136].

opalotype 1890's
Opal (milky) glass with a gelatin-bromide emulsion exposed and printed conventionally, or a transferred carbon-gelatin image. Some images were collodion-silver or platinum.
References: Gilbert [65, 165]; Cassell's [84]; Gill [67].

Relievo

See ambrotype.

<u>sphereotype</u>
Patented 1856 - Albert Bisbee, United States.
Positive image on spherical glass.
Reference: Gilbert [65, 168].

<u>Photomechanical</u>

<u>aquatint</u>
A dusting process predating photography, for producing a random grain pattern in etched plates for halftone printing: grain gravure as opposed to geometrical screen gravure.
References: Cassell's [84, 35]; Crawford [38, 245]; Eder [48, 591]; Jussim [85, 56; 339]; Towler [145, 289; 294].

<u>Autotype</u>
Trade name from 1868, the Autotype Company was known for its collotypes, carbon prints, and other processes.
Colors - more than fifty.
References: Crawford [38, 73]; Eder [48, 626 - 631]; Gernsheim [61, 548]; Newhall [105, 61]; Welling [150, 189; 259].

<u>Bromoil</u>
1911; first suggested 1907 by E. J. Wall, England.
Prints resemble oil paintings. Ink transfer process; prints were also made without transference. Greasy-ink impression from a gelatin silver bromide print. Ink may show a microscopic random grainy texture (not a dot pattern) because of variable ink penetration in the paper. Sometimes the final picture simply consisted of the inked gelatin matrix; the variations in gelatin thickness can be detected by finger touch. The inked transfer print is as flat as the paper.
References: Crawford [38, 94; 213]; Eder [48, 563]; Gernsheim [61, 484]; Holme [77, 215]; Thomas [142, 77; 78].

<u>chalkotype plates</u>
1866; Also Spitzertype, Stagmatype plates.
Brass halftone plates, forerunner of cuprotype plates in 1880.
References: Eder [48, 637]; Gilbert [65, 162].

<u>collotype</u>
(also Albertype, Albertotype, Autotype, Artotype, bromoil, heliotype, Levytype, Paynetype, phototype, photoglyphic).
Inked print from bichromated gelatin plate; gelatin is a protein colloid, hence the name collotype. Matte or glossy, any color, black commonest. Microscopic wrinkled reticulated pattern, irregular but not like the random grains in aquatint. Processes not using a geometrical screen pattern closely resemble original photographs. No fading.
Basic process patented 1855 by Alphonse Poitevin, France. Many

variations; some examples:

Albertype - 1873; collotype process; often used for post-cards; maximum size 20 x 25 inches; ref. Jussim [85, 106]; Eder [48:431,513].

artotype - 1879; a collotype process; ref. Welling [150, 259].
heliotype - Patented 1870, E. Edwards, England; commercially successful, used by Mathew Brady; refs. Gernsheim [61, 548]; Hearn [75, 341]; Welling [150, 274].

phototype -refs. Jussim [85, 248]; Welling [150, 235].

photoglyphic - Talbot; ref. Crawford [38, 245].
Other references: Crawford [38, 269]; Eder [48, 553; 563; 617]; Gernsheim [61, 547]; Gilbert [65, 276]; Gilbert [64, 162]; Jussim [85, 56; 248]; Newhall [105, 61; 251]; Welling [149, 85]; Welling [150, 202; 222; 235].

Dallastype
1863 - Campbell Duncan Dallas formed short-lived company.
Inked engravings, not halftones.
References: Eder [48, 582]; Gernsheim [61, 543].

Leggotype
1871 - William August Leggo
Screened halftone, inked. First used for printing a newspaper.
References: Eder [48, 627]; Gilbert [65, 162].
Levytype
Patented 1875 by L. E. Levy and D. Bachrach Jr.
Electrotyped swelled gelatin; a form of collotype.
References: Gernsheim [61, 551]; Welling [150, 236].

Meisenbach Process
1886 - The Autotype Co.
One of the earliest commercial halftone processes.
References: Gernsheim [61, 550]; Jussim [85, 68]; Newhall [105, 251; 253]; Welling [150, 277].

Paynetype
See 'collotype'

Plumbeotype
A trade name for Daguerreotypes made in the United States by John Plumbe. Listed here because he also made etchings derived from Daguerreotypes for ink reproductions.
References: Gernsheim [61, 126]; Gilbert [65, 163].

Woodburytypes

Patented 1864 - Walter B. Woodbury, England. Also photoglyptic (French name); stannotype, a variation. The image consists of dyed gelatin with no grain or screen pattern, applied to paper under hydraulic pressure. Maximun size 11 x 14 inches. Any color but warm brown was commonest, with long tonal range, no fading. More closely resemble original photographs then any other photomechanical process. Sometimes marked "permanent" or "Woodburytype" on mounting. Frequently mass produced and bound or "tipped" into books. More likely to show raised relief at the edges of shadows than carbon prints. Carbon and Woodburytype prints are difficult to distinguish: both have glossy shadows, but Woodburytypes may also show gloss in the highlights. Fibers are visible in the highlights of both types. Woodburytypes have trimmed paper edges because the hydraulic process caused oozing of the gelatin, and sometimes showed dark particle flaws in the highlights.
References: Crawford [38, 285; 289]; Eder [48, 619]; Gernsheim [61, 340; 341; 540]; Gilbert [65, 163]; Newhall [105, 251]; Welling [149, 85]; Welling [150, 202; 235]; Reilly [122, 65, 72].

Metal

Daguerreotype
Patented 1837 - L. J. M. Daguerre, France. The first commercially successful photographic process. Made until about 1860. Always enclosed in glass-fronted case. Voluminous documentation: see Chapter 7 for full description and references.

enamaline
Several types: collodion image fired on enamelled copper; or fish glue sensitized with ammonium bichromate, fired on copper or zinc; many colors.
References: Burbank [28, 165-189]; Cassell's [84, 217-218]; Gernsheim [61, 343]; Towler [145, 308]; Thomas [142, 79].

Gem
Patented 1863 - Simon Wing, Boston
A miniature tintype 1 x 1-3/8 inch. Figure 11 shows a typical Gem in a brass frame crimped to a cardboard carte de visite; there were many mounting variations.
References: Gilbert [65, 160]; Taft [140, 164]; Welling [150, 31].

tintype
(also ferrotype, Gem, melainotype).
Patented 1856 - Hamilton L. Smith, United States.
Collodion image on black or brown japanned iron, which is magnetic. The image often shows crazing, especially visible in the highlights. Very popular process, in use until about 1930. The largest size was 6-1/2 x 8-1/2 inches. See Chapter 7 for full description.

References: Crawford [38, 44]; Eder [48, 370]; Gernsheim [61, 237]; Gilbert [65, 155; 160]; Taft [140, 153]; Towler [145, 142]; Welling [149, 31]; Welling [150, 117].

tithnotype
J.W. Draper, U.S.
Copper-plated duplicate of gilded Daguerreotype.
Reference: Cassell's [84, 543]; Gilbert [65, 168].

Miscellaneous bases

atrephograph
Tintype process (collodion) applied to varnished cardboard or leather. In other variations both collodion and bichromated gelatin were transferred.
References: Cassell's [84, 330]; Gilbert [65, 158]; Welling [150, 113].

diazotypes
Late 19th century. Colored aniline dye images on paper and fabrics.
References: Cassell's [84, 184]; Eder [48, 550]; Gilbert [65, 165].

Eburneum
1865 - E. Burgess.
A collodion-gelatin composite transfer process, with zinc oxide pigment backing that looked like ivory. First deposited on glass, then peeled off and remounted. Reference: Cassell's [84, 206]; Gernsheim [61, 344].

linograph
Also linotype ("lin-" refers to the linen base, not to be confused with the newspaper linotype machine). 1856 - linen base, stretched on frames and oil-colored. Image printed by Talbotype salt print process. Few surviving specimens.
Reference: Eder [48, 325]; Gilbert [65, 165].

nitrate film
1889-c1950
Patented by Eastman chemists. Widely used for roll and sheet film in many sizes including 35mm cine and still film. Extremely flammable and unstable: see Chapter 3.
References: Eastman [47, 90]; Eder [48, 489]; Hager [69, 1]; Gernsheim [61, 408]; Rempel [124, 7].

pannotype
1853 - Wulff & Co., France.
Collodion image on black waxed linen or dark leather. Few surviving specimens. Reference: Eder [48, 370].

Safety film
c1939, Eastman Kodak Co.
Principally cellulose acetate, marked "SAFETY FILM" on edges. Eastman produced acetate films as early as 1909 (Eder 31, 491) but they were not widely used at that time. Some stripping films were made from 1884 to c1890 that were composed of gelatin, which is not very flammable, depending on condition. Others were collodion-gelatin composites, less flammable than nitrate film but still not considered safety films. See Chapter 3.

