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Urban decay: a case study of the negatives in the Toronto Telegram fonds, Clara Thomas Archives and Special Collections

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Urban Decay: A Case Study of the Negatives in the Toronto Telegram fonds

Clara Thomas Archives and Special Collections, York University

by

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Abstract

The negatives in the Toronto Telegram fonds (1876 – 1971), at the Clara Thomas Archives and Special Collections at York University, in Toronto, Canada are representative of eras in history and are of great historical, geographic and intrinsic value. The declining condition of the negatives is of significant concern for the longevity of these photographic artifacts. The fundamental value this fonds has to support research and teaching at the Clara Thomas Archives and Special Collections, York University Libraries and York University must be recognized.

My research concentrates on the 830,000 negatives, which include glass plate, cellulose nitrate, and cellulose acetate materials, all suffering from minor to severe forms of chemical and physical degradation. Vinegar syndrome is a major problem; the consequences of which are permanently deformed cellulose acetate negatives. This case study investigates the deteriorating condition of each type of negative within this fonds, and suggests appropriate measures for decelerating degradation.

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I would like to express a special thanks to Michael Moir, Head Archivist at the Clara Thomas Archives and Special Collections, at York University, for allowing me to access the archive throughout the past year to conduct hours-upon-hours of research. His help has been truly invaluable.

Finally, thank you to my family for their constant support and encouragement, I would not be where I am today without all of you. In particular I would like to thank my mother Marilyn, for spending so much time editing drafts and my brother Bram for all of his help formatting my thesis.

Dedication

I dedicate this thesis to my grandmother Ellen Gruneir and my bubbie Doris Bakst.
They touched my life in more ways than they will ever know.
Their memories will forever be in my heart.

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1 Introduction

This section investigates the history of the Toronto Telegram fonds, inventory, process of evaluation, current storage and environmental conditions. Relevant literature and resources are also reviewed.

1.1 Literature Review

All primary research was conducted with the negatives in the Toronto Telegram fonds, Clara Thomas Archives and Special Collections at York University in Toronto, Ontario. Two hundred and fifty of the four hundred and eighty-seven boxes of negatives, approximately half of the fonds, were examined. The negatives were examined for current conditions including storage, housing and environmental conditions, as well as evidence of degradation.

Secondary research included preservation leaflets and publications regarding negative degradation, appropriate housing and storage conditions. In particular, the publications available through the Image Permanence Institute including articles and publications concentrating on new tools for preservation, storage guides for various film types and a report on the preservation of safety film, have been excellent assets to my research.

The Image Permanence Institute is dedicated to scientific research in the preservation of visual information. Publications including the *'IPI Media Storage Quick Reference'* by Peter Z. Adelstein, the *'IPI Storage Guide for Acetate Film'* by James M. Reilly and

'Photographic Negatives: Nature and Evolution of Processes' by Maria Fernanda Valverde, proved to be most useful for this topic.

Peter Z. Adelstein's *'IPI Media Storage Quick Reference'* is exactly that [4]. This brief, yet thorough publication covers topics such as film decay, causes of deterioration, appropriate storage for all photographic materials, as well tools to assess and understand the condition of a collection. These tools include A-D Strips which are used to assess the acidity of cellulose acetate negatives and were utilized on three occasions to evaluate this fonds. Also included in this publication, is a wheel that allows users to predict the longevity of their collection based on temperature and relative humidity conditions. Adelstein's publication was most useful in understanding each type of negative structure, decomposition of the film bases and tools for preservation.

The *'IPI Storage Guide for Acetate Film'* by James M. Reilly was extremely useful when researching the degradation process of cellulose acetate negatives [19]. This publication examines the stages of vinegar syndrome, as well as preservation tools for decelerating this syndrome. Chemical deterioration of both nitrate and acetate are discussed and appropriate measures for enhancing their longevity are explored. The importance of proper environmental conditions including temperature and relative humidity are discussed in detail, as they are the leading factors of cellulose acetate decomposition. The tools for measuring free acidity within a microenvironment in addition to general requirements for film storage are also examined.

Maria Fernanda Valverde's *'Photographic Negatives: Nature and Evolution of Processes'* written in conjunction with the Mellon Advanced Residency Program in

Photographic Conservation at the George Eastman House and the Image Permanence Institute, is a description of the evolution of the negative [3]. Valverde's publication is essential when researching various types of negatives including their history, fabrication, stability, degradation, identification and storage. This publication was a useful source of research as it provided a wide range of information on various types of negatives and their essential components.

Informational leaflets from the Northeast Document Conservation Centre, Conserve O Gram and the Canadian Conservation Institute have been useful sources when researching preservation for film-based collections. These leaflets provide specific, relevant and useful information on topics ranging from negative housing, to environmental conditions to specific types of care for each of the negative types considered. These leaflets focus on subject matter that relate directly to negative degradation and preservation.

Books devoted to the preservation of film bases are difficult to locate. Therefore, books that dedicate chapters to negatives must suffice when doing research. *'Photographs Archival Care and Management' by* Mary-Lynn Ritzenthaler and Diane Vogt-O'Connor published by the Society of American Archivists, was a useful resource when investigating the deterioration of film bases [8]. Although a small section of this book was dedicated to negatives, the information provided was a helpful resource.

Bertrand Lavedrine's book '*A Guide to the Preventive Conservation of Photograph Collections*' was also extremely useful when researching the history and decline of film bases [16]. This book briefly outlines the development of film production and stages of deterioration. Although quite brief, this source is filled with vital information on negative types and was most beneficial to my research.

'Conservation of Photographs', edited by Elizabeth Eggleton, and published Eastman Kodak Company, was another valuable source when researching the evolution of the negative [6]. This book focuses on the conservation of photographs and discusses negative conservation including duplication and glass plate surface cleaning. The history of film bases, the makeup of film supports and identification of negatives are also briefly reviewed, as well as causes and types of negative degradation.

1.2 Toronto Telegram fonds

The Toronto Telegram fonds is comprised of press photographic objects dating from 1876 to 1971. The Toronto Telegram newspaper documented Toronto, Canada as well as international news events. The primary importance of the fonds is to offer visual reference for researchers, students and individuals in search of specific information. The fonds consists of 1,330,000 photographic objects, approximately 830,000 being negatives. These photographic objects consist of glass plate, nitrate and both colour and black and white cellulose acetate negatives. The prints and negatives are housed separately but within the same storage environment. The negatives are organized alphabetically and by subject matter with subheadings originally formulated by the Toronto Telegram library staff.

1.3 Current Inventory

The Toronto Telegram fonds is organized and accessioned in the order in which it was originally received by York University Archives, currently the Clara Thomas Archives and Special Collections. The negatives can be searched using the finding aid that lists the inventory of the fonds. A call number is used to describe the year the images were accessioned and the storage box number, for example 1974-001/001. The call numbers are also found on the exterior of each archival box (Figure 1.1). Located within the finding aid are alphabetically ordered subject headings and subheadings, as well as sleeve numbers. The subject headings and subheadings are quite broad in scope, which can hinder immediate accessibility when searching for a specific negative. Individual negatives are not numbered, but are referenced by the boxes and sleeves in which they are housed.

Figure 1.1: Example of Accession Number

1.4 Process of Evaluation

When evaluating the current condition of the negatives in the Toronto Telegram fonds, two hundred and fifty boxes, or approximately half of the fonds, were examined. From 40 to 200 sleeves were found within each box and 1 to 330 negatives were housed within each paper sleeve. The boxes examined were chosen at random from various areas of the storage room. Evaluations of the negatives were based on current housing, physical condition and overall state of the negatives. It is important to note that this fonds has recently moved to a new storage space within the same institution.

1.5 Current Storage: For All Negative Types

The bulk of the negatives in the Toronto Telegram fonds are stored in their original Kraft sleeves and housed in 'Hollinger Bully Boxes' which, are lignin free, carbonated, buffered material with a minimum of 8.5 pH (Figure 1.2) [1]. The boxes are stored on a seven-layer metal shelving unit. There are a total of four hundred and eighty seven document boxes that contain various types and sizes of negatives, with approximately 40 to 200 paper sleeves in each box, as noted above (Figure 1.3). These sleeves endanger the negatives by leeching chlorine, lignin and other chemical impurities common to commercial paper manufacturers [2]. A limited number of negatives are stored in non-buffered paper envelopes that are water marked and appear to be in very good condition. Glassine sleeves as well as Transview polypropylene sleeves are also utilized. Approximately 75% of the medium format negatives and 35 mm negatives are housed in polyethylene sleeves or in paper envelopes. Oversize negative sleeves have been replaced with archival papers sleeves that have side and bottom seams. The oversize negatives, also known as sheet film, are housed in Hollinger Storage boxes that have removable lids (Figure 1.4).

Figure 1.2: Hollinger Bully Box

Figure 1.3: Overcrowded Box/Kraft Sleeves

Figure 1.4: Oversize Hollinger Box/Archival Paper Sleeves

Colour paper is utilized throughout the boxes as subject dividers and note cards. The dividers and note cards range in colour from blue to pink to green to yellow to white (Figure 1.5). These dividers and cards inform the viewer of subject change as well as notification of the removal of a negative and its newly assigned location. Cream coloured paper is utilized to fill empty spaces in negative boxes (Figure 1.6). This fonds is organized alphabetically by subject matter, therefore there is no separation of negative types. Thus various types of negatives can be found within a given box.

Figure 1.5: Paper Dividers/Note Cards

Figure 1.6: Paper Box Filler

1.6 Storage Inconsistency

The boxes that house colour negatives are labelled appropriately, informing the user that the negatives found within the box are colour negatives. Unfortunately, these boxes also house black and white negatives, which causes storage inconsistency. During examination, one box labelled 'Colour Negatives' housed only black and white negatives. It is important for all boxes to be labelled appropriately and ensure that the contents of the box match the label affixed.

1.7 Biological Decay

Biological decay, caused by living organisms including mould, insects, rodents and bacteria, can be detrimental to the artifacts. Biological decay is largely dependent on environmental conditions, thus appropriate temperature and relative humidity is advised. To date, data is not available to predict pest infestations [4]. After thorough examination of the negatives in the Toronto Telegram fonds, there appears to be no sign of biological decay.

1.8 Current Environmental Conditions

Environmental conditions within a storage facility are one of the central factors in sustaining longevity of negatives. The Toronto Telegram fonds recently moved into a new storage room that is climate controlled with little to no fluctuation in temperature or relative humidity. Final readings from two specific areas in the previous storage room, the front door and the hose wall, dated in April of 2006 are as follows. A temperature of approximately 24° Celsius and a relative humidity fluctuating between 37% and 42% at the front door and a temperature reading of approximately 23° Celsius with a relative humidity fluctuating from 36% to 43% at the hose wall. The new storage room environment provides a consistent temperature of 23.2° Celsius and a relative humidity of 42% in all areas of the room.

Both the current and previous storage rooms maintain a lower temperature and a lower relative humidity as compared to exterior areas. However, the overall environment is still too warm for the negatives in this fonds. The negatives are stored in the same environment as the Toronto Telegram photographs, written documents, books, paintings and other forms of ephemera. The previous storage environment at York University's Clara Thomas Archives and Special Collections in which the Toronto Telegram fonds was housed for a considerable number of years, was a warm environment that produced a high level of relative humidity. High relative humidity is a breeding ground for bacteria, insects and can also stimulate chemical reactions. Improper temperature is also one of the major causes of negative degradation thus increasing the rate of deterioration. All of these environmental factors advance the rate of deterioration of the negatives and in some cases, left some negatives damaged and disfigured. In most of these cases, these changes are irreversible.

1.9 Note on the Organization of this Paper

There are various ways that the material in this thesis paper could have been structured. One option would have been to have a chapter outlining the history and composition of all the various negative types found within this fonds, followed by chapters discussing the deterioration issues and recommendations across negative types. Since many of the deterioration issues of the negatives in the fonds are common across negative types, this approach would have been reasonable. Instead, my thesis paper is organized into chapters based on negative types. Each chapter is devoted to a detailed description and issues relating to specific negative types (i.e., history, composition, deterioration issues and recommendations). The justification for this is that the end users of the document will be the archival staff working with the Toronto Telegram fonds and others who have an interest in preservation/deterioration issues relating to negatives. I felt the document would be more useful to the end user if it were organized in a "one-stop shopping" format, where all information relevant to a particular negative type could be found in a single chapter.