Stanhope
Microphotograph (about 1/8 inch diameter) mounted with an integral lens in jewelry and souvenirs, such as tiny ivory telescopes and many other forms. The lens was invented by Lord Charles Stanhope before 1816.
Reference: Gilbert [64, 171]; Gilbert [65, 167].

transferotype
Also atregraph.
Collodion and albumen emulsions and bichromated gelatin were transferred to many kinds of base materials. Transfer processes reverse the image (Chapter 10).
References: Cassell's [84, 546]; Eder [48, 558; 607-624]; Gilbert [65, 158; 166]; Towler [145, 150; 305].

Chapter 14

Section 4

Computer Program for Identification of Photographs

*****

The FOTOFIND program on the disk accompanying this book starts with three questions to establish whether the unknown picture is on paper, glass, or in a group of miscellaneous bases including metals. The answer to these screening questions determines which of three groups of questions are presented to the user. The three groups contain respectively ten, eight, and nine questions, thus limiting the questions to the ones most relevant to the base material. Some questions are yes/no, while others are multiple choice; all are prompted on the screen. The operator is instructed to type "u" for "uncertain" wherever there is doubt. Details of the program are given in Appendix III; instructions on answering the questions are listed below.

Many history books choose to group photographic processes in such categories as silver and non-silver. However logical these categories may be for teachers or historians, they are not useful for an identification search. Archivists who are confronted with boxes of old photographs do not usually sort them into two piles of silver and non-silver, because there is no simple observational way to do it. This is the reason base materials were chosen as a first screen.

The program loses its ability to distinguish between types of photographs made after approximately 1900, based on simple visual observations; other types of analysis are then needed.

How to run FOTOFIND

(NOTE: SINCE THE WRITING OF THIS MANUSCRIPT FOTOFIND IS NOW AVAILABLE AT THE SHARLOT HALL MUSEUM’S WEB SITE)

This version of FOTOFIND runs in Microsoft DOS or Microsoft Windows 98; it will not run under MicroSoft Windows 3.x or 95. Windows 98 users can run it by several methods (UPPER or lower case may be used in the following procedures):

1) Go to the DOS command in the Programs menu, then enter the drive containing the FOTOFIND disk. The starting command is foto27

2) Reboot the system from a floppy disk containing the DOS command files, or restart the computer in the MS-DOS mode from the

SHUTDOWN command in the START menu.

3) In Windows 98 desktop, enter the opening menu with the START key. Go to RUN, enter the drive followed by the file name, eg - a:foto27.exe

4) Find the program in "My Computer" on whatever drive you have installed foto27.exe, and double click on it.

In modes 3 and 4, the display should be expanded for best visibility.

foto27.exe may be installed on a hard drive in a directory such as c:\FOTOFIND\ which allows easy and quick access. It only requires about 180 kb disk space. FOTOFIND creates temporary *.dat files on its drive when it is run, for each of the base materials entered. These files are small, and can be deleted at any time to save space, without interfering with subsequent runs.

Reports can be printed either from DOS or Windows 98. The printer response time is faster under DOS than under Windows 98, and the DOS screen looks better. If printing problems are encountered on a particular machine in Windows operation, DOS operation should be satisfactory. In either case, screen displays and search times will be nearly instantaneous on most machines.

Apple machines should be able to run FOTOFIND with a suitable conversion program. At this writing we have no specific instructions on running FOTOFIND on Apple machines, nor on Windows NT or ME. Future upward compatibility, of course, cannot be predicted, which is a well known problem with archival data storage and retrieval.

Notes on answering the questions

Is the picture on paper?

Usually this is self-evident, even if the picture is framed under glass.

Is the image on glass?

One possible ambiguity is the crystoleum or Crystal photograph, which was an albumen print sealed to the underside of a convex cover glass, which is included in the listing of glass bases. Pictures framed under glass should not be confused with images printed on glass.

If both the above answers concerning bases are 'no', the program brings up the questions pertaining to miscellaneous bases.

Questions on Paper Photographs

1. Is the image a positive or negative?

Generally a self-evident question except perhaps for ambrotypes, which were made as negatives but viewed as positives. Ambrotypes were coded as positives based on their intended use.

2. Is there a baryta subcoat?

A baryta coating was used under the photosensitive layers of all commercial papers starting in the 1880's (see chapter 3). This included bromide, chloride, and chlorobromide papers such as Aristo and gaslight varieties with both gelatin and collodion emulsions. It is usually markedly whiter compared to albumen and earlier papers; also the baryta completely covers the paper fibers in highlights and shadows.

It is impractical to identify separately all of these types by the questions in FOTOFIND. Close examination is necessary, possibly augmented by chemical or physical analysis. Answering "yes" to the baryta question serves to catagorize a print to a group of commercial papers fron the 1880's on.

3. Is the image faded?

Fading is a lightening effect, not to be confused with staining or spotting. It is difficult to evaluate without a comparison with the original appearance, yet it can be an important descriptor. Here are some clues:

Platinotypes have a long tonal range and soft shadows, but are not faded because of their stable chemistry. On the other hand, calotypes usually have low contrast because they <u>are</u> faded. Albumen prints are nearly always faded; their color has been variously described as brownish, rose, sepia, and yellow. Their faded yellow color is almost unique: a yellow print is likely to be an albumen, but not all albumens are yellow. Among the types that are never faded are carbon, carbro, gum, and all inked prints such as collotypes. Note that these images do not fade, although the paper base may have become brown or yellowed. Cyanotype images are stable and they were coded as not faded, but they have a short tonal range and both highlights and shadows may be distinctly blue. It may be due to original overexposure or contaminated chemicals in the processing, which causes a gradual increase in blue density over the years. However, cyanotypes will fade if they are stored in contact with buffered archival paper.

In general, prints made late in the 19th century are less likely to be faded than earlier ones, and their highlights will be whiter because of baryta undercoating. Silver bromide and chloride prints, except certain POP papers such as Aristo, did not contain excess silver nitrate as early salt prints did. If bromide prints faded, the cause was usually insufficient fixing or washing, which showed up as uneven spotting and fading. Many prints were toned gold or sepia to improve stability, producing a brownish color.

4. Is the image color black, brown, blue, gray, yellow, purple, or

"u"?

The above remarks on fading should first be reviewed, along with Chapter 10. Color can be an important clue, but it is difficult to describe colors verbally. Some of the carbon processes included pigments or dyes: the Autotype Company advertised more than fifty colors. Most dyes were unsaturated, or pastel. Sepia and brown are similar, and brown was coded as the descriptor. The ink used in collotypes was generally black, but colors were used in intaglio printing. Cyanotypes are uniquely blue or blue-black, and most platinotypes are a distinctive silver gray or neutral black that was called gray rather than silver to avoid confusion with Daguerreotypes and brown platinotypes. In case of doubt about the color of any print, type "u" for the first run, then try running with other answers.

5. Is the surface glossy, matte, matte fibers, or glossy shadows only?

"Glossy" includes smooth, which is a minor variation. Matte surfaces were made by adding cornstarch to the emulsion, or by mechanical stippling, which can be observed microscopically. Both glossy and matte are emulsion-coated overall, usually with a baryta undercoat that hides the fibers. "Matte fibers" means that the paper fibers are exposed over the entire surface. "Glossy shadows only" refers primarily to gum and carbon processes; the shadows are coated with gelatin but the highlights show exposed paper fibers where the gelatin was washed away during development. These surface types can usually be identified with a hand magnifier or with a microscope and illumination at grazing angle, concentrating on differences between shadows and highlights. Some emulsion reticulation patterns look almost like fibers: a microscope is needed. Gelatin emulsions coated by photographers were sometimes so thin that fibers are visible; adjustment of the microscope light will show small areas of sheen between the fibers. This is also true of albumen paper, which had no baryta undercoat: the fibers are visible but not exposed, so the descriptor is "glossy".

6. Are the shadows heavily tarnished?

Many silver processes show this effect to some degree, but it is so pronounced with gaslight papers and nitrate negatives that it is a fairly reliable identifier. It is also known as bronzing, silvering, or mirroring, and is caused by deposition of metallic silver on the surface by processing residues or storage environment.

7. Is the picture glued to an embossed card mount?

Although many paper photographs were mounted on cardboard, this question refers to cartes-de-visite, cabinet cards, and others with specific dimensions listed in Chapter 9. These mounts were usually printed with the photographer's name or studio on front or back, sometimes with advertising messages, and with decorative borders; they have a manufactured look. Processes include albumen, aristo, and chlorobromide papers, and some carbon and Woodburytypes. Tintypes were often mounted on small cards behind a thin paper cutout, and this is included as a tintype descriptor; it is easily distinguished from other card mounts.

8. Is there a screen pattern?
The commonest example is the geometrical dot pattern in screened newspaper halftones, a positive indication of an inked print. Other screen patterns are random dots and reticulated line patterns, all examples of ink prints: see Chapter 5. These patterns are coarser than photographic grain and can be seen under low magnification.

9. Are paper fibers visible in highlights only?
Emulsion-coated papers that did not have a baryta undercoat reveal paper fibers through the translucent coating. It is visible only in highlights because shadows are opaque. Careful lighting and magnification may be necessary. A clue is the color of highlights: baryta retained its whiteness better than most uncoated papers, which have usually yellowed in a century.

10. Is the picture retouched to look like a painting?
Many early portraits were tinted to some degree, but in some "crayon" prints the retouching essentially obscured the underlying image. Both colored tints and charcoal were used. Sometimes the silver image was chemically weakened or removed to foster the impression of a free-hand drawing or painting. See Appendix II.

Questions on Glass Photographs

1. Is the image a positive or negative?
It is often necessary to use lighting at various angles to minimize reflections.

2. Is the picture in a hinged case?
This question refers to the distinctive cases of ambrotypes, Daguerreotypes, and tintypes. These cases originally had hinged covers and glass over the picture; the covers are sometimes missing today. Metal lockets on chains are not identifiers of any particular photographic process.

3. Is the picture magnetic?
All tintypes are magnetic, and some transferotypes may also be: see Chapter 9. A weak magnet is adequate for testing; a magnetic compass can sometimes be used.

4. Do the highlights show silver reflections?
This is a property unique to Daguerreotypes; it is a specular or mirror reflection. Tarnish and reflections from the cover

glass can hinder the observation, but the tarnish (usually occurring in a diffuse zone around the edge) helps distinguish Daguerreotypes from ambrotypes and tintypes.

5. Is the image reflection tinted, milky, or dark?
The difference in reflection color is most visible in the image shadows; see Chapter 6.

6. Is the transmission color brown, black, or tinted?
Daylight viewing is preferred.

7. Is the glass flat, curved, or milky?
Milky refers to opal glass, not to be confused with the reflection in question. Curved means part of a spherical surface, convex to the viewer.

8. Is the edge coating even or uneven?
This refers mostly to wet-plate collodion negatives: hand coating was uneven at the edges. Ambrotypes are cased and their edges are not visible without dismantling; the same is true of bound lantern slides. The descriptor is based on what is normally visible to the viewer without taking things apart.

Questions on Metal, Cased, or Other Types of Photos

1. Is the picture a positive or negative?
Rarely a problem with most subject matter in adequate light.

2. Is the picture in a hinged case?
See comments in number 2 under glass photographs.

3. Is the image on a flexible transparent base?
This question refers to what is now called "film". It does not include translucent bases such as paper negatives (waxed, oiled, or plain), which are coded under "paper" and "negative."

4. Is the picture fixed to a card mount?
Some Gem tintypes were mounted in tiny brass frames that were crimped to a card mount. Other tintypes were mounted on cards behind a thin paper cutout. Many pictures were simply glued to cardboard, either plain or decorated. Plain cardboard is not a helpful clue, but decorations are fairly well documented; see Chapter 8.

5. Is the picture magnetic?
See comments in number 3 under Glass Photographs. Glass is not magnetic, but cased tintypes sometimes resembled ambrotypes, and the magnetic test is simple and definite.

6. Do the highlights show silver reflections?

See comments in number 4 under Glass Photographs.

7. Is the picture printed on fabric?
Several processes were printed on different kinds of fabrics. Most are fragile and rare.

8. Is the picture printed on leather?
The leather was sometimes lacquered to resemble japanning, and is fragile and rare.

9. Is the picture printed on metal?
The commonest example was the tintype, but transferotypes were made on many metals. Some were non-magnetic, such as copper and brass.

Section 5

Process Chronology

This is a summary of the earliest dates of patenting or discovery of the processes listed in Section 3, insofar as historical records appear to be consistent. The dates listed are believed to be the earliest dates that specimens of these processes could have existed, even though common usage may have been considerably later. In some cases processes were withheld until patent rights could be sold; in other examples the processes were 'leaked' or published prior to patenting, for commercial gain. Many processes were merely 'announced' and never patented.

The period of use of many processes is even less well defined. Daguerreotypes and ambrotypes had fairly definite cessation of usage; others such as albumen prints and tintypes did not go out of fashion so abruptly, and historical termination dates cannot accurately be defined. A number of processes had revivals, and some are even currently in (limited) use.

Listed alphabetically:

Albertype	1873
albumen	1850
ambrotype	1854
amphitype (see alternate names)	1851
Archertype (see collodion wet plate)	1851
Aristotype	1867

Autotype	1868
Breyertype	1839
Bromoil	1911
calotype	1841
cameo	1860
carbon (see alternate names and dates)	1839
carbro	1873
catalysotype	1844
catatype	1901
ceroleine	1851
Charbon Velour	1893
chromatype	1843
chrysotype	1842
collotype	1855
crystallotype	1850
crystoleum	1850's
cyanotype	1842
Dagerreotype	1837
Dallastype	1863
diaphanotype (see alternate names)	1856
Eburneum	1865
ectograph	1850's
energiatype	1844
Feertype	1889
fluorotype	1844
gaslight paper	1893
Gaudinotype	1853
Gaudinotype	1861
Gem tintypes	1863
gum bichromate (see also carbon)	1839

gum platinum	1898
heliotype	1870
Hyalotype	1850
hydrotype	1889
Ivorytype	1855
kallitype	1889
Leggotype	1871
Levytype	1875
linograph	1856
Meisenbach process	1886
melanograph	1853
nitrate film	1889
ozobrome	1905
ozotype	1899
palladiotype	1870's
pannotype	1853
platinotype	1873
safety film (cellulose acetate)	1939
Simpsontype	1864
sphereotype	1856
tintype	1856
Woodburytype	1864
Wothlytype	1864

Listed by dates:

Dagerreotype	1837
Breyertype	1839
carbon (see alternate names and dates)	1839
gum bichromate (see also carbon)	1839
calotype	1841

chrysotype	1842
cyanotype	1842
chromatype	1843
catalysotype	1844
energiatype	1844
fluorotype	1844
albumen	1850
crystallotype	1850
crystoleum	1850's
ectograph	1850's
Hyalotype	1850
amphitype (see alternate names)	1851
Archertype (see collodion wet plate)	1851
ceroleine	1851
Gaudinotype	1853
melanograph	1853
pannotype	1853
ambrotype	1854
collotype	1855
Ivorytype	1855
diaphanotype (see alternate names)	1856
linograph	1856
sphereotype	1856
tintype	1856
cameo	1860
Gaudinotype	1861
Dallastype	1863
Gem tintypes	1863
Woodburytype	1864

Wothlytype	1864
Eburneum	1865
Aristotype	1867
Autotype	1868
heliotype	1870
palladiotype	1870's
Leggotype	1871
Albertype	1873
carbro	1873
platinotype	1873
Levytype	1875
Meisenbach process	1886
Feertype	1889
hydrotype	1889
kallitype	1889
nitrate film	1889
Charbon Velour	1893
gaslight paper	1893
gum platinum	1898
ozotype	1899
catatype	1901
ozobrome	1905
Bromoil	1911
Safety film (cellulose acetate)	1939

Epilogue

Historians are happy to find plateaus in the flow of time at neat chronological intervals, such as "the turn of the century". If nothing else, it serves as a mnemonic device, or a euphonious book title. As this is written, we have passed such a marker in time, and it seems appropriate to review our perspective.

With a little rounding of dates photography can be said to have completed an era by the end of the 19th century. This era was marked by the first successful attainment of the long-sought permanent image of nature, and by the enthusiastic efforts of a multitude of individual inventors, many of them amateurs. As in so many fields this activity gave way in the 20th century to the trusts and combines of big business and big science.

In the 20th century the number of basically new processes is much smaller than in the 19th century. Not that progress has slowed; rather, it has accelerated, but it is of a different nature. We have seen the introduction of 35mm still photography (cinematography had its roots in the 19th century), and finally the end of the insidious nitrate film. Color photography, also rooted in the 19th, has reached dominance in amateur processing. Fast highly corrected lenses are commonplace, along with electronic light metering and a cornucopia of less fundamental gadgets. In the 19th century photographers proudly advertised "instantaneous" portraiture, meaning that exposure times were short enough that the human subject did not have to be propped up with a concealed support. Today "instant" photography means color prints from the camera in a minute - not, however, according to Webster's definition of instant as "an infinitesimal space of time"; for that, it appears that we must abandon chemistry.