2 Glass Plate Negatives

This chapter investigates the history, current condition, chemical and mechanical deterioration of the Telegram glass plate negatives based upon examination.

2.1 History: Glass Plate Negatives

The wet plate collodion process was introduced in circa 1850. Gelatin dry plate glass negatives replaced collodion in the late 1870s and, by the mid 1880s, gelatin glass plate negatives were widely employed by professional and amateur photographers [1]. The dry plate process was widely utilized until the mid 1920s [5].

The introduction of the dry plate allowed for the production of high quality negatives with a vast tonal range of sharp blacks, grays and clear tones. "Gelatin changed all aspects of photographic technology and quickly became the dominant medium after the introduction of the dry plate process" [3].

The glass plate negatives in the Toronto Telegram fonds are gelatin dry plates dating from approximately 1936/1937. It is interesting to note that glass plate negatives were not a popular means of capturing an image by the mid-1930s. One theory that may explain the Toronto Telegram's late utilization of glass plate negatives is related to the long shelf life of this type of negative. It can be hypothesized that prior to the demise of gelatin glass plates, the Toronto Telegram purchased these negatives in bulk and utilized all that were purchased.

2.2 Types of Deterioration

Glass plate negatives exhibit specific types of deterioration. Glass plates were coated with a light sensitive gelatin emulsion, which eliminated the more technically challenging preparations of wet collodion. Dry plate negatives were factory made, "came in a box, and could be stored for months either before or after exposure with little loss of image quality" [5]. Glass negatives become quite brittle with age and the smooth glass surface allows the material carrying the photographic image to separate. Glass plate negatives occupy a substantial amount of space in storage, are quite fragile and have a tendency to break [6]. Unsuitable temperature and relative humidity play a significant role in preservation issues and concerns in the decay of glass plate negatives. Silver image degradation, glass stability decay, image layer separation and the production of mould are considerably affected by environmental conditions [4]. The glass plate negatives in this fonds were examined for physical changes and chemical events.

The longevity of glass plate negatives is in direct correlation to the stability of their component materials, method of production, chemical processing and storage environment. Harmful enclosures such as office envelopes, coloured mat boards, metals and poor quality plastics as well as inappropriate handling play a significant role in the longevity and preservation of the glass plate negatives [4].

Although glass can be seen as a delicate support, it is also considered to be quite stable. Glass deterioration is most commonly seen in early, dry plates. The early plates were prepared with chemically unstable soda and soda lime glass, which contained excess sodium or potassium oxides. Glass plates composed of these ingredients are "likely to dehydrate at low relative humidity and to leech out hydrated alkali ions at high relative humidity" [3]. The stability of glass plates improved and by the 1920s, the addition of aluminium oxide to the glass formation resulted in a more chemically stable support. A limited number of the glass plate negatives in the Toronto Telegram fonds have the appearance of moist droplets on the gelatin surface of the glass. This chemical deterioration in the form of droplets is a direct result of the formation of a highly alkaline, hydrated gelatin emulsion layer [3].

Although there is no mould growth found within the glass plate negatives in this fonds, an environment of high relative humidity promotes the growth of mould within the gelatin layer of glass negatives. The formation of mould in the gelatin layer advances the solubilization of the binder and the destruction of the image [3].

The glass negatives in the Toronto Telegram fonds are suffering from moderate to severe levels of silver mirroring deterioration. This type of decay compromises the majority of the glass negatives in this fonds. Degradation of the emulsion in the form of silver mirroring, also known as sulphiding out, silvering out and oxidation, appears as a metallic sheen in high-density areas of the negative [7]. This silver image decay is a common type of degradation found in photographic artifacts. Silver mirroring is caused by the "oxidation of the silver particles which causes fading, discolouration and mirroring a bluish silver sheen on the surface of the binder resulting from exposures to high relative humidity" [3].

As previously noted, the structural support of glass plates is quite stable yet, through deterioration, weakening of adhesion between the glass support and the binder layer may occur. This results in lifting or flaking of the emulsion layer from the glass base. This is a common type of deterioration found in gelatin dry plates and is seen throughout the glass objects in the Toronto Telegram fonds. Lifting and flaking of the emulsion is influenced by the chemical and physical characteristics of the component materials, physical characteristics of the binder and the storage environment [3].

The storage environment greatly affects the structural stability of the glass artifacts. "The glass support is dimensionally stable in changing humidity, but the gelatin binder is not and will contract at low humidity" [4]. A low relative humidity causes shrinkage of the gelatin layer resulting in lifting, flaking and stress between the binder and glass resulting in layer separation. A high relative humidity promotes softening of the gelatin binder causing the adherence of the gelatin layer to surfaces in contact with the plate and the possible production of mould. When glass plates are exposed to drastic environmental changes, the gelatin layer can be found to shrink, lift and flake [3].

2.3 Current Condition: Glass Plate Negatives

On examination of the glass plate negatives in the Toronto Telegram fonds, visible signs of deterioration are noted. The deterioration includes moderate to severe silver mirroring, tarnishing of the image, lifting of emulsion, spotting, droplets, scratches, punctures/tears to emulsion, punctures to glass, finger prints, dirt, dust, cracks in the glass and broken glass (Figure 2.1). The above noted forms of deterioration are caused by physical changes and chemical events.

Figure 2.1: Example of Silver Mirroring

The glass plate negatives in this fonds demonstrate significant deterioration which can be attributed to a number of factors including the current housing, the storage environment and inappropriate handling. The glass supports themselves appear to be quite stable, however, in some instances the emulsion side displays severe degradation. No changes are noted when comparing negatives housed on the top shelf of the storage room to those stored on lower shelves. Notations and captions are present on the emulsion side of the negatives in this fonds. The negatives have been marked using graphite and white ink. The inscriptions provide information in reference to the location and subject matter of the negative captured. As well, descriptive caption slips, both handwritten and typed, can be found housed alongside the glass negatives. These notes provide a wealth of information about the subject, date, location, event and photographer. However, in many cases, these paper additives have also deteriorated and their close proximity to the negatives is a potential source of further deterioration.

2.3.1 Storage Arrangements of Glass Plate Negatives

As previously noted, the current storage arrangement of the glass plate negatives in the Toronto Telegram fonds includes original Kraft sleeves, archival sleeves, glassine sleeves and small, cardboard boxes with removable lids. The black and white glass plates range in size from 2 x 3 inches to 5 x 7 inches, with the majority being 4 x 6 inches in size. One to sixteen negatives can be found within each sleeve. The glass plate negatives are housed within the same boxes as various other types of negatives including cellulose acetate negatives and often share sleeves. The bulk of the glass negatives are housed in aged paper sleeves while the oversize glass plates are housed in archival paper sleeves. It is important to note that throughout the boxes of negatives, glass plate negatives are also found dispersed within small boxes and glassine sleeves.

The glass plate negatives are stored lengthwise and upright within the boxes utilizing neighbouring negatives for support. When the adjacent negatives are not glass plate, unnecessary pressure is placed upon the plastic based negatives.

The original Kraft sleeves used to house the negatives have side and bottom adhesive seams. These sleeves are made of paper appropriate for office use, but not for the storage of negatives. As well, these sleeves are not archival safe for the housing of glass plate negatives and are in direct contact with the negatives, causing staining and discolouration. As the paper sleeves continue to degrade and age, becoming quite brittle and discoloured, the direct contact between the paper sleeves and the negatives increases the chemical deterioration of the glass plates. Upon the removal of negatives from a sleeve for examination or observation, tearing of the paper sleeve occurs. The slightest touch to the paper sleeve results in tears and rips, which eliminates any support that has been provided. In addition, paper fragments from the sleeves can be found housed with the negatives and are commonly stuck between two or more negatives.

The oversize glass negatives are housed in archival paper sleeves that have a bottom and side edge adhesive seam. No deterioration of these archival sleeves is noted. At times, these sleeves house more than one negative resulting in direct physical damage to the glass plates. Rubbing of emulsions when in storage, or when removed for viewing, results in lifting and detachment of the gelatin emulsion layer as well as other punctures and scratches.

A varied number of glass negatives are housed within small boxes that are held together with a linen type string. Printed on the exterior of these boxes are the ingredients and instructions to make 'Developer for Eclipse Plates and Films' (Figure 2.2). These boxes are fabricated of thick cardboard that has deteriorated and discoloured with age. Fragments from these cardboard boxes have broken off from the housing and are dispersed between glass negatives. Up to sixteen negatives can be found piled one on top of another within each box (Figure 2.3). The over packing of boxes results in tension on the negatives, tearing, scratching and ripping of the gelatin emulsion and the possible puncturing and/or cracking of the glass.

Figure 2.2: Glass Plate Housing Example 1

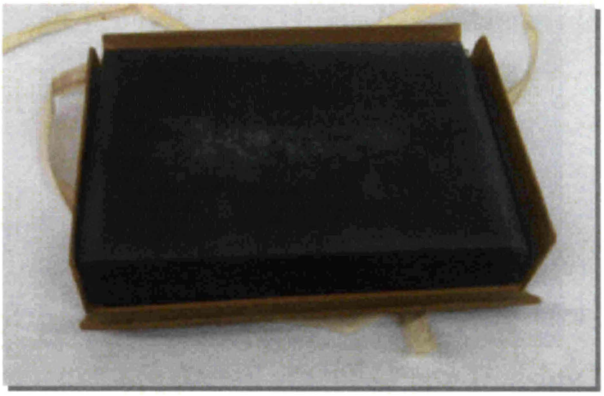


Figure 2.3: Glass Plate Housing Example 2

Glassine sleeves with side and bottom edge adhesive seams, although rare in the fonds, house glass plate negatives. Glassine is a glazed, semitransparent or transparent paper that is often acidic. Glassine is hydroscopic and can therefore adhere to a negative emulsion surface when stored in a high humidity environment [8]. The glassine sleeves have seriously discoloured along the edges and the seams and are quite brittle and hard to the touch (Figure 2.4). The deteriorated sleeves are in direct contact with the glass plate negatives, increasing chemical deterioration in contacted areas (Figure 2.5).

Figure 2.4: Glassine Sleeve

Figure 2.5: Detail of Glass Plate Housing

2.3.2 Crowded Housing

The glass plate negatives are stored upright and are tightly packed, restricting viewing access to the contents of the sleeve. These overstuffed sleeves pose a great concern for the quality of the negatives. The tight storage quarters result in direct tension and pressure on both the negatives and the protective sleeves. The overcrowding of the sleeves, with the resulting tears and rips, reduces the level of protection provided to the negatives (Figure 2.6). Crowding of the sleeves causes friction between the glass negatives and promotes physical damage including lifting and removal of the gelatin emulsion and chipping and cracking of the glass. In order to view one specific negative, all negatives in a given sleeve must be removed causing unnecessary handling of negatives and increasing the probability of physical damage. In high relative humidity, the gelatin may adhere to the surface of another glass plate negative and/or paper sleeve.

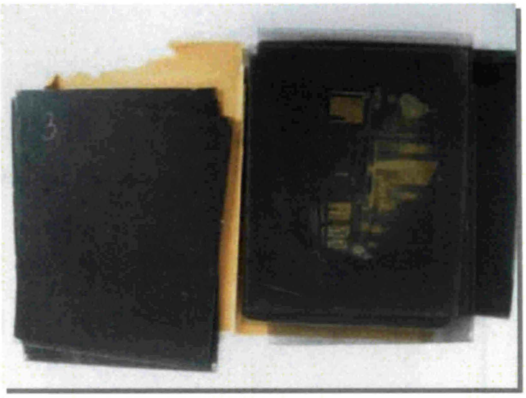


Figure 2.6: Damage Caused by an Overcrowded Sleeve

2.3.3 Broken Glass Plate Negatives

Chipped, cracked and broken glass negatives can be found throughout the fonds. Broken negatives, housed with either glass or plastic-base negatives, promote damage to the neighbouring negatives. Broken pieces of glass are found within the sleeves commonly wedged between two glass negatives. Glass fragments are hazardous to the integrity of the glass negatives they are in contact with (Figure 2.7). This storage arrangement results in physical damage to the glass negatives including scratches, lifting of the gelatin emulsion and punctures to the glass plates. Plastic-base films that are housed along side broken glass negatives incur similar damage. Glass shards also create a potential health risk for the user. When pieces of glass are found lodged between two or more glass negatives, the damage to the negatives is evident resulting in disfigurement of the emulsion base and support (Figure 2.8).

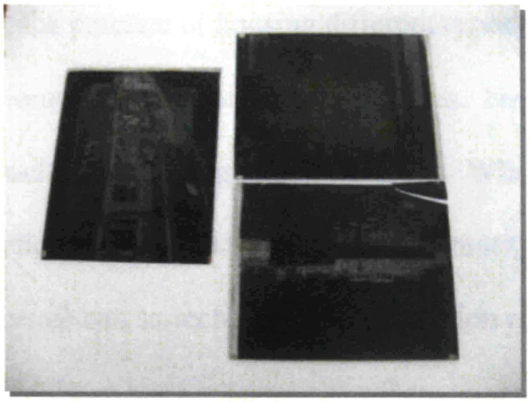


Figure 2.7: Example of Glass Fragment Found Wedged Between Negatives

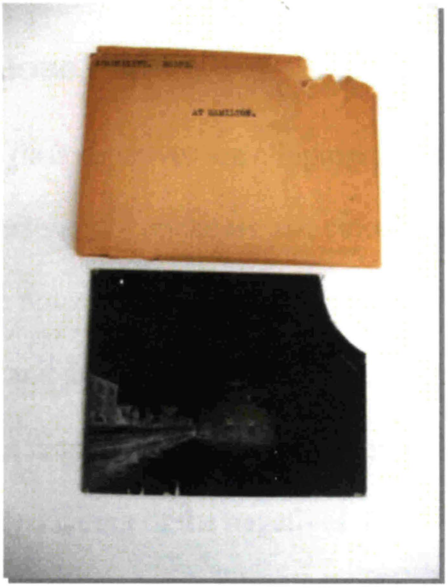


Figure 2.8: Example of Broken Negative and Deteriorated Sleeve

2.3.4 Mixing of Negatives

Glass negatives can be found throughout the fonds and commonly share housings and sleeves with other types of negatives including cellulose acetate. As each type of negative degrades in a unique form specific to its chemical makeup, various types of deterioration can be found housed with the glass negatives. When housed together, the simultaneous deterioration of different types of negatives can create a damaging microenvironment. Thus, the practice of housing different types of negatives together can cause increased deterioration to the glass plate negatives. Negatives are constructed from different materials each of which degrades differently. When sleeving negatives together, rubbing and physical interaction between the different types of negatives occurs and sharp corners from acetate can scratch the gelatin emulsion of the glass plate. As stated above, the gelatin emulsion has a tendency to adhere to other surfaces including various types of negatives.

2.3.5 Clippings and Loose Papers

Stored within the sleeves of glass negatives are clippings, loose papers, written notations and typed notes. These papers vary in thickness and colour but typically are discoloured and brittle due to age. These notes provide useful information about the subject matter, date, location, photographer and developing instructions. Unfortunately, these papers are either loosely placed between negatives and/or paper clipped to them. These notes are essential for a complete understanding of the negatives, however these papers also contain acids, which are in direct contact with the negatives causing permanent stains that will worsen over time.

2.3.6 Paper Clips

The use of paper clips presents another major concern for the glass plate negatives. Commonly utilized to hold notes and papers together, paper clips tarnish or rust with age. Rust can stain emulsions. In addition, these objects are sharp causing scratches, punctures and cracks to the glass plates and the lifting of the gelatin emulsion.

2.4 Recommendations

The following section discusses recommendations to decelerate the deterioration process of the glass plate negatives in the Toronto Telegram fonds.

2.4.1 Re-Housing

It is important to consider the interaction between negative storage and the surrounding environment. Appropriate housing of glass negatives is vital for their well being and longevity.

Appropriate paper sleeves are necessary to provide a level of protection to the negatives from the environment. The majority of the sleeves currently in use are the original paper sleeves in which the Toronto Telegram negatives arrived at the archives in the early 1970s. The use of improper sleeves can both stimulate and increase the rate of deterioration. The lignin, wood pulp, bleach and impurities commonly found in paper stock begin to off-gas in a closed microenvironment, leading to chemical damage of the negatives. Only in the oversize boxes have the original sleeves been replaced with buffered acid- and lignin-free sleeves without a thumb cut. These sleeves have a pH of 8.5 and have acid free bottom and side seams [1].

It is strongly recommended that all the sleeves be removed and replaced with four-flap buffered paper enclosures with a neutral pH of 7-8 [9]. Sulphur free and aluminium free paper that meets the American National Standards Institute (ANSI) standard, which includes the Photographic Activity Test (P.A.T.), should be utilized for re-housing [10]. The P.A.T. test ensures that the materials employed to house the negatives are free of any particles that could cause chemical reactions and/or damage to the photographic objects[10]. It is also important to avoid the use of neutralized pulp boards and papers, which decompose over long periods of time. As well, glassine, PVC, wood pulp derivatives, or coloured paper enclosures should not be utilized. Polythene should be avoided as an enclosure material for glass plate negatives as a tight seal or poor environmental conditions can create a damaging microenvironment of condensation and sweating [9].

To provide glass plate negatives with the highest level of protection, a four-flap paper enclosure is recommended. The negative is placed in the center of the enclosure and the pre-scored flaps are folded down over the glass object. This type of housing secures and encapsulates the photographic object in place without the need to use an adhesive. The enclosure is secured with a piece of linen string ensuring that the glass object is fully shielded and protected [9]. This enclosure design is quite advantageous as it eliminates the possibility of scratching the plate upon insertion or removal and avoids any hazardous adhesives that are commonly utilized in seamed sleeves [12]. This housing configuration provides maximum coverage and protection for these delicate photographic objects.

A four-flap paper enclosure is optimal for housing, but if a seamed sleeve must be used, the adhesives utilized in the fabrication of the paper should be taken into consideration. Many adhesives, including spirit-based glues, can migrate through the paper enclosure directly onto the emulsion of the negatives causing irreversible and severe damage and decay [9]. When utilizing a paper sleeve, one end always remains open thus exposing the glass negative to the microenvironment of the storage box. If seamed sleeves are the only option, it is important to ensure that the seam runs down the side of the enclosure on the glass side of the plate not on the gelatin side.

2.4.2 Storage

The recommended storage technique for the glass negatives in the Toronto Telegram fonds is to house the negatives in a manuscript box or a box outfitted with grooves for the plates to sit in. The boxes should be fabricated of strong plastics such as polypropylene, polyethylene, polystyrene or a baked enamel metal box could be employed. It is suggested that cardboard or wooden boxes be avoided [7]. Individual glass plates should be stored vertically on their longest side within each box [9]. Glass plate negatives should be grouped according to size, and each size stored separately. When varying sizes of glass negatives are stored together, negatives will not receive equal support resulting in unbalanced pressure and weight on the plates which may lead to breakage [8]. Each inch of glass negatives requires a piece of corrugated board to be inserted as interleaving, adding another layer of support to the plates [9].

Although the negatives do require protection from the outside world, it is also imperative that they have a level of protection from one another. Separate enclosures restrict interaction between neighbouring negatives. The individual housings also shield the negatives from scratches, punctures and cracks as well as dust and dirt from the environment [13]. Overcrowding of paper enclosures can result in tearing and ripping of the paper sleeve, thus limiting the level of protection for the artifact. It is highly recommended that all the glass negatives be re-housed into appropriate housings to ensure the appropriate amount of protection. Although re-housing and the purchasing of flour-flap enclosures can be quite costly, it is the best way to limit deterioration of these artifacts and to sustain them for the future.

2.4.3 Physical Damage: Handling

Physical damage to the glass plate negatives can be avoided with the use of proper storage and care. Further damage can be controlled and avoided through the use of appropriate handling methods. Improper handling of these photographic artifacts is a significant factor in their physical decline. Glass plate negatives are delicate objects that are at risk for damage each and every time they are handled. If suitable protocols and conditions are adhered to, physical deterioration should not present a significant problem for the glass negatives.

The present physical state of the negatives exhibits dirt, finger oils and scratches as a result of inappropriate handling. Prior to viewing the negatives, it is imperative that the viewing surface be clean, dry and flat. Gloves should always be worn when handling glass plate negatives thus, eliminating the possibility of finger oils being transferred onto the negatives. Non-vinyl plastic, latex or Nirtile gloves are recommended when handling glass negatives. Cotton gloves are not suitable as cotton has a tendency to be slippery which may result in accidental dropping of the plates. As well, cotton is a fibre that can be easily caught on the corner or edge of a glass plate and can cause the emulsion to flake off. A glass plate should be handled with both hands at opposite edges thus, providing the entire plate with support. It is vital to avoid holding a glass plate negative with one hand, especially at a corner or edge, as the pressure applied onto the negative can result in breakage [9].

It is very difficult to remove a glass plate from a paper sleeve. A user typically pulls the negative out of the sleeve by means of the thumb cut as a guide or simply pulls the negative from the sleeve. The pressure applied to the negative has the potential to cause cracking or breaking of the plate. A four-flap enclosure eliminates this kind of physical damage from occurring. If the enclosure is secured with linen string, the object appears to be precious and the handling of the object will be more delicate. The act of untying the string and opening up each flap needs to be completed on a flat surface, which reduces the potential of glass breakage.

When viewing the glass negative, the plate should be placed emulsion side up, avoiding any interaction of the emulsion and viewing surface. Pressure should not be applied to the glass plate when viewing, nor should one lean, press or write on the negative.

When viewing the negatives, stacking the plates should be avoided as this could lead to physical damage. It is imperative to work with only one negative at a time and to re-house negatives that are not being viewed [9]. Clearly labelled boxes with appropriate labels such as 'Fragile', 'Glass' and/or 'Heavy', helps to ensure that the box of negatives will be handled with care.

2.4.4 Broken Negatives

Broken glass plates negatives are a significant problem for the negatives in this fonds. All negatives in contact with broken plates are at a high risk of being severely damaged. It is recommended that all broken glass negatives be housed independently. Broken plates should be sandwiched between pieces of acid-sulphur-and lignin-free, buffered board. Once the negative is secured between the boards, it can be placed in a four-flap enclosure. All broken plates should be stored flat and the enclosure should be marked 'damaged'[9]. The separation of broken plates from intact plates will eliminate glass fragment damage. When storing a plate that has broken in two pieces, 4 ply, acid-free board that has been cut into three pieces corresponding to the size of the negative should be constructed. The mat support is prepared by tracing one of the two fragmented pieces onto the board. The negative is placed emulsion side up, eliminating any potential damage to the plate by scratching the emulsion. The outside edge of the fragmented piece of negative is then traced onto a second board and the board is cut to size. This results in two boards being created that match the shape of the broken piece of glass. The final step is the attachment of the cut board onto the full size board using wheat starch paste or double stick adhesive. The negative fragment should fit directly into the cut out area of the board. This creates a type of sink mat for the negative where the object sits level or just below the surface mat, providing support to the broken fragment. The same technique is followed for the second fragmented piece of glass, utilizing the pre-cut board [10].

2.4.5 Mixing of Negatives

As previously mentioned each type of negative degrades in a unique way. Housing glass negatives together with other negative types in the same boxes and sleeves can create a damaging microenvironment. The corners of polyester and acetate film are quite sharp and can scratch and puncture the emulsion on glass negatives. It is highly recommended that all glass negatives be separated from other types of negatives.

2.4.6 Clippings and Loose Papers

Currently many sleeves house glass negatives as well as corresponding notes and paper clippings. These informative papers can be temporarily housed with their paring negatives. However, it is essential to eliminate direct contact between the papers and the glass negatives. These loose papers are acidic and long-term housing with the negatives will create a damaging microenvironment. It is recommended that these paper additives be removed and housed separately from the negatives in Mylar sleeves. It is also important to note that, as stated above, coloured paper subject dividers and index cards are housed within the same boxes as the negatives. It is recommended that these papers be replaced with archival paper.

2.4.7 Paper Clips

All paper clips sharing sleeves with the glass negatives should be discarded as they cause permanent damage to the negatives. The removal of paper clips will aid in eliminating further physical damage to the negatives.