A few years ago there was concern that the world would encounter a shortage of silver for photography in the foreseeable future, and research efforts were begun to find a substitute.
At first these proprietary efforts were concentrated in the field of chemistry, until the computer revolution exploded. For a time it appeared that chemistry had been outflanked by solid state physics, and to a significant extent this has happened, particularly in video. Today silicon chips serve as the eyes in color television cameras, camcorders, and still cameras, generating pictures that are stored on magnetic or silicon media for instant (sic) playback without chemical intervention.

However, the outflanking has not decided the battle. As Tadaaki Tani concludes in his important 1995 survey [141], there are fundamental technical reasons to sustain our faith in chemical photography for many applications. As we approach a new era, the 21st century, the day of silver and wet chemistry in photography is definitely not over, but the time line is murky.

One source recently estimated that 66 billion photographs will be made this year. It seems likely that this number will increase as technology opens new doors, just as it did in the 19th century for the same reason. A more detailed prognosis would be extremely rash, given the unpredictable nature of invention. Progress is inexorable and merciless, and some of our present processes may one day be relegated to "revivals". But after 150 years the prospects for innovation are bright, though inspired amateurs and artists may not have the remarkable influence they enjoyed (and profited from) in the 19th century.

Appendix I

A Scanning Electron Microscope Looks at a Daguerreotype

Surviving Daguerreotypes exhibit several kinds of surface deterioration. The appearance of mechanical scratches and large area abrasions can effectively be eliminated by retouching a copy (not the original). Stains may be cancelled by copying with colored filters, and weak images can be improved by high-contrast copying. However, large area silver tarnishing that obscures image detail on many Daguerreotypes cannot be compensated by optical copying methods. For this reason, chemical removal of tarnish on the original plates was a common practise for many years.

Potassium cyanide was first used to remove tarnish and, inevitably, some of the image information, since it dissolves silver, but in the early 1970's a "new and improved" formula was published that utilized acidified thiourea. It became widely used because, besides being less toxic than cyanide, it produced bright clean surfaces that appeared not to have sustained noticeable damage or loss of image.

Of course it was realized that tarnish returns quickly to clean silver unless the storage environment is completely free of sulfur. But some cleaned Daguerreotypes soon developed unsightly blemish spots that were dubbed "measles", rather than the expected hazy film of tarnish.

In March 1973 the author, at the request of colleague Leon Jacobson, examined corrosion spots on a sixth plate Daguerreotype of an unknown subject using a scanning electron microscope (SEM). The results were published in a short article [80] in 1974. Following is a more complete discussion of the technique and results, including previously unpublished SEM micrographs from that work.

Figure 9 shows the appearance of the test picture chosen for analysis, after it had been cleaned in the thiourea solution. The "measles" spots are hardly visible in this specimen, but they were sufficient for analysis. They were of much greater concern on other historically valuable Daguerreotypes.

Figure 9

Because of the vacuum environment in electron microscopes, it was necessary to remove the Daguerreotype plate from its case and from its binding tape and cover glass. Thus prepared, the bare Daguerreotype plate is better able to withstand a vacuum environment than any other photographic image. The plate was larger than our available SEM specimen stages so a holder was improvised that, unfortunately, did not allow optimum tilt angles, but the resolution was not seriously degraded at magnifications less than about 10,000.

In the years since this work, many other SEM analyses have been reported, notably by M. Susan Barger and coworkers, and by Swan et al. But the earlier work still usefully illustrates the nature of a corrosion problem and one of the pitfalls of restoration. It also reveals details of the Daguerreotype microstructure that a light microscope cannot achieve.

Microstructure of a Daguerreotype Image

Fig. 10 is a low magnification (about 15x) SEM micrograph of a portion of the white shirt chosen for its sharp edge contrast. Various kinds of blemishes are visible, some of which are nearly invisible by light microscopy. The SEM image depends on the secondary electron emission properties of surfaces rather than on light reflection. This fundamental difference between the two imaging processes often reveals organic and inorganic thin film contaminants not visible in light, even though the concept of color is inapplicable to electron images as it is to light images.

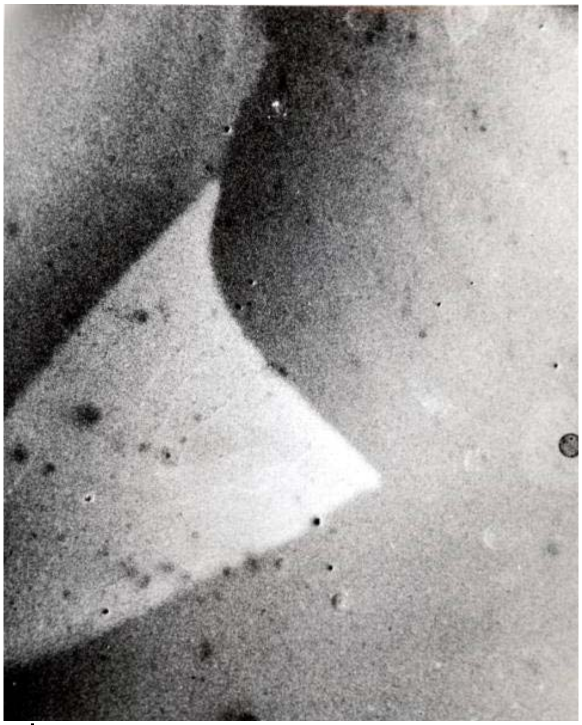

Figure 10

Figure 11

Figure 11 shows the light/dark boundary at about 200 magnification; the particulates in the white region are becoming visible. Figure 12 clearly shows the amalgam particles in the white area, as well as buffing scratches in the silver-plated base metal. Figure 13 shows details of the amalgam particles at about 5000 magnification. This sequence of pictures shows that the "white" expanse of the shirt contains many more amalgam particles than the dark regions. The particles are silver-white in visible light, and their shape scatters incident light so that the viewer's eye has an appreciable acceptance angle for this reflected light. Light that is reflected from the highly polished areas where there are no particles is efficiently reflected, but in a narrow angle that depends precisely on the angle of incidence. This has the effect of sharply reducing the eye's acceptance angle. Thus a viewing angle can be found where the contrast is at a maximum, within perhaps twenty degrees on either side of the perpendicular. The actual dependence of contrast on viewing angle depends on several factors; it has been studied by Barger et al [12]. If the eye is far off to the side, contrast is nearly zero, and the image vanishes.

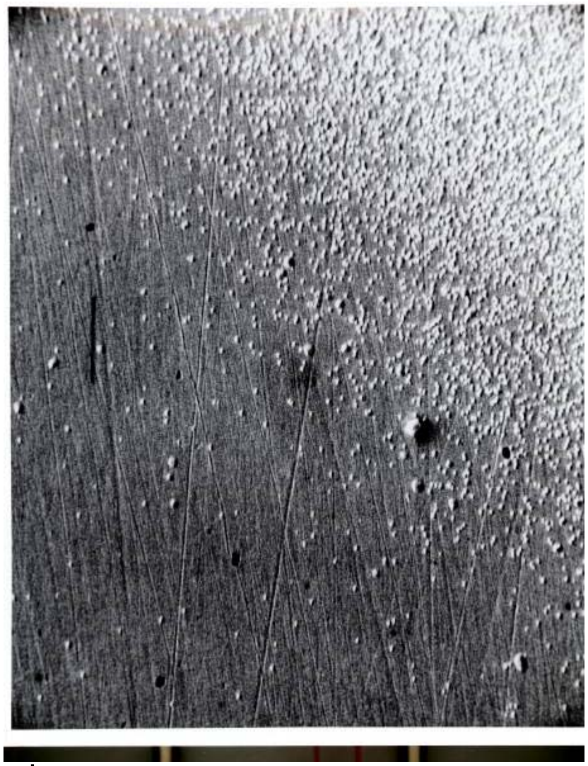

Figure 12

Figure 13

Daguerreotypes have been described as "grainless", but from these pictures this is obviously in error. The grain of the particles is apparent in a light microscope at 300x. They appear textureless in comparison with salt prints, their contemporary competitors, which had a visible paper texture.

The mechanism of particle nucleation and growth which accounts for the range of particle sizes is discussed more fully by Barger [8, 12] and by Pobboravsky [117]. Since we examined only one specimen, we have no information on the original effects of process and materials variations.