2.4.8 Environment

The temperature and relative humidity in which photographic objects are housed are determining factors for chemical reactions; in particular those leading to negative deterioration. Under poor environmental conditions, the emulsion will expand and contract resulting in cracking, lifting and blistering [14]. Appropriate environmental conditions are vital for sustaining the longevity of the negatives. The current storage room environment is climate controlled. The recommended temperature for storing glass plate negatives is 16° to 18° Celsius with minimal temperature fluctuation [4]. Currently, the temperature in the storage room is 23.2° Celsius. A cooler temperature is recommended to decelerate the rate of chemical reactions that result in glass plate negative degradation [15]. Relative humidity is intrinsically tied to the rise and fall of temperature. A fluctuation of no more than 3% relative humidity is acceptable [15]. It is ideally recommended that gelatin glass plate negatives be stored between 30% to 40% relative humidity [16]. With temperature change, the relative humidity will adjust and compensate for the moisture in the air, thus a constant relative humidity is imperative. Currently, the relative humidity is at 42%, which is slightly high for adequate permanence of the glass negatives. Lowering the current relative humidity is strongly recommended. If cold storage will be employed, the relative humidity must be maintained otherwise mould growth may occur [17].

2.4.9 Conservation Treatments

Silver mirroring and tarnishing of glass photographic objects are the most prevalent and obvious types of chemical deterioration found within the Toronto Telegram fonds. A conservator can complete restoration of the emulsion side of the glass plate. By immersing the glass negatives into a plate solution, the surface damage can be cleaned [6]. A trained photographic conservator should conduct this procedure, as glass plate negatives are quite fragile and delicate and the possibility of the emulsion separating and/or lifting from its base is a concern [6].

2.5 Summation

To ensure long-term preservation of the glass plate negatives in the Toronto Telegram fonds, the above mentioned preservation techniques should be adopted whenever possible given fiscal limitations. These negatives are of significant historical value on the municipal, provincial and federal levels; proper care will ensure that they remain a viable research resource for future generations.

3 Nitrate Negatives

This chapter investigates the nitrate negatives in the Toronto Telegram fonds. The history of nitrate negatives, current condition of the negatives and types of deterioration will be discussed. Additionally, this section outlines the chemical and mechanical deterioration discovered during examination.

3.1 History: Cellulose Nitrate Negatives

In August 1889, Eastman Kodak introduced the sale of the first flexible cellulose nitrate film; initiating the ultimate demise of the market for glass plate. The utilization of gelatin as a binder for nitrate film, when mixed with silver salts, resulted in the formation of a suitable photographic emulsion [3]. However, as a film support, cellulose nitrate is a hazardous material as it has a tendency to curl and becomes extremely flammable as it degrades.

In 1903, nitrate film was refined with the integration of a thicker nitrate base and the addition of a gelatin coating on both sides of the film [18]. The bottom layer of gelatin compensated "for the tension exerted by the binder layer and provided dimensional stability to the negatives. The bottom gelatin layer contained anti-halation dyes to prevent the exposure of the silver salts from the light bouncing off the back of the support" [18]. The gelatin coating also inhibits the curling of the film thus, suppressing a form of physical damage. A subbing layer of diluted nitro cellulose, which is a thin "transparent layer that adheres to the binder in the negative support" [3] was added to the nitrate film. “Cellulose nitrate film base is chemically similar to guncotton, but is not as highly nitrated” [6].

Nitrate film was available in various formats including x-ray film, 135 mm film, professional and commercial sheet film, aerial film, film packs, film rolls and motion picture film [3]. Despite the known dangers of nitrate film, nitrate sheet film continued to be widely utilized until the mid 1930s. While the dangers associated with nitrate film led to its eventual demise as a film support, it remained in limited use in various formats until the early 1950s [17].

3.2 Types of Deterioration

This section investigates the process of chemical deterioration common to nitrate film. Although the nitrate negatives identified within the Toronto Telegram fonds display no visible signs of deterioration, it is imperative to be aware of the degradation process that nitrate film follows and to take proper precautions when interacting with cellulose nitrate. Cellulose nitrate degradation is a chemical process that is an unavoidable consequence of the chemical composition of the film base itself, but is exacerbated by the conditions under which the film is stored.

“To make nitrate plastic, nitro (NO_2) groups are grafted onto the long molecular chains of native cellulose” [19]. The chemical deterioration process of cellulose nitrate can be quite slow, as long as the nitro ‘side groups’ stay intact. The ‘side groups’ become detached via the action of moisture in the air, acids and heat [19]. One problematic product of nitrate decay is the formation of the strongly oxidizing acid known as nitric acid. The presence of a pungent odour, sticky, brittle base and/or brownish yellow discolouration of the base are typical degradation characteristics for cellulose nitrate film. The life expectancy of nitrate negatives is in direct correlation to the stability of component materials, chemical processing and storage environment. Inferior enclosures and inappropriate handling play a vital role in the deterioration of nitrate negatives. Cellulose nitrate film is inherently unstable and large quantities of this film support can be quite hazardous. The degradation of cellulose nitrate film is irreversible and autocatalytic: as deterioration products form, they cause the deterioration rate to increase. Nitrate deterioration can be classified into five distinct stages :

1. The first stage of cellulose nitrate film decomposition includes the discolouration of the base. A yellowish colour is evident on the negative and transforms overtime into a dark brown tone. The presence of silver mirroring due to silver image oxidation is visible. The image is still legible.

2. The next stage in negative deterioration includes the formation of a sticky, tacky emulsion that adheres to adjacent sleeves as a result of humidity. A dry environment produces a brittle film base. At this point in the degradation process, a prominent odour of nitric acid is present but one can still decipher the image.

3. During the third phase of film breakdown, the base becomes increasingly fragile with the formation of gas bubbles. A strong, pungent scent of nitric acid and nitric oxide is noticed. These oxidizing agents released during deterioration of nitrate film are corrosive and attack other photographic artifacts including acetate base negatives and prints that are in close proximity to the degrading film. With the release of these gases

into the air, a damaging microenvironment is created that further hastens the rate of cellulose nitrate decomposition. Image fading is active with partial illegibility of the image. At this point, the photographic objects are endangered by the acid vapour and risk of fire. Duplication should be conducted before the image is lost.

4. The negatives become increasingly sticky and are at risk of adhering to one another, as well as to their paper sleeves during this stage of degradation. The separation of negatives becomes very difficult and image decay is complete with no image visibility. At this point, negatives present a high risk for the rest of the collection and should be removed or destroyed.

5. The fifth stage of cellulose nitrate negative decay includes the destruction of the plastic support and the gelatin binder. The negative deterioration is at the final stage and the negatives have transformed into a brownish, acidic powder [16].

3.3 Identification of Cellulose Nitrate Negatives

Nitrate negatives can be challenging to identify unless decomposition of the nitrate base has commenced. All negatives that were produced prior to 1950 are suspect, although they can also be acetate. Nitrate negatives can be identified through the date of production, edge printing, notch codes and three destructives tests. It is common for early nitrate film to be marked 'SAFETY FILM' which can mislead users; thus, appropriate identification tests may be in order [20]. When in doubt regarding the film base in question, it is advisable to take action as though the negatives are nitrate or contact a conservator or photo preservationist for appropriate identification.

Cellulose nitrate film produced between the 1930s and the 1950s often displayed the edge printing 'NITRATE', distinguishing nitrate from acetate film. Edge printing, unique to nitrate, aids in identifying this film type. Further, when the emulsion is facing the viewer, the upper right edge of the negative commonly displayed nitrate notch codes. Kodak utilized the notch code 'V' to identify its brand of the film.

Not all brands of film included notch codes on their negatives. Therefore, at times drastic measures may be required to identify the film base. In the Toronto Telegram Fonds a large percentage of the negatives do not display notch codes or edge printing. Three tests, the diphenylamine test, the flotation test and the flame test, can be conducted to differentiate nitrate film from other films supports.

A trained photographic conservator or photo preservationist should conduct the diphenylamine test as the solutions and products are hazardous [3]. This test provides an indication of the film base from a micro-sample utilizing a binocular magnifier. To conduct this test, one drop of 0.5% diphenylamine solution in sulphuric acid is placed onto a glass slide. Utilizing tweezers, a minute fragment (under one square millimetre) of the film base to be examined in placed onto the droplet. A positive reading of cellulose nitrate film produces the appearance of an intense blue colour on the glass slide [16]. The blue colour is a product of the reaction between nitrate and diphenylamine [3].

The flotation test, which is "based on density differences in polymers,"[16] is completed by placing a small sample of the negative base into a test tube of trichloroethylene solvent. If the film base is nitrate, the sample will sink to the bottom of the test tube. If the sample is cellulose acetate, the negative will stay near the top of the tube [3].

The final test conducted to differentiate cellulose nitrate is the burn/flame test. A small sample of the film base is burned. A negative made of cellulose nitrate will "produce a bright yellow flame that will consume the sample quickly" [3]. This test should be preformed away from any photographic objects due to risk of fire. The burn/flame test is not as reliable as the two previous experiments and is potentially hazardous therefore, it is not frequently conducted [16].

3.4 Current Condition: Cellulose Nitrate Negatives

During examination of the negatives, one nitrate negative was found. Based on the size of this fonds, only half of the negatives were examined and the possibly of identifying additional nitrate negatives is highly possible. In January 1983, project funding was granted at the Clara Thomas and Special Collections Archive to duplicate the nitrate negatives found within the fonds. This project, which duplicated the nitrate negatives onto safety film, was completed in March of 1983. The boxes that housed nitrate negatives were refilled with the new duplicate negatives in April of 1984. The original nitrate negatives were disposed of. The nitrate negatives found within the fonds were in fact a leading cause of the accelerating degradation of the photographic materials. This project eliminated the dangers caused by, and associated with, nitrate film. Following this reproduction project, few nitrate negatives remain within the fonds.

Upon examination of the nitrate negative in the Toronto Telegram fonds, fingerprints were found to be present on the negative due to poor handling techniques. No additional signs of deterioration were noted. The negative appeared to be in generally good condition.

3.4.1 Storage Arrangements of Nitrate Negatives

The current storage and housing of the 5x7 inch black and white nitrate negative found in the Toronto Telegram fonds is in an archival paper sleeve which has bottom- and side-edge adhesive seams. The original sleeve or housing has been replaced with this sleeve and no deterioration to the sleeve is noted. It may be that in the remaining, unexamined part of the fonds there are additional nitrates and that some of these may be stored in non-archival sleeves and/or with than one negative per sleeve resulting in direct physical damage to the negatives. When glass plate negatives are housed adjacent to nitrate based film, pressure is exerted on the negatives. When more than one negative shares a sleeve, this poses great concern for the quality of the negatives in the enclosure as discussed earlier. In order to view one specific negative, all negatives in a given sleeve must be removed causing unnecessary handling of the negatives and increasing the probability of physical damage. In high relative humidity, the nitrate emulsion becomes very sticky and can adhere to its paper sleeve and adjacent negatives.

3.4.2 Mixing of Negatives

The nitrate negative found within the Toronto Telegram fonds shares a housing and a sleeve with other types of negatives including glass plate and cellulose acetate negatives. As each type of negative degrades in a unique way specific to its chemical makeup, various types of deterioration can be found within each box. The act of housing different types of negatives together causes increased deterioration of nitrate and other negatives. When housed together, the simultaneous deterioration of different types of negatives can create a damaging microenvironment. This shared environment may cause physical interactions between negatives often resulting in further deterioration. As previously stated, degrading nitrate base negatives emit potent oxidizing agents into the air that are dangerous for photographic materials and human health. When decay occurs within a closed storage microenvironment, the damaging effects of these oxidizing agents are increased, thus hastening the deterioration of all negatives types present.

3.5 Recommendations

The following section discusses recommendations to decelerate the deterioration process of the cellulose nitrate negatives in the Toronto Telegram fonds. It further provides precautionary information to users of cellulose nitrate negatives which may be found to be suffering from advanced stages of deterioration.

3.5.1 Re-Housing

The housing of cellulose nitrate negatives is vital for their well being and longevity. It is important to consider the interaction between negative storage and the surrounding environment. Appropriate paper sleeves are necessary when providing a level of protection from the environment. All enclosures should pass the Photographic Activity Test as prescribed by the American National Standards Institute, which provides standards on enclosure formats for photographic materials. Buffered envelopes are suggested to house photographic objects as "buffered paper has an alkaline reserve or buffering agent that is added during production to alter the pH. Buffering protects the museum object against migrating acids. Calcium carbonate and magnesium carbonate are common buffering agents" [21]. Nitrate negatives should be re-housed into either flour-flap envelopes or L-weld sleeves that meet photographic archival standards.

L-weld sleeves refer to the adhesive seams that run the length of adjacent sides of the sleeve [21]. Paper envelopes with thumb cuts should be avoided as the user has the tendency to press directly onto the negatives and pull the negative out the sleeve causing further physical damage.

3.5.2 Storage

Adequate storage of the nitrate negatives in the Toronto Telegram fonds is vital to provide a secondary level of protection for the negatives from the environment and to provide protection for other photographic artifacts from the nitrate negatives. The negatives should be housed snugly, but not tightly, into appropriate boxes. Excess room enables the negatives to shift, thus adding unnecessary pressure to neighbouring negatives. "The boxes should have reinforced seams, be acid-free with a high alpha-cellulose content, and meet ANSI Standard" [17]. The boxes should have firm fitting lids, similar to a clam shell box. Nitrate negatives can also be stored in ventilated metal boxes and stored away from other photographic objects [6].

3.5.3 Physical Damage: Handling

Physical damage to the negatives can be avoided with the use of proper storage and care. Further damage can be controlled and avoided through the use of appropriate storage and proper handling methods. If the conditions described below are adhered to, physical deterioration should not present a significant problem for the cellulose nitrate negatives. Improper handling of these photographic artifacts is a governing cause of their physical decline. Cellulose nitrate negatives are delicate objects that are at risk for damage each time they are handled.

When working with nitrates, it is imperative, even at a stage of no deterioration, that the user be aware of the dangers involved when working with the materials. Therefore, when handling or viewing the negatives, written documentation of any problems within the workspace, odours, discomfort or ill feelings should be recorded. Prior to viewing the negatives, it is imperative that the viewing surface be clean, dry and flat.

The present physical state of the nitrate negative exhibits finger oils as a result of inappropriate handling. The employment of gloves eliminates the possibility of acidic finger oils being transferred directly onto the negatives, thus reducing physical damage. Gloves should be worn at all times when interacting with cellulose nitrate negatives to eliminate direct contact with the negatives. Impervious glove materials such as rubber or neoprene are recommended. If the negatives are at an advanced stage of deterioration, a smock, safety glasses and respirator mask for protection are advised [21].

Due to the delicate nature of cellulose nitrate negatives, the film should be handled along the edges making sure not to touch the image. Only one negative should be handled at a time and negatives not being viewed should be re-housed. When removing a negative from its enclosure, it is vital not to press directly onto the negative and pull the negative out. The negatives should always be placed emulsion side up, thus avoiding interaction of the emulsion with the viewing surface. When viewing the negatives, pressure should not be applied to the negative nor should one lean, press or write on top of the negative.

3.5.4 Mixing of Negatives

It is imperative that all negative types be housed separately from one another as various forms of degradation creates an especially detrimental microenvironment which, in turn accelerates the rate of negative deterioration. The separation of nitrate negatives is crucial for the longevity of the nitrate negatives themselves and the life span of other negative formats. The fact that cellulose nitrate emits oxidizing agents as it degrades, and that these attack other photographic materials, is another reason why isolation of nitrates is essential [22].

3.5.5 Environment

The life span of nitrate-based films is largely dependent upon their environment. High temperatures and relative humidity accelerate the deterioration process of cellulose nitrate film. Unsuitable temperature, combined with a high relative humidity and poor ventilation creates an especially undesirable environment for the preservation of the film [6]. The current storage room environment is climate controlled with a temperature of 23.2° Celsius and 42% relative humidity.

The temperature in the storage area for cellulose nitrate negatives is an essential component in decelerating the rate of deterioration of the negatives. The film begins to decompose in temperatures as low as 38° Celsius, which in turn results in off gassing large quantities of poisonous gasses [23]. A cold storage environment is ideal for the preservation of cellulose nitrate film. A dark, cold storage vault or a frost-free freezer at less then 2 ° Celsius is recommended for long-term storage of the cellulose nitrate negatives. If cold storage options are not available, a cool environment must be employed otherwise degradation of the film will proceed. The temperature in the storage room should not exceed 21° Celsius.

The appropriate relative humidity in a storage environment is also critical to the life span of nitrate negatives. As stated above, a cold storage facility is ideal for the long-term storage of cellulose nitrate negatives. If cold storage is not a viable option, a storage room that is well ventilated is significant as ventilation aids in preventing the build up of acidic gases that accelerate the autocatalytic deterioration of cellulose nitrate film. The room should be as dry as possible, with a relative humidity between 20% to 30% and minimal fluctuation [17].

3.5.6 Duplication and Destruction

Although one cellulose nitrate negative was found within the Toronto Telegram fonds, and this negative was not suffering from advanced stages of deterioration, it is important to be aware of the degradation process and the steps required when duplicating negatives and preparing them for destruction. Negatives displaying minimal to moderate signs of deterioration are ideal candidates for duplication. Negatives exhibiting extreme deterioration cannot be duplicated as they are disfigured and image visibility is lost. Camera duplication is the most cost effective form of duplication, but the option to hire a professional is always recommended depending on the level of negative decay. All camera duplications should be made onto polyester-based film. All duplicated negatives should be cut to an appropriate size and housed in buffered envelopes [17].

Destruction of the cellulose nitrate negatives is a reasonable option for negatives that have reached the third stage of deterioration. At this point, the film is rapidly decomposing. Once it is determined that the film is to be destroyed, it is classified as hazardous waste and a trained professional should be called in to advise staff of the appropriate disposal processes [24].

3.6 Summation

The chemical degradation process of cellulose nitrate film results in an extremely hazardous material as, under poor environmental conditions, the film can self ignite. The demise of nitrate film base accelerates the deterioration process of other photographic materials in close proximity. It is imperative that individuals working with cellulose nitrate be aware of the dangers involved with this film base. Although the project completed in the 1980's with the Telegram fonds reduced the hazards of deteriorating cellulose nitrate, it is still highly recommended that all boxes of negatives be thoroughly examined for any remaining nitrate negatives.

4 Cellulose Acetate

This chapter investigates the decline of the cellulose acetate negatives in the Telegram fonds. The history of this film base type, current condition, causes of deterioration as well as approaches to decelerate damage will be examined.

4.1 History: Cellulose Acetate Negatives

The instability of cellulose nitrate film, lead to the introduction of cellulose acetate film as early as 1897. At the time of the film base's inception, cellulose acetate based films were known as 'safety film' as they could not self-ignite [25].

Cellulose acetate films include diacetate, acetate butyrate, acetate propionate and cellulose triacetate. Cellulose triacetate has been the most popular of the acetate bases from 1949 until the present [25]. The first publicly sold safety film was cellulose diacetate, which was marketed in the early 1920s in conjunction with a rise in popularity of 16mm home films. From 1925 to 1950, research was conducted on film supports producing "cellulose acetate that would replace cellulose nitrate but also duplicate its good mechanical qualities and its resistance to moisture" [3].

Cellulose "triacetate is a polymer manufactured from a chemical reaction involving cellulose and acetic acid, just as nitrate film is made from cellulose and nitric acid" [26]. A cellulose polymer is a long, continuous molecular chain ranging from 500 to 2000 repeating cellulose units. The hydroxyl (OH) groups, which are part of the cellulose polymer, can be altered to give a polymer substituted with acetate (CH_3CO) or nitrate.

The type and number of such substitutions determine the mechanical and optical properties of the final polymer as well as its chemical stability [25].

Cellulose film is constructed of four layers and, as with cellulose nitrate, gelatin is utilized as a binding layer. The "gelatin emulsifies the silver salts that, after exposure and processing, form the silver particles" [3]. The top layer is the gelatin emulsion, followed by the subbing cellulose nitrate, the support layer of cellulose acetate film and the bottom anti-curl layer of gelatin, which provides dimensional stability to the film. The subbing layer in cellulose acetate film is "diluted cellulose nitrate ... used...to improve the adhesion between the binder and the cellulose acetate support" [3].

Kodak introduced colour cellulose acetate negatives in 1942. "Colour photography is referred to as a silver-based sensitive system even though after processing there is no silver left in the film. Cyan, magenta and yellow dyes are formed during the development of the negatives in three distinct layers in the emulsion" [3]. The dye colours in these film supports are not truly permanent, thus the film suffers both from instability of the base and dye fading [3].

Although safety film is not at risk of self-ignition, the film base itself is unstable and disfiguring deterioration does occur [3]. This deterioration is predominantly due to a process called 'vinegar syndrome'. "Vinegar syndrome, is autocatalytic and moisture and temperature dependent" [3]. The Eastman Kodak Company was the first to report problems with cellulose triacetate film degradation. It was at this point, that Kodak began to research the stability and permanence of cellulose film at various storage temperatures. By the 1980s, it was reported that after approximately thirty years of storage most triacetate films displayed symptoms of vinegar syndrome [16]. Based on examination of two hundred and fifty boxes of negatives, approximately 90% of the negatives in the Toronto Telegram fonds are cellulose acetate. Vinegar Syndrome is therefore a potentially serious problem.

4.2 Causes of Cellulose Acetate Deterioration

Vinegar syndrome is an autocatalytic chemical reaction and “once the degradation begins it starts to feed upon itself and the deterioration process begins to snowball” [27]. It is initiated by trace amounts of acids. One of the products of vinegar syndrome is acetic acid. As the reaction proceeds, it generates the initiating condition (i.e., acidity) for further reaction. Since it is volatile, the acetic acid that is generated as a result of the reaction of the film is released into the atmosphere resulting in film degradation at sites remote from the initial location of damage. This degradation causes irreparable damage to cellulose acetate film. It has been noted that cellulose acetate film has an acidity threshold, and once the threshold is reached, it is not possible to stop or reverse the process, only to decelerate it [16].

A significant cause of cellulose acetate degradation is the so-called hydrolysis reaction, which involves chemical removal of the acetate groups via the action of water. Once hydrolysis has begun, one important factor that determines the course of deterioration for each film type is the type of side groups that are present. The “side groups in all cellulosic plastics are acids after they have been hydrolyzed from the cellulose backbone” [19]. In this case, the acids take the role of a catalyst and an increase in hydrolysis results in an increased released of acid [25]. Thus, the chemical deterioration in cellulose acetate film can be influenced by improper temperature, relative humidity and inappropriate enclosures.

The longevity of cellulose acetate negatives correlates directly to the stability of the component materials, method of production, chemical processing and storage environment. Based on A-D Strip tests results, a high percentage of the cellulose acetate negatives in the Toronto Telegram fonds are suffering from moderate to severe levels of vinegar syndrome. This type of decay compromises the other negatives within the fonds. Inappropriate enclosures such as office envelopes, coloured mat boards, metals and poor quality plastics, as well as inappropriate handling, play a significant role in the longevity and preservation of the cellulose acetate negatives [25]. The cellulose acetate negatives in this fonds were examined for physical changes and chemical events as part of this case study.

4.3 Effects of Cellulose Acetate Deterioration

Vinegar syndrome is easily detectable and recognizable as the degradation process is specific to the cellulose acetate type film base. The symptoms of this syndrome are not only olfactory, but also visual and may include extreme deformities to the cellulose acetate film base. The indications of vinegar syndrome consist of a pungent vinegar odour, embrittlement and shrinkage of the base, crystallization and bubble formation on the film emulsion and the appearance of pink or blue spotting. All the above stated forms of physical and chemical degradation are evidenced within the negatives in the Telegram fonds.

The pungent vinegar odour, which is the "most obvious symptom of acetate base deterioration…is a warning that chemical deterioration is progressing in the acetate film base" [19]. This vinegar odour is a result of the acetic acid produced by hydrolysis evaporating into the air. During this warning period, the chemical and physical makeup of the film has begun to change and the "acetyl side groups split off" [19].

As cellulose acetate film degrades, physical deformities become visible. Embrittlement of the plastic base occurs. Acetate film in its normal state is strong, tough and flexible. Once deterioration has begun, the film becomes weak and "easily shatters with the slightest flexing" [19]. This physical transformation is due to changes in the chemical structure of cellulose acetate, which is normally comprised of long chains of repeating polymer units. "When acetic acid is liberated as the acetyl side groups come off, the acid environment helps to break the links between cellulose units, shortening the polymer chains causing brittleness" [19].