The fact that the particles are bright by reflected light and also bright in secondary electron images does not have an intuitively obvious explanation. It has been said that the earliest secondary electron images surprised the pioneering workers because of their unpredicted resemblance to light microscope images. SEM images, besides being capable of more than fifty times greater magnification, have some five hundred times greater depth of field than light micrographs. It is convenient that the two imaging technologies complement each other so well.

The width of the black band at the bottom of some of the pictures is a micrometer marker (not all the pictures have a marker because one of the SEMs we used lacked a marker mechanism). The band marked '100 microns' thus represents about 0.004"; '4 microns' represents 0.00016". One micrometer, or its formerly-used synonym "micron", equals one thousandth of a millimeter or about 4 one-hundred thousandth of an inch; the wavelength of green light is half a micrometer. It is more accurate to refer to these internal markers, because apparent magnification may change during subsequent reproduction. The maximum magnification of which most light microscopes are capable is less than 2000x.

Corrosion Analysis

Figure 14 shows one of the "measle" spots near the left side at about 850x; it consists of a dark center surrounded first by a narrow white ring, then a broader dark ring. This specimen had been cleaned in the acidified thiourea solution. The corrosion site is approximately twenty-six times larger than a typical amalgam particle, making it visible to the unaided eye.

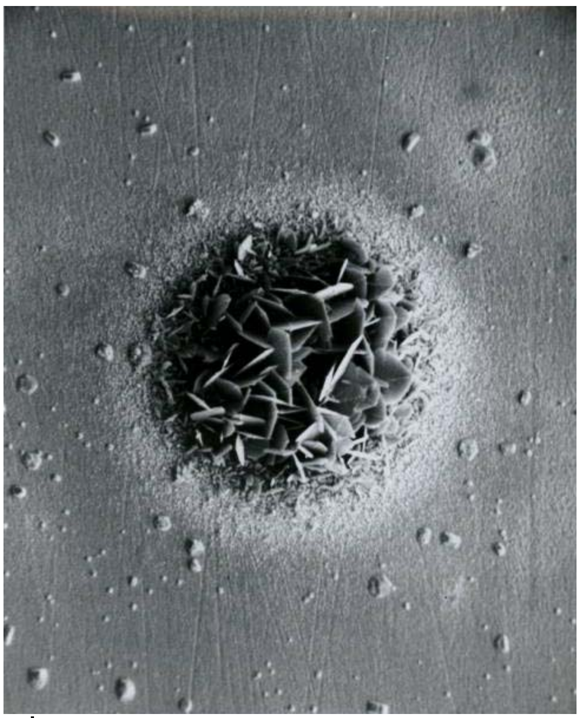
Figure 14

We performed X-ray fluorescence analysis in the SEM by focusing a stationary electron beam with an energy of 9 kilovolts on the center of the corrosion site and on other selected sites for comparison. The energy spectrum of the X-rays emitted at the site of electron bombardment was analyzed by a solid state energy dispersive detector. X-rays are emitted from a pear-shaped volume substantially smaller than the overall corrosion site but large enough to include several of the crystalline "petals".

Analytical results were as follows:

1. Center of corrosion site: strong silver and sulfur, trace chlorine and mercury.
2. Small white particles surrounding corrosion "petals": strong silver and sulfur.
3. Dark zone - Fig. 10: strong silver and sulfur.
4. Amalgam particle: silver, mercury, trace chlorine.
5. Clean base metal between particles: silver, mercury. Gold was not detected; not all Daguerreotypes were toned.

Towler [145] listed the following materials used to make Daguerreotypes:

Jeweler's rouge (iron sesquioxide).
Iodine, and sometimes bromine, sensitizer.
Mercury.
Sodium hyposulfite ("hypo").
Gold chloride toner, not always used.

However, this list is oversimplified: there were many variations. Other polishing compounds such as pumice were used, and combinations of sensitizers were used, including chlorine, as discussed by Swan et al [138].

Both the narrow light ring and the broad dark ring showed strong silver and sulfur. The results indicate that these collars are spreading contaminants that hide the normal composition of the clean surface, and that they are largely responsible for the expanded visibility of the corrosion sites. Neither the amalgam particles nor the base metal between particles contained detectable sulfur.

The plate was then cleaned again in thiourea solution, followed immediately by several distilled water washes and an ultrasonic wash in distilled water. A second SEM analysis showed essentially no change in the appearance of the crystalline corrosion, but the sulfur and chlorine peaks in the X-ray spectrum were almost undetectable. The measles were much less apparent to the eye, and did not change over a storage period of six months.

<u>Conclusions and discussion</u>:

The crystalline corrosion spots act like tiny sponges that retain traces of the thiourea cleaning solution. This thiourea, which contains sulfur, effused outward over a period of days, forming a collar of increasing visibility around each corrosion site. It was the thiourea residue that was largely responsible for the visibility of the measle spots: the original crystalline centers were much smaller and relatively obscure. The ultrasonic wash was vigorous enough to remove the residual traces from the interstices of the microcrystalline "sponges".

Thiourea is the active ingredient in most commercial silver cleaners. It is an organic compound containing sulfur, nitrogen, carbon, and hydrogen (H_2NCSNH_2). It had been recommended by reputable restorers in the 1970's for removing tarnish on Daguerreotypes (eg Weinstein & Booth [148], and the 1979 edition of Eastman Kodak Publication F-30.) But there is no cleaning process that removes chemically bound corrosion without also losing some picture information. Chemical cleaners cannot convert silver corrosion compounds back to metallic silver and redeposit it precisely in its original sites. Cleaners convert the corrosion products (usually sulfides) to a soluble organo-metallic complex that can be washed away. This selectivity is useful: the silver in the corrosion is lost but not the uncorroded silver. Dirt and inactive foreign substances, if they are not chemically bound to silver, may be removed by solvents or detergents.

The cause of the crystalline form of corrosion is unknown. The fact that no copper was detected was interpreted to mean that there was no pinhole in the silver plating to expose the base copper. This is not conclusive: the crystalline structure may have grown in several phases, effectively concealing the original defect. We believe that the most effective means of analysis would be to remove the corrosion by argon or krypton focused ion bombardment in the SEM; Barger et al [11] discusses this technique. This would permit SEM inspection during the dissection process and eliminate exposure to other chemical reagents that would confuse interpretation. At the time of our original work (1973) this technique was being explored but was not then operational. It has become a recognized tool in recent years.

Neither bromine nor iodine (the usual sensitizers) were detected in our analyses. Pobboravsky [117] has measured typical silver iodide film thicknesses of the order of 30 nanometers, or about 300 atomic diameters. Because of the unfavorable placement of the specimen plate in our SEM, it is likely that this was below our detection limit. The presence of these materials was not of particular interest unless they were concentrated in the corrosion sites, which was not the case.

The origin of the chlorine traces is not certain. It may have been added as an accelerator during sensitizing. It may also have been a trace impurity in the original process (before the days of 'Chemically Pure' reagents), or simply have come from recent handling or during more than a century of storage.

Particles of the original polishing compound may have been left on the surface, which could have served as corrosion nucleation sites. Our SEM had a substantial iron background X-ray peak caused by wall scattering and aggravated by the unfavorable specimen position. Therefore no conclusion was justified on this question.

Other limitations of the SEM analysis:

The X-ray spectrum at the time of this analysis detected chemical elements but did not yield information on the chemical compounds or on the quantitative amounts. In a heterogeneous surface such as this specimen, quantitative information would be meaningless unless the analyzed microvolume could be defined.

There are detection problems with elements whose atomic numbers are below about fluorine, which includes carbon, oxygen, and nitrogen. The X-ray yield is small at low atomic numbers, and the escape probability of the low energy X-rays also decreases, especially in heavy matrices such as silver. Instrumentation is continually improving, and many new analytical techniques are emerging that are capable of identifying organic compounds in microstructures.

Our results, like those of many other investigations, leave unresolved a number of questions. They did lead to a conclusion regarding a cleaning process that was experimentally verified, which is a useful outcome for a small volunteer effort. The study has been discussed in detail to show the power of the scanning electron microscope, a modern analytical tool in common use in many fields. Hopefully this experience may encourage other workers to make similar efforts.

Appendix II

Analysis of a Paper Photograph

Occasionally one encounters an old photograph that is different in some respect from all the standard types in our memory, either personal or computer. The frequency of such encounters is a function of the experience process: there is always something new to be learned. Following is the story of the casual investigation of a photograph that puzzled this writer for several years in spite of diligent literature searches. I hope it sheds some new light on a topic that was found to be very sparsely documented.