Shrinkage of the film base is another form of physical change and deterioration that occurs during the decomposition of cellulose acetate films. Shrinkage occurs as the polymer chemical chains begin to break apart into smaller pieces as the side groups break off. This shrinkage is also in part due to the indirect result of hydrolysis or release of water. When severe shrinkage takes place, the film base buckles away from the emulsion. In the case of motion picture film, shrinkage of greater than 1% is significant enough to cause damage to the film. With acceleration in negative deterioration, the shrinkage of the film can be as high as 10%, which results in irreversible physical damage to the film. In extreme cases of film shrinkage, the acetate film base shrinks while the gelatin emulsion remains uniform. This is a result of the "bond between the emulsion and base letting go in some areas, thus relieving the stress caused by shrinkage" [19]. In severely degraded cases, buckled emulsion "actually tears as it buckles" [19]. This is referred to as channelling.

The visible appearance and presence of crystalline deposits, as well as liquid filled bubbles on the emulsion of the film, is another outcome in the degradation of cellulose acetate film. "This is evidence of *plasticizers*, additives to the plastic base, becoming incompatible and oozing out on the surface" [19]. The presence of these bubbles can occur on either the base or the emulsion side of the negative. Plasticizers can be located throughout the plastic support and are chemicals that are integrated into the cellulose acetate during fabrication. Approximately 12% to 15% of the weight of the acetate negative is composed of plasticizers [19]. The integration of plasticizers had two main purposes; the primary one was to "slow down the rate of burning of the film, should it ever catch on fire" [19]. The secondary purpose of incorporating plasticizers into the body of cellulose base films was to "reduce the dimensional instability of film due to solvent loss or humidity change" [19]. Cellulose based films are known to alter in shape when exposed to various temperature and relative humidity conditions. Thus, under dry temperature conditions the film will shrink in size, while exposure to a damper environment will cause expansion in size. Plasticizers can limit such changes.

The need for plasticizers is vital in minimizing changes and maintaining the stability of the film [19]. As acceleration of deterioration occurs in acetate film, "the capacity of the base to retain the plasticizer is reduced, and the plasticizer exudes out of the base and crystallizes on the surface" [19]. This crystallization can emerge in a needle like shape, which has the unique ability to melt away under a mild temperature and reappear in a cooler environment. When extreme degradation has taken place, the plasticizers commonly flow in a liquid form that causes the appearance of bubbles under the emulsion layer in the centre of the film [19].

During the stages of deterioration of cellulose acetate film (see section 4.5), it is common for pink and blue colours to appear on the film. This is caused by dyes that have been incorporated into the gelatin layer of the film base. Also known as antihalation dyes, these substances were included in the emulsion to aid in the prevention of halos in the final images. During film manufacturing and processing, it was thought that these dyes were in fact colourless. However, it was later determined that in cellulose acetate film deterioration, acetic acid formed in the film caused these dyes to revert back to their original hues of pink or blue [19].

The cellulose acetate negatives in the Toronto Telegram fonds are suffering from moderate to severe levels of vinegar syndrome deterioration. This type of decay compromises the majority of the cellulose acetate negatives in this fonds as vinegar syndrome is contagious. The acidic acid emitted during deterioration also results in softening of the gelatin layer and accelerating the rate of fading of colour dyes in colour film [19].

4.4 Identification of Cellulose Acetate Negatives

Cellulose acetate negatives can be challenging to identify unless decomposition has taken place. As vinegar syndrome is unique to cellulose acetate, once severe disfigurement or release of acetic acid has begun, the base is easily identifiable. Cellulose acetate negatives can also be identified through edge printing, notch codes and two destructive tests.

The edge printing for cellulose acetate negatives typically displays the word 'SAFETY' or 'SAFETY FILM' along the edge of the negative, depending on its manufacturing location. The presence of symbols such as '°' are typically seen between letters of the word safety, for example edge printing such as 'S°AFETY' represented cellulose acetate film manufactured by Kodak in the United States [3].

Notch codes are cuts along the edge of the negative, which aid in the identification of film types as well as the emulsion side of the negative when working in the dark. Manufacturers often have their own type of notch code thus, making their brand of film recognizable. Between 1925 and 1949, Kodak cellulose acetate negatives could be identified by their U-shaped notched code [3].

It was also common for safety film to be produced without edge printing or notch codes. As mentioned in the previous chapter on nitrate negatives, the flotation and the burn tests can be performed if the identify of the film base is in question. When performing the floatation test, the film clipping will remain close to the surface of the test tube if it is acetate. When conducting the burn test "acetate may ignite, but very slowly in comparison to nitrate, and it will burn without a flame" [3].

4.5 Stages of Cellulose Acetate Film Deterioration: Acid Detecting Strip Testing

As stated above, the breakdown of cellulose acetate film is not only disfiguring to the film base but also creates a damaging microenvironment. Acid Detecting Strips (A-D) measures free acidity representing the total amount of acid present in the film base. Testing the free acidity is the most reliable source for measuring acetate film degradation [19]. The utilization of A-D Strip testing allows the user/institution the opportunity to test their collection and determine the level of deterioration of their acetate negatives. (Figure 4.1) This makes it possible for the user to make informed decisions regarding the most appropriate measures for stabilizing the process of deterioration.

Figure 4.1: A-D Strips

The stages of cellulose acetate film deterioration can be measured in 0.5 intervals using the A-D Strip test findings (Figure 4.2). These calculated findings represent the level of deterioration via vinegar syndrome, and acidity level, that can be found within each box of negatives. The 0.5 intervals of deterioration begin at 0 and end at 3, describing a maximum of seven stages of deterioration (Figure 4.3). As is demonstrated in Table 4.1 [19] each 0.5 interval represents an increase in the level of deterioration and acidity of the negatives.

Table 4.1: Stages of Vinegar Syndrome

Acidity Level	Negative Condition
0	Good: no deterioration
0.5	Good: slight deterioration beginning
1	Fair to Good: deterioration beginning
1.5	Rapid Degrading Starting: point of autocatalytic decay
2	Poor: actively degrading
2.5	Poor/Critical: extreme degradation
3	Critical: extreme shrinkage & warping; possible handling hazard, illegible image

Figure 4.2: A-D Strips Prior to Testing

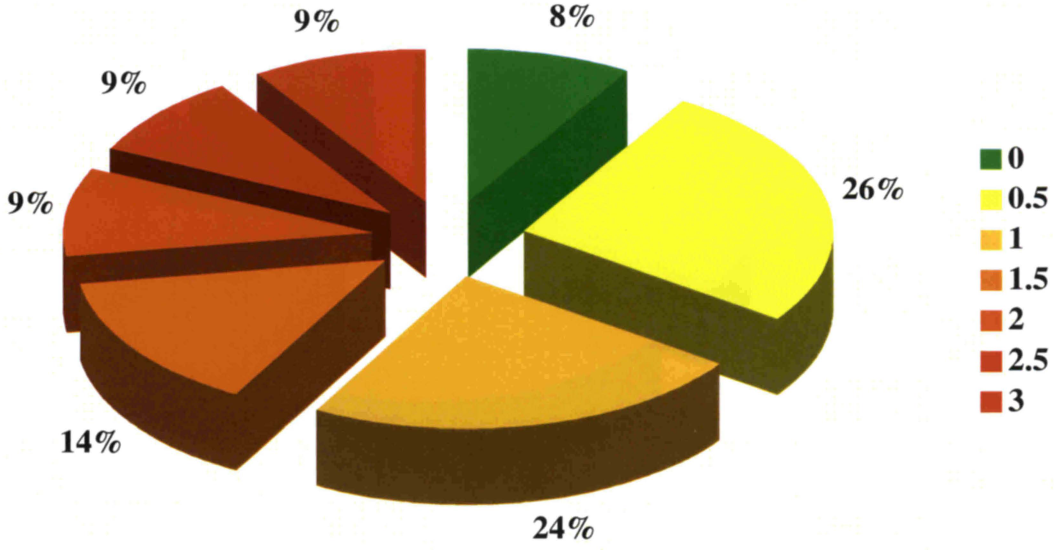
Figure 4.3: A-D Strip Colour Change Following Testing

4.6 A-D Strip Findings

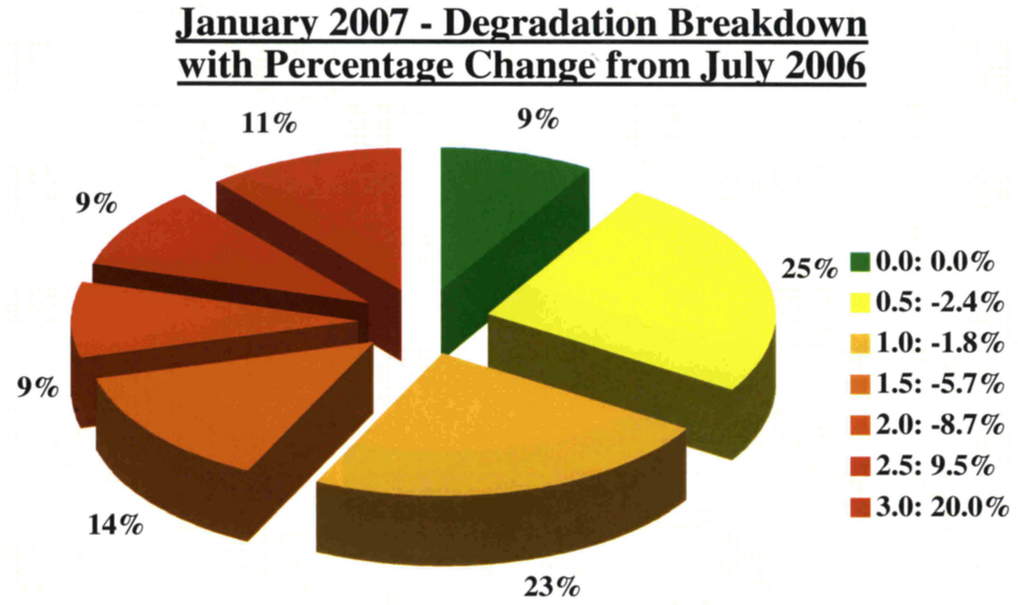
Three A-D Strip tests were carried out on the Telegram fonds' negatives over the course of 12 months: test 1 at 0 months, test 2 at 6 months and test 3 at 12 months. Test results have been tabulated and provide useful information on the condition of the negatives in the Toronto Telegram fonds and their levels of deterioration. These findings are a useful, comparative analytic tool to determine the condition of the acetate negatives in this fonds. After the first set of A-D Strip tests were completed, each box examined was colour coded according to its level of deterioration. This informs the user of the level of degradation to expect when working with a specific box.

The following charts display the results from each set of A-D Strip tests, providing a visual overview of the level of degradation found within this fonds. The legends in the graphs indicate the percentage change of degradation from one set of tests to the next. Results from each of the A-D Strip tests have been tabulated. The increase in the overall level of degradation is evidenced over a 12 month period, where 44% of the negatives are at a "point of no return" (which is defined as having reached the autocatalytic point or stage 1.5; please refer to graph 4.4). Once the negatives reach this state, it is imperative that appropriate preservation strategies be employed to decelerate deterioration. What is noteworthy is the significant rate of change in the negatives at stages 2.5 and 3 level of deterioration. From the first to third test, an interval of 12 months, an increase of 31.1% deterioration is observed at the level 3 stage of deterioration, which is a considerable increase. Ultimately all the negatives within this fonds will eventually reach this point of degradation unless proper measures are taken. Although it is true that more then 50% of the acetate negatives are suffering from minimal degradation, once the autocatalytic point (stage 1.5) is reached the rate of deterioration increases and can be detrimental to the condition of these negatives. The increasing extent of deterioration can be observed by the fact that the only positive percentage change over the course of 12 months is in the 2.5 and 3 stages of deterioration. This positive change actually reflects advancing deterioration to the point where extreme disfigurement occurs. Also note the size of the percentage changes shows two different modes with the changes in levels 0.5, 1, 1.5, and 2 all being negative and less than 16%, while the levels 2.5 and 3 changes are positive and in the 30% range. Please refer to the following charts for further understanding of the degradation breakdown.

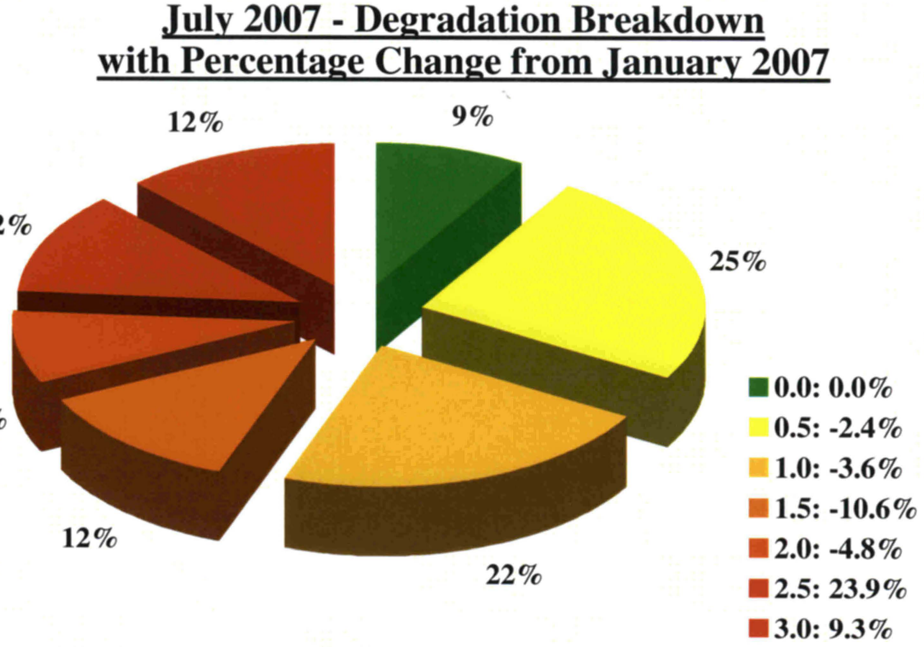
July 2006 - Degradation Breakdown



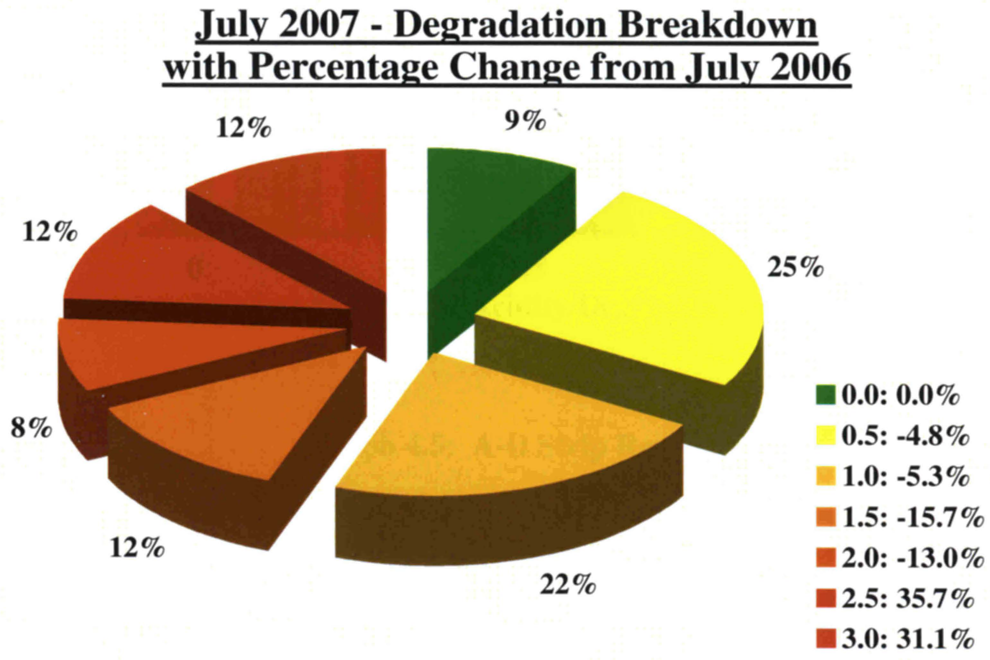
Graph 4.1: Degradation Breakdown July 2006



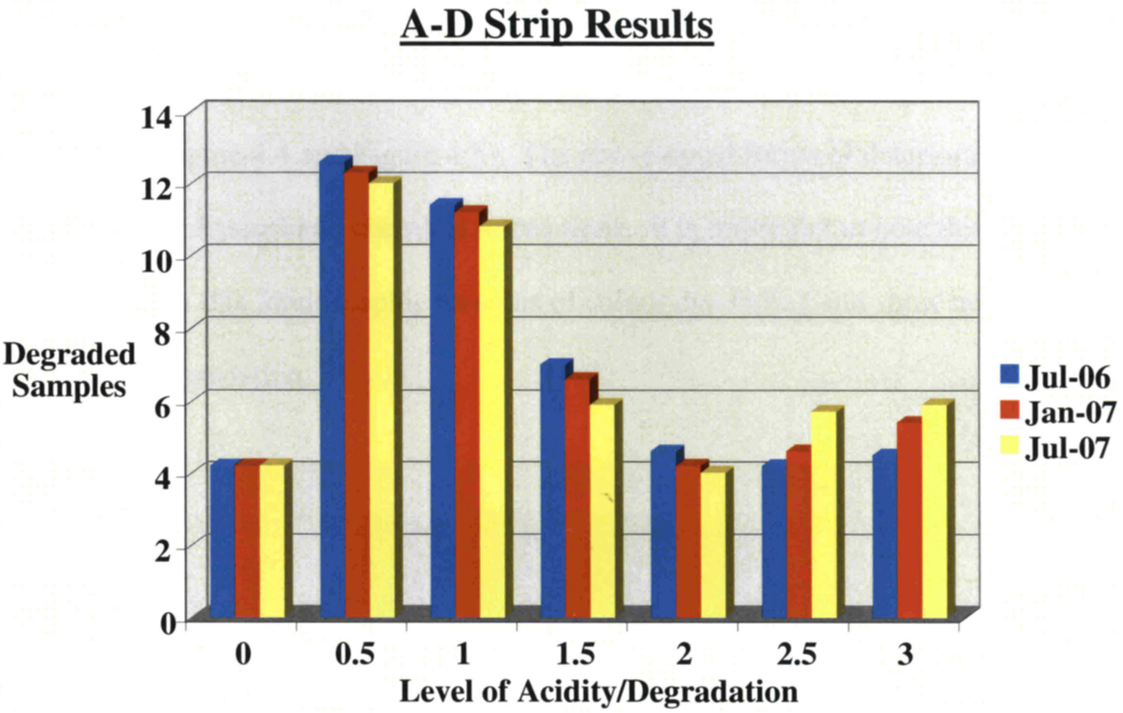
Graph 4.2: Degradation Breakdown January 2007 Percentage Change from July 2006



Graph 4.3: Degradation Breakdown July 2007 Percentage Changes From January 2007



Graph 4.4: Degradation Breakdown from July 2007 Percentage Change from July 2006



Graph 4.5: A-D Strip Results

Graph 4.5 illustrates the combined A-D Strip test results from July 2006 to July 2007. As depicted in this graph, a high percentage of negatives are not in a critical stage of degradation. It is important to note that within this graph there are an increased number of negatives from all three tests that are suffering from advanced critical stages of deterioration. This is illustrated with the increased number of degraded samples from the July 2006 tests as compared to the July 2007 tests.

4.7 Current Condition: Cellulose Acetate Negatives

After a thorough examination of the cellulose acetate negatives in the Toronto Telegram fonds, visible signs of deterioration and disfigurement were noted. The deterioration includes a strong vinegar odour, severe warping, buckling and channelling of the negatives, embrittlement and shrinkage of the base, formation of crystals and bubbles on the film and the presence of blue and pink colours, finger prints, punctures to the film, dirt and dust (Figure 4.4 and Figure 4.5). The above noted forms of deterioration are caused by both physical and chemical interactions. It is important to note that the colour negatives within this fonds display no signs of colour dye fading and show no visible signs of film degradation.

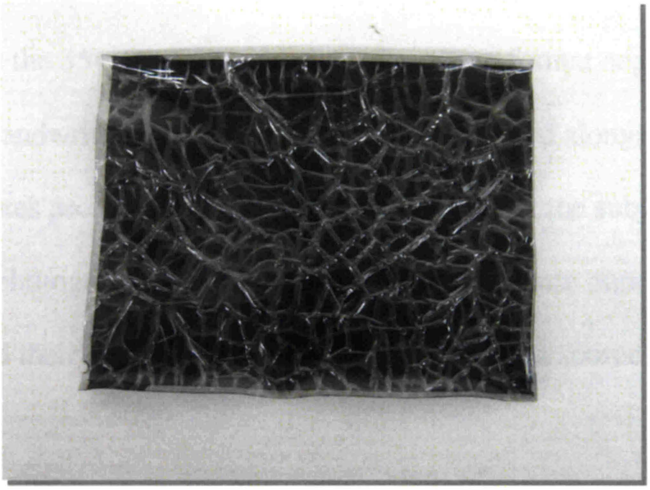


Figure 4.4: Negative Degradation: Vinegar Syndrome Displaying Channelling

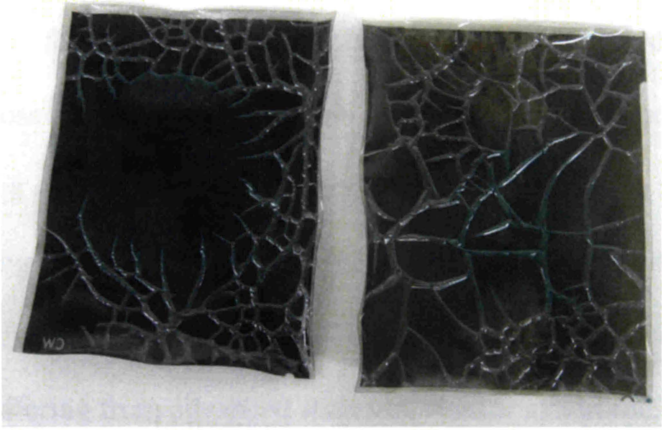


Figure 4.5: Negative Degradation: Vinegar Syndrome Displaying Channelling

The cellulose acetate negatives in this fonds demonstrate significant deterioration which can be attributed to a number of factors in addition to vinegar syndrome, including the current housing, environment and inappropriate handling. As stated above, 90% of the negatives in this fonds are cellulose acetate negatives and 44% are at a deterioration point of 1.5 or greater. No changes are noted when comparing negatives housed on the top shelf of the storage room to those stored on lower shelves. Notations and captions are present on both sides of the cellulose acetate negatives as well as on the polyethylene sleeves which house the 35 mm and a selection of medium format negatives. Descriptive caption slips, both handwritten and typed, can be found housed alongside acetate negatives. These notes provide a wealth of information about the subject matter, date, location, event and photographer. However, in many cases these paper additives have also deteriorated and their close proximity to the negatives is a source of further deterioration.

4.7.1 Storage Arrangements of Cellulose Acetate Negatives

As previously noted, the current storage arrangement of the cellulose acetate negatives in the Toronto Telegram fonds includes original Kraft sleeves, archival sleeves and glassine sleeves. The cellulose acetate materials in this fonds include black and white and colour negatives. The black and white negatives vary in size from 35 mm to 5 x 7 inches and colour negatives range from 35 mm to 4 x 6 inches in size. The majority of the colour negatives are 35 mm in size. The 4 x 6 inch black and white acetates are the negatives that appear to be suffering from advanced stages of vinegar syndrome. One to three hundred and thirty cellulose acetate negatives can be found within each paper sleeve. As previously noted, cellulose acetate negatives are housed within the same boxes as various other types of negatives, including glass plates, and often share sleeves. The bulk of the cellulose acetate negatives are housed in their original aged paper sleeves while the oversize negatives are housed in archival paper sleeves. It is important to note that throughout the boxes of negatives, cellulose acetate negatives are also found housed in glassine sleeves and non-buffered paper envelopes that are water marked.