Figure 15 shows an unframed tinted portrait whose actual dimensions are 16 x 20 inches. It is on rough matte paper glued to coarse cardboard; the paper is 0.0087 inch (0.22 mm) thick on 0.035 inch (0.88 mm) cardboard. It is tinted in at least three colors, and the paper and cardboard are yellowed and crumbling. The photographic image was barely perceptible and evidently served only as a guide to tinting. There are no identifying marks on front or back, but it was known to have been made in Columbus, Ohio in 1901 plus or minus one year; the date and location are known because the subject is the mother of the author. Figure 16 shows a small mounted print obviously from the same negative that was printed on conventional contemporary paper, untinted.

Figure 15

Figure 16

The question is what type of exposed-fiber photographic paper was used, and what was the sensitizing process. Bromide enlarging paper was widely used by the date of the photograph, and is easily identified by the baryta-undercoated emulsion. Some practitioners were still using albumen paper, but this also is easily identified. Presumably the photographer used fiber paper because, being rough, it was easier to tint, either with water colors or Conte crayons or other media.

The FOTOFIND program (Chapter 14, Section 4) was used to list all the paper processes with exposed fibers (no emulsions). The result is shown in Figure 17, including responses to the questions. Note that 'n' was answered to the question about retouching; if we had answered 'y'or 'u', the program would have returned 'crayon print' as the search result. We answered 'n' because we were trying to list possible uncoated processes. Since the subject photograph is a commercial product from the photographer who produced the table portrait, only the first six candidates need be considered. Cyanotype can be discarded: it was the result of answering 'uncertain' to the color question. If we discard platinotype and palladiotype because of the high cost of a 16" x 20" picture (unneeded cost because of subsequent tinting), we are left with calotype, kallitype, and diazotype.

```
*********************************************************************
         Results of FOTOFIND search of paper photographs:
      Date  06-18-2001
      Photo No.
      Subject:  HL crayon print?
      -------------------------

         calotype positive
         cyanotype positive
         diazotype
         kallitype
         palladiotype
         platinotype
         transferrotype
         catatype  (rare)
         crystallotype  (rare)
         amphitype positive  (not commercial)
         catalysotype  (not commercial)
         chromatype  (not commercial)
         chrysotype  (not commercial)
         energiatype  (not commercial)
         Feertype  (not commercial)

      -------------------------
      DESCRIPTORS for this run:
      Positive/negative: positive
      Baryta? n
      Faded? u
      Color: u
      Texture: matte fibers
      Tarnished? n
      Mounted? n
      Screen pattern: none
      Visible fibers? n
      Retouched? n

     End of report   [Copyright (c) 1988-2001 William E. Leyshon]
     *********************************************************************
```

Figure 17

There was an additional consideration: a gum-bichromate print, under-exposed and almost totally washed-out, which would have exposed most of the paper fibers (gum prints were popular in the 1890's). But this is improbable because it is clearly an enlargement and bichromate processes were too low in sensitivity for enlargers of the day. Microscopic examination of this print at 90x failed to show an emulsion.

Conversations with archivists of four museums revealed that they, too, possessed similar portraits, some of them charcoaled rather than tinted. In at least two cases the subjects were of historical interest. In conversations with this writer, none of the museum personnel could identify the process or the dates.

I found two other similar family portraits 14 x 17 inches in size that had a monochrome brownish color. Matching copies on cabinet cards were also found that were obviously made from the same negatives. The cabinet cards appear to be made on conventional silver chloride paper and showed some tarnishing, but the large prints did not show tarnishing.

The most obvious explanation was that the photographic process consisted merely of an under-exposed silver print to give the illusion of free-hand art work. An experienced dealer in 19th century photographs was consulted, who made the plausible suggestion that the pictures may have been printed on a thin diluted emulsion hand-coated by the photographer. But the failure to find traces of emulsion at 90x was puzzling. It was a reminder that there were many private process variations in the 19th century, not all of which were publicly documented. However, library searching failed to turn up any mention of such work, which was inconclusive.

Closer examination of the center of the large print at higher magnification was needed, to search for traces of residual emulsion. For this, and other work, we wanted to examine all regions of these pictures at 200 - 300x. We modified the mount of a biological microscope to permit inspection of the centers of such large prints. With this new capability it was possible to see faint shiny traces in scattered locations in the center of the image, but no coherent or continuous layer. The examination did not establish whether the tints were water colors or pigments. There were faint traces of highly diluted color that had no discernible grain, but there also were some larger clumps of color.

The crumbling of the paper provided several loose or semidetached flakes. My colleague James Thrall examined and analyzed two of these flakes by x-ray fluorescence in the scanning electron microscope described in Chapter 14 and Appendix I. By this analysis it was hoped to determine the nature of the sensitive material. A quantitative analysis of two loose flakes showed the following results:

Table 4

Element	Sample #1 Weight %	Sample #2 Weight %
Si	16.39	13.28
S	12.35	11.36
Cl	1.48	ND
Ca	ND	4.86
Fe	8.48	6.77
Br	20.65	14.18
Ag	12.67	9.62
Sb	14.91	ND
Ba	13.06	14.23
Pb	ND	25.70
Total	99.99	100

(ND = Not Detected)

Conclusion: the sensitizer was probably silver bromide. Chlorine was low, eliminating the salt print or calotype process. The chemical elements in diazotypes could not be detected in the SEM, and the silver content that was found eliminates diazotypes.

The iron content could be indicative of the kallitype process; the SEM analysis suffers from an artifact iron peak, which probably did not entirely account for the reported iron percentage. Pernicano [115] gives several fomulae for coating modern kallitype paper that include silver and iron; one method also uses barium. But as we shall see later in this Appendix, some of the components in the analysis are probably from tinting pigments, including iron.

If a known kallitype print had been available for calibration, it would have been helpful. But there were several variations of the process, and a single analysis will not be conclusive. It was fairly common for workers to sensitize their own paper with the kallitype process during this period; there are more details in Chapter 2 and in the references.

Since the electron microprobe generates x-rays from a very small sample volume (a few cubic micrometers), the quantitative percentages are probably not representative of the image macro-structure or the sampling sites. The precision is likely to be no better than two significant figures at best, and can only be improved by more sampling.

Our analysis showed the atomic ratio of silver to bromine to be about 1:2 in both samples. Silver bromide, AgBr, has an atomic ratio of 1:1. Normally, exposed silver bromide is reduced to metallic silver during development, and the unexposed silver bromide is removed by hypo. This should leave a surplus of silver relative to bromine, instead of the 1:2 deficiency we found. If the silver in the image had been selectively removed by a chemical treatment before or after tinting, it could account for the deficiency. To verify this, it would be necessary to analyze more sites in the portrait to be sure of representative sampling. Our evidence is suggestive, but verification by other workers would be desirable.

Conclusion:

The most probable interpretation is the kallitype process, coated by the photographer. The chemical elements in the tinting compounds, and the lack of a known sample for comparison, leaves the identification tentative.

Scanning electron microscopes are widely used in industrial and academic research applications, but time on the instruments is not inexpensive. Our analysis was a volunteer effort performed by a good friend and colleague (see acknowledgments) who donated two noon hours. The information on the unexpected elements was a bonus. Analytical work frequently yields information that raises new questions, but one has to stop somewhere.

In Chapter 11 I have described what little I have found on "crayon prints" in the literature. Darrah [39, 43] describes tinting, especially the use of water colors and liquid aniline colors. These are organic dyes that would not have been detected in our microprobe analysis. Darrah [40, 192] is a more relevant reference. It describes crayon portraits that were reworked with ink or pencil, followed by removal of the silver image "by chemical treatment". Darrah identifies this process narrowly in the Boston area about 1870-1873, as applied to cartes de visite. Enlarged charcoal portraits were made in the same manner, and apparently also retouched by wax or pastel crayons.

This is the only reference found so far that mentions removal of the silver image after retouching, rather than weakening the image before retouching (leaving a dim image that is visible in our pictures). Darrah does not describe the chemistry, but various bleaches were available, some of which embrittled the paper; weak sulfuric acid is one such bleach. Our portrait showed serious paper crumbling, more than is usual with old photographs, which could have been the consequence of image removal, or just inferior paper. Different practitioners are known to have used many process variations.

A book by Barhydt, reference [19], published in 1892, is the only book solely devoted to crayon prints that this writer has encountered. It was found in the rare book section of the Library of the George Eastman House. Unfortunately the book is not informative about the various photographic processes. It describes the use of 'Conte crayons', which are still sold in artists' supply stores; they have been manufactured for two hundred years. They have a square cross-section and are hard and 'chalky', rather than waxy like our present-day children’s crayons.

The Arizona Paper and Photograph Conservation Group held a symposium on December 2, 1989, at the Center for Creative Photography at The University of Arizona. The guest speaker was James Reilly, Director of the Image Permanence Institute in Rochester, New York. One topic was crayon prints. From the discussion concerning similar specimens, the specimen in our analytical study was definitely identified as a crayon print, and our analytical conclusions were essentially correct. We still would like more details of the photographic process; no doubt there were many variations among individual practitioners. But crayon prints evidently had considerable vogue.

The excellent book by Reilly [122 page 6] mentions crayon prints explicitly but does not elucidate the photographic process beyond mentioning the use of both POP and DOP processes. His book was published several years after our unpublished SEM analysis was performed.

Other Speculations

The presence of the other elements leads to some interesting speculations. With the exception of trace chlorine in sample #1, the remaining elements are not associated with silver bromide systems, and it seems likely that they may be constituents of tinting pigments or paper fillers. The following list of pigments containing these elements was compiled from tables of pigment compositions *. It is interesting to note some common pigment elements that were not detected, such as titanium, zinc, cadmium, mercury, copper, cobalt, sodium, arsenic, and manganese.

* Handbook of Chemistry and Physics, 61st Edition 1980-81, pages F85-86, CRC Press, Boca Raton, FL 33431.

Lead-containing pigments:

- PbO - yellow litharge
- $PbSO_4$, $PbCO_3$, $Pb(OH)_2$ - white lead
- Pb_3O_4 - red lead
- $Pb_3(SbO_4)_2$ - Naples yellow

Calcium-containing pigments:

- $CaSO_4$ - white gypsum
- $CaCO_3$ - white chalk

Iron-containing pigments:

- Fe_2O_3 - red or yellow ochre or burnt sienna
- $Fe_4[Fe(CN)_6]_3$ - Prussian blue

Barium-containing pigments:

- $BaSO_4$ - white baryta
- $BaCO_3$ - white

Antimony-containing pigments:

- Sb_2S_3 - vermillion
- Sb_2O_3 - white
- $Pb_3(SbO_4)_2$ - Naples yellow

Sulfur-containing pigments:

- $BaSO_4$ - baryta white

Sb_2S_3 - vermillion

Silicon-containing pigments:
SiO_2 - sand or diatomaceous earth.

The principal colors in the portrait are blue in the eyes and in the background wash, red lips and cheeks, and white tracery in the blouse. Yellow or green are not apparent.

The color of pigments depends not only on their chemical composition but also on their crystal structure, hydration, and on trace impurities. The electron microprobe could not detect hydrogen, carbon, oxygen, or nitrogen, which eliminates information on oxidation states, water of hydration, and organics.

With these caveats, the following compounds are possible but cannot be confirmed by the instrument used in this analysis:
PbO - yellow litharge
$PbCO_3$, $Pb(OH)_2$ - white lead
Pb_3O_4 - red lead
$CaCO_3$ - chalk
Fe_2O_3 - red or yellow ochre
$Fe_4[Fe(CN)_6]_3$ - Prussian blue
Sb_2O_3 - white
$BaCO_3$ - white
SiO_2 – sand

The following materials were not present, within detection limits:
Clay or kaolin (no aluminum found).
Talc (no magnesium found).
No Ultramarine pigment (no sodium or aluminum found).

The following compounds, all containing sulfur, <u>may</u> be present, depending on how the available sulfur is allocated (since we have no valence or bonding information):
$PbSO_4$ - white lead
$Pb_3(SbO_4)_2$ - Naples yellow
$CaSO_4$ - gypsum
Sb_2S_3 -vermillion
$BaSO_4$ - baryta
AgS - silver sulfide

Sample #1 showed antimony but no lead, while sample #2 showed lead and no antimony. It may be that two red pigments were used: Sb_2S_3 for vermillion and Pb_3O_4 for red. When we selected the loose flakes for analysis, their locations in the image were unfortunately not precisely noted. The cheek coloring appears to be a slightly different shade of red than the lips, so one may have been lead and the other antimony. We were originally more interested in the silver question than in identifying pigments.

We have indulged in these speculations to show some of the possibilities of non-destructive x-ray fluorescence analysis. It should be emphasized that a thorough analytical treatment would have required additional sampling, and compound information from other techniques such as infrared spectrophotometry.

Appendix III

Notes on the philosophy of the FOTOFIND Program

An experienced archivist or collector can weigh at a glance many observational and subconscious details and come to a conclusion that has a certain probability of being right. Such a judgment will always be subjective; it may be biased for or against rarities, or a decision may be rendered in haste that should be deferred for more detailed analysis. There is a need for improved decisions based on better quantified data. Because of the widespread availability of microcomputers for data retrieval and keyword sorting, it was decided to explore computer programs for sorting photographic identification data.

Obviously it is not necessary to use a computer to tell the difference between glass and paper photographs, but the problem is more complicated than that. In Section 2 are listed sixty nine types and fifty nine synonyms or closely related processes, including rarities and non-commercial processes. Previously published flow charts have been forced to disregard some of the rarities and ignore synonyms as a concession to convenience. A printed flow chart has room for only short queries and abbreviated conclusions: there is little room for text unless the chart assumes the dimensions of wallpaper.

A general purpose commercial database program was tested, but the built-in sorting procedure turned out to be completely unsuitable for a variety of reasons. The need for a special program was evident, and an exhaustive search was undertaken of available sources of descriptive data on old photographs.

An interactive computer program can be designed to formalize decision-making in a linear progression: a new decision is not considered until the current one is resolved, encouraging a certain amount of mental discipline. Flow charts are used in the same way, but when the whole chart is visible, our eyes tend to wander along several paths, and linear progression breaks down when indecision causes vacillation.

Three different computer algorithms and numerous revisions were tried in attempting to develop workable logic. The first approach was basically a computerization of the type of flow charts found in Coe & Haworth-Booth [32], Gill [67], and Rempel [124]. Twenty-five questions were formulated for yes/no answers; after each answer the program branched to another question that depended on the previous answer. Usually a conclusion could be reached in about half the questions, so the operator did not have to go through all twenty five questions. If the operator was uncertain which answer to give to a particular question, it was suggested that two runs be made with that question answered both ways and the results compared. This approach simulated the use of a flow chart, with the advantage that the computer could present more detailed questions and answers. It also provided a printout of the questions and answers for filing a permanent record with each picture.

This program worked fairly well, but an awkward flaw became apparent during trials. The rigidity of yes/no answers caused confusion because of imprecise descriptors, and the preprogrammed conclusions could only suggest groups of many possible identifications. Some descriptors are easy (paper versus glass), but color can be both a misleading indicator and a useful clue. Of course this is a fundamental problem in identifying photographs, and a computer cannot be expected to be smarter than the data it contains.

The final FOTOFIND program is based on matching key words and is more user-friendly. It also uses a fundamentally different approach to the problem of uncertainty that makes it a useful learning tool. The program operates as follows:

The user answers are read into a temporary memory array along with the same number of corresponding descriptors for the first identification candidate stored in memory. The answers are then sequentially compared to the candidate descriptors in a series of tests. Each test decides whether to reject the candidate. If there is a definite mismatch in any one of the tests, the candidate is rejected and the program moves on to the next candidate in memory. If rejection does not occur, then that candidate is printed as a definite "ID".

If the user answered "u" for "uncertain" in any question, the program treats this as a conditional acceptance rather than rejection. If further answers do not cause definite rejection of that candidate, it will be printed as a "possible ID". It is then up to the user to decide whether to seek further information to clarify the uncertainty and narrow the possibilities.

The program has provision for printing a report, including both answers and results, with the photo inventory number, so that it can be filed with the photo. It is suggested that archival paper be used for such reports.

The program makes several thousand decisions in a few seconds for a single unknown paper photograph. Since paper photographs outnumber glass or other types, paper searches take a little longer. The difference is almost imperceptible on modern personal computers.

The number of possible identifications depends on the information available. For example, tintypes are always magnetic, and transferotypes might be. If "y" is given in answer to the magnetic question, the identifications "tintype" and "transferotype" will be returned even if all the other answers are "u". Answering 'u' to all questions returns a complete list of all types in memory, which is a convenient way to list all the candidates.

When more than one identification is returned, the detailed descriptions elsewhere in the book should be consulted. If incorrect or inconsistent answers are given by the user, then no identification will be returned by the program.

The return of more than one ID or possible ID is not an ideal outcome; computers, like experts, are expected to give unqualified answers. To accomplish this, it will be necessary to ask better questions and to store more definitive descriptors for the types that closely resemble each other.

Not all descriptors are definitive; indeed, this is a fundamental problem of judgment in all identification processes. An example of ambiguity is the color of old photographs. Many paper prints show shades of brown, either from fading, toning, or process characteristics, and the color may be only a secondary clue. In other cases such as blue cyanotypes or black printers' ink, the color is a useful descriptor. In designing the DATA array certain descriptors in the memory were censored so that they are inactive even if the user enters what is thought to be a definite answer.

Another example of the difficulty of using color as an identifier is the case of calotypes, or salt prints. Variations in chemical processing and light exposure could produce colors ranging from dark brown to light green, as discussed by DuBose [45]. If FOTOFIND were programmed to recognise all possible hues, chroma, and luminance, a large number of other processes would also be candidates. To prevent confusion, the comparison data in FOTOFIND was coded to ignore certain keyboard answers to the color question as applied to calotypes and a few other processes.

FOTOFIND attempts to distinguish between some sixty identities on the basis of only ten questions, and compromises are inevitable. The questions chosen are, of course, not the only possible ones, and could probably be improved. Dealing with observational uncertainty is a basic problem in identification. In mathematics there is a field of investigation known as "fuzzy logic", which endeavors to extract meaningful conclusions from real world data that are full of uncertainty. It is a difficult problem that often requires the largest and fastest computers. However, the FOTOFIND program is only a type of interactive 'expert system'; it is an adjustable sieve that rejects the clearcut misfits and labels the remainder as definite or possible identifications. The program is useful in narrowing the list of candidates and in providing a structure for future improvement. It will usually yield greater clarity than eyeball judgment, which all too often is really 'fuzzy' logic.

The program was written and compiled in Microsoft QUICK BASIC, which is a fairly old language (the only one the author knew). The algorithm treating the problem of uncertain data entry seems to be original with this author: it was not borrowed from any other application. The source code contains nearly two thousand lines; the compiled EXE program requires about 180 kilobytes of memory in a Personal Computer. The running time for a worst-case search is about a second. BASIC limits file names to eight characters, which accounts for the spelling of FOTOFIND.

Glossary

Aquatint: A process for enhancing the tonal range of intaglio plates. A random etched pattern was produced on the plates by applying resin particles to the plates before etching. It was called a "ground", and was used as early as 1804.

Asphaltum: Synonyms bitumen, pitch, tar. Used by J.N. Niepce in 1826 for the oldest surviving photograph, and as an etch resist in various photolithographic processes. It was usually obtained from Trinidad or the Dead Sea (hence "Bitumen of Judea"). Pieces broken at temperatures below the softening range exhibit conchoidal or brittle fracture patterns, unlike tar from most other sources such as petroleum.

Baryta: Barium sulfate, a natural or synthesized mineral used as a white pigment; in photography, used as a paper coating under emulsions to hide paper texture.

Base: This is the bottom supporting material for photographs. It is one of the attributes listed in Section 1. The light-sensitive material may be coated directly on the base, as in salt prints; it may be in an emulsion layer on the base, or there may be a baryta layer between the base and emulsion.

Bichromate: The modern spelling is dichromate. The sensitizer for gum or gelatin processes such as carbon, carbro, collotype. Sodium, potassium, or ammonium dichromate have been used, for example $K_2Cr_2O_7$.

Catalysis: Acceleration of the rate of a chemical reaction by a substance that does not become a constituent of the final reaction products. At one time it was thought to explain the appearance of the visible image in a printing-out paper, hence the name "catalysotype" in 1844.

Collodion: A solution of gun-cotton in ether and alcohol; gun-cotton is cotton reacted with nitric acid. It is highly flammable in liquid form. Towler [108] has a complete description. See "Guncotton" below.

Colloid: A suspension of particles in a liquid medium that fails to settle out. Examples are gelatin and gum arabic. Colloidal particles are of the order of 1000 times the size of the molecules of the supporting medium, making them visible under light microscopy.

DOP, or Developing-Out-Paper: Photographic paper on which the visible image is chemically developed from an invisible latent image; first used about 1873, now the predominant type.

Embedded image: The light-sensitive material is soaked into the paper rather than carried in a binder such as gelatin, collodion, or albumen. Paper fibers are easily visible in all parts of the matte image. Examples are salt prints and platinotypes.

Gelatin: Animal derivative first successfully used by Maddox in 1871 as a binder for silver bromide. It was also used as a safety film base in stripping films. The old spelling was "gelatine".

Grain: Visible development centers in a photographic image, not to be confused with paper fiber texture in salt prints, or the screen pattern in halftone engravings.

Ground: Roughening applied to intaglio plates to aid in retention of ink. The aquatint process was an example.

Gum Arabic or simply gum: A colloid produced from the bark of certain trees, used in the gum bichromate process.

Guncotton: The product of the reaction between certain organic substances such as cotton, and acids such as nitric or sulfuric. Guncotton is highly inflammable or explosive, and is soluble in ether and alcohol, yielding collodion, which has played an important role in photography as an emulsion base. Eder [48, 342-347] has a detailed discussion of the chemistry.

Halftone: The complete tonal range from white to black. A term often applied to inked prints made by various screen processes.

Halide: Chemical compounds containing the halogens fluorine, chlorine, bromine, and iodine. Silver halides have been the most important photographic compounds since 1839.

Index of Refraction: A measure of the bending of light as it passes from one transparent medium to another, where the velocity of light differs.

Intaglio: ink printing process in which the ink is held in engraved recesses below the main surface of the printing plate, as contrasted to relief printing where raised surfaces are inked, such as rubber stamps.

Lithograph: a paper print made by oil based inks transferred from an engraved master on stone.

Latent Image: the invisible chemical change produced by light in a photosensitive material.

Matte: a surface from which reflected light is scattered in all directions; rougher than a glossy or smooth surface. Salt prints and platinotypes have matte surfaces because the paper is uncoated. Matte or semi-matte surfaces were produced on coated papers by the addition of starch, or by mechanical embossing or roughening.

Orthochromatic: A photosensitive surface sensitive to all colors of the visible spectrum except red; sometimes called 'color blind'.

Panchromatic: A photosensitive surface sensitive to all colors of the visible spectrum.

pH: a measure of acidity or alkalinity of a water solution, on a logarithmic scale of 0 to 14. Neutrality is 7.0 on this scale; above 7.0 represents alkaline solutions, while below 7.0 are acids. Alkaline solutions etch most glasses. "Buffered" paper contains alkaline materials such as calcium carbonate to neutralize acids that deteriorate paper. The pH scale is based on hydrogen ion concentration, and is meaningful only in water solutions; the pH of dry paper must be measured by certain archival procedures.

Plasticizer: an oil-like chemical added to polymers ("plastics") to make them soft or flexible.

POP or Printing-Out-Paper: photographic paper on which an image appears spontaneously after light exposure without chemical development. Excess silver nitrate in the older emulsions often caused such photolytic development. Examples are albumen paper and some silver chloride and bromide papers; still used as proof paper for portraiture.

PPM: Parts Per Million, a measure of concentration, either by weight or by volume. Example: 0.1% = 1000 PPM.

Provenance: documentation on the known history of an artifact.

Resin: (1) Natural organic solids secreted from plants; example - rosin from pine trees. (2) Synthetic organic polymers used as "plastics".

Reticulation: a microscopic worm-like pattern in gelatin emulsions resulting from rapid and extreme temperature changes in solution, or drastic acid-alkaline cycling. It is a damage condition that is sometimes used for special effects. It was deliberately used in the collotype process to produce a random screen for halftone printing.

Sizing: a treatment applied to paper to produce a smooth base for subsequent coatings, to improve wet strength, and to reduce absorption of chemicals into the paper fibers. Many materials have been used, such as animal glue, tapioca, arrowroot, and gelatin, as well as modern resins.

Specular: Reflection of a coherent image from a smooth surface such as a mirror, as opposed to diffuse light from a matte surface. The direction of reflection is determined by the direction of the incident light, which can only occur when the height of irregularities does not exceed a small fraction of the wavelength of light.

Thermoplastic: a polymer whose solid shape can be reversibly altered by the action of heat and pressure. Examples are polyvinyl chloride ("vinyl"), and polymethyl methacrylate (acrylic).

Thermosetting plastic: a polymer whose shape cannot be altered by the action of heat and pressure without the occurrence of decomposition. Examples are epoxies, and phenolic resins such as Bakelite.

Translucent: An optical property that passes diffuse light but not clear images.

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The sources listed in "Acknowledgements" page 4 provided much of the material for this book. Out-of-print book dealers, antique dealers, and Internet sites have also been useful.

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William Leyshon is a retired industrial physicist with a lifelong interest in photography, having using it as a tool in his electronics research, and as an amateur. In 1974 he co-published some of the first scanning electron microscope pictures of a Daguerreotype. He holds five patents and has written papers on many subjects. He has been active in museum archival work since 1981.

He and his wife Emily have homes in Prescott, Arizona, and in Syracuse, New York.