The cellulose acetate negatives are stored lengthwise within the boxes, thus utilizing adjacent negatives for support. When neighbouring negatives are not cellulose acetate or are smaller in size, unnecessary pressure is placed upon the smaller scaled negatives and the cellulose acetate negatives themselves.

As previously described, the original Kraft sleeves that house the majority of the negatives have a side and bottom adhesive seam. These sleeves are made of paper appropriate for office use, but not for the storage of negatives. As well, these sleeves are not archival safe for the housing of cellulose acetate negatives and are in direct contact with the negatives, which can cause further degradation including staining and discolouration of the emulsion side of the negative. As the paper sleeves continue to degrade and age, they become quite brittle and discoloured. Direct contact of cellulose acetate negatives with harmful enclosure materials can hasten the decomposition of the plastic base, as the enclosure materials off-gas and emit harmful fumes [8]. The adhesives utilized in the seams of the envelopes are acidic and may stimulate vinegar syndrome as they degrade. The combination of aged paper, adhesive and negatives housed together results in a contaminated microenvironment. Upon the removal of negatives from a sleeve for examination or observation, tearing of the paper sleeve occurs. The slightest touch to the paper sleeve results in tears and rips to the sleeve and eliminates any support that has been previously provided. (Figure 4.6) In addition, paper fragments from the sleeves can be found housed with the negatives and are commonly stuck between negatives.

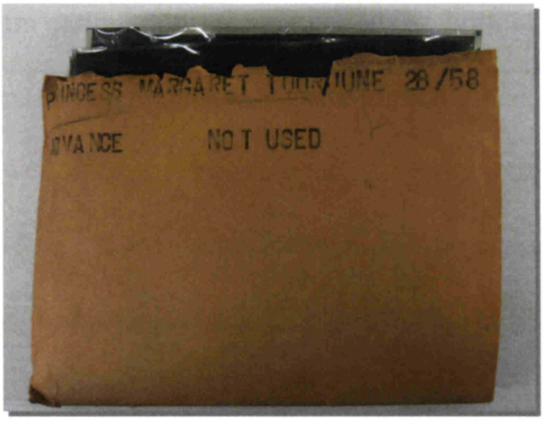


Figure 4.6: Example of Torn Sleeve

The oversize cellulose acetate film sheets are housed in archival paper sleeves that have a bottom and side edge adhesive seam. The original sleeves or housings have been replaced with these sleeves and no deterioration of the archival sleeves was noted. At times, these sleeves house more than one negative resulting in direct physical damage to the plastic base negatives. Rubbing and/or sticking of the emulsions when in storage, or when removed for viewing, results in emulsion lifting, scratches and tears to the film.

Glassine sleeves were once considered photographic archival material [8]. The glassine sleeves in the fonds have side and bottom edge adhesive seams. Although they are rare in the fonds, they do house a limited number of black and white cellulose acetate negatives. As mentioned earlier, glassine is a glazed, semitransparent or transparent paper that often becomes acidic as it degrades. Glassine is waxy and hydroscopic and adheres to a negative emulsion surface when stored in a high humidity environment [8]. The glassine sleeves have seriously discoloured along the edges and seams and are quite brittle and hard to the touch. The deteriorated sleeve is commonly in direct contact with the cellulose acetate negatives increasing chemical deterioration in contacted areas.

The majority of the 35 mm and medium format negatives, both black and white and colour, have both primary and secondary protective layers. These negatives are housed in polyethylene sleeves as well as in paper envelopes. Anywhere from one to thirty negatives share an individual polyethylene sleeve. Polyethylene is considered to be the "softest, most easily scratched, and least rigid" of plastic housings [28] (Figure 4.7).

Figure 4.7: Overcrowded Sleeves 35 mm Negatives

4.7.2 Crowded Housing

The cellulose acetate negatives are often tightly packed, restricting access to viewing the contents of the sleeve. These overstuffed sleeves also pose a great concern for the quality of the negatives. The tight storage quarters result in direct tension and pressure on both the negatives and on the protective sleeves. As previously stated, anywhere from one to three hundred and thirty cellulose acetate negatives can be found within one sleeve. The overcrowding of the paper sleeves, with the resulting tears and rips, reduces the level of protection provided to the negatives. Crowding in the sleeves causes friction between the cellulose acetate negatives, promotes physical damage including warping and adhesion of the negatives (Figure 4.8). In order to view one specific negative, all negatives in a given sleeve must be removed causing unnecessary handling of negatives and increasing the probability of physical damage (Figure 4.9).

Figure 4.8: Example of Overcrowded Sleeves

Figure 4.9: Example of Overcrowded Sleeves

It is challenging to re-house warped and buckled negatives once they have been removed from their enclosure. Attempts to re-house can also result in further tearing and ripping of the enclosure as well the application of direct pressure onto the negatives. Furthermore, the handling of negatives that are compromised by advanced stages of vinegar syndrome can result in tearing or flaking of the negative.

4.7.3 Mixing of Negatives

Cellulose acetate negatives, which encompass the majority of the Toronto Telegram fonds, are found coexisting with the previously described negative types throughout the fonds. The degradation process of cellulose acetate film is hazardous to intact acetates as "acidic acid is emitted as a by-product of their deterioration" [8]. As each type of negative degrades in a unique form specific to its chemical makeup, various types of deterioration can be found within each box of negatives. When housed together, the simultaneous deterioration of the various types of negatives generates a damaging microenvironment. Thus, the practice of housing different types of negatives together can increase the rate of degradation of cellulose acetate negatives.

As mentioned in previous chapters, the act of housing negatives within the same sleeve promotes physical interaction and contact between negative types, which can be detrimental to the condition and longevity of all negatives in the fonds. The physical contact of negatives can result in severe physical damage including ripping, tearing, rubbing and scratching of the plastic base film. As well, the interaction of cellulose acetate with other cellulose acetates is harmful as the negatives adhere, warp and buckle together. As stated above, the gelatin emulsion has a tendency to adhere to other surfaces including various types of negatives. Negatives that are suffering from vinegar syndrome have changed so drastically in some cases that they have buckled, curled and expanded. Thus, extreme pressure may be placed on the paper sleeve and adjacent negatives.

4.7.4 Markings and Notations

The markings and notations found on the cellulose acetate negatives and/or polyethylene sleeves in the Toronto Telegram fonds were originally used to communicate specific information. These notations include location, event and subject matter. Commonly these notations and markings are made utilizing a thin, black permanent marker. The notations made on the polyethylene do not endanger the negatives. Notations and/or markings made directly along the edge of the negatives result in discolouration and permanent damage to the areas inscribed.

4.7.5 Clippings, Loose Papers and Photographs

Stored within the sleeves of cellulose acetate negative are clippings, loose papers, written notations, typed notes and small coloured photographs. As stated earlier, the papers found vary in thickness and colour but are discoloured and brittle due to age. These notes provide useful information about the subject matter, date, location, photographer and developing instructions. These papers are either loosely placed between negatives, paper clipped or stapled to them. These papers are vital for the intellectual integrity of the negatives in this fonds and provide a secondary level of knowledge to the user. However, these papers also contain acids, which are in direct contact with the negatives causing permanent stains that will worsen over time

Small coloured photographs are housed alongside their corresponding negatives. These prints are commonly found loosely sharing a sleeve, paper clipped or stapled to their pairing negatives. Negatives and photographs have different storage requirements, thus their separation is imperative to their individual longevity.

4.7.6 Staples, Paperclips and Elastic Bands

The use of staples, paperclips and elastic bands presents another concern for the negatives in the Toronto Telegram fonds (Figure 4.10). Staples and paperclips tarnish with age, leaving the negatives in direct contact with decay and tarnish markings. These additives also leave puncture holes, permanent indentations, gashes and scratches directly on the cellulose acetate negatives to which they are attached as well as on adjacent negatives (Figure 4.11). Elastic bands can be found wrapped around paper sleeves within this fonds. The use of elastic bands, results in permanent damage by applying pressure to the negatives. This in turn can leave the negative curled and warped in addition to damaging their protective housings (Figure 4.12).

Figure 4.10: Example of a Paper Clip

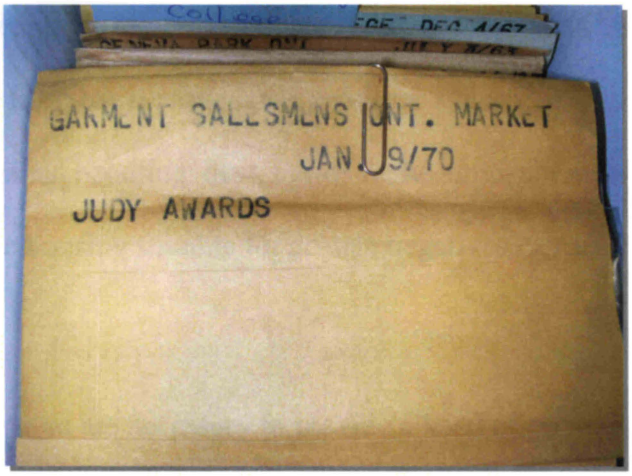


Figure 4.11: Example of a Paper Clip

Figure 4.12: Example of an Elastic Band

4.8 Recommendations

The following section examines recommendations to decelerate the deterioration processes of the cellulose acetate negatives in the Toronto Telegram fonds.

4.8.1 Re-Housing

It is imperative to consider the interaction between the cellulose acetate negative storage housings and their surrounding environment. Appropriate storage enclosures for acetate based film are significant for decelerating vinegar syndrome. As vinegar syndrome is contagious, isolating film that is experiencing vinegar syndrome is essential. Suitable enclosures protect against handling, dust, toxins in the atmosphere and rapid temperature changes. Appropriate housing suitable for acetate negatives is vital for their well being and longevity.

Appropriate paper sleeves are necessary to provide a level of protection from the environment and other negatives within each box. The majority of the sleeves currently in use are the original paper sleeves in which the Toronto Telegram negatives arrived at York University in the early 1970s. The use of improper sleeves can both initiate and increase the rate of deterioration. The use of poor quality paper not suitable for housing photographic materials results in staining and further damage to the artifacts. The current Kraft paper envelopes are acidic. As they age, they can initiate vinegar syndrome as they become brittle and weak. The Kraft paper enclosures are not capable of supplying acceptable long-term protection to cellulose acetate negatives [8]. In the oversize boxes, the original sleeves have been replaced with buffered acid and lignin free sleeves without a thumb cut. These sleeves have a pH of 8.5 and have acid free bottom and side seams [1]. This is a more suitable arrangement.

"All enclosures should be chemically inert toward the components of film — the base, the gelatin emulsion, and the silver or dye image" [19]. It is strongly suggested that all sleeves be removed and replaced with either four-flap alkaline-buffered paper enclosures or side seamed sleeves that meet the American National Standards Institute (ANSI) standard, which includes the Photographic Activity Test (P.A.T.) [9]. The P.A.T test ensures that the materials employed to house the negatives will not interact chemically with the negatives [19].

To provide large format cellulose acetate negatives with the highest level of protection, a four-flap paper enclosure is recommended. The negative is placed in the center of the enclosure and the pre-scored flaps are folded down over the cellulose acetate negative. This type of housing secures and encapsulates the photographic object in place without the need for an adhesive. The enclosure is secured with a piece of linen string, thus ensuring that the cellulose acetate negative is fully shielded and protected [19]. This enclosure design is quite advantageous as it eliminates the possibility of scratching the negative upon insertion or removal and avoids any hazardous adhesives that are commonly utilized in seamed sleeves [12]. Four-flap enclosures are recommended for damaged negatives suffering from advanced stages of vinegar syndrome, as this type of housing isolates the object to some extent and permits non abrasive access to the desired negatives [8].

Enclosures for cellulose acetate negatives should encompass several layers of protective packaging, thus providing physical protection from environmental changes. A four-flap paper enclosure is optimal for housing, but if a seamed sleeve is utilized, the adhesives used in the fabrication of the sleeve should be taken into consideration. The adhesives utilized in Kraft seams are not archival safe for photographic objects. "Adhesives discolor with age and contain impurities (such as iron, copper sulfur, plasticizers or solvents) that are harmful" [8] to photographic objects. Many adhesives, including spirit-based glues, can migrate through the paper enclosure directly onto the emulsion of the negatives causing irreversible and severe damage and decay [9]. When utilizing a paper sleeve, one end always remains open exposing the acetate negative to the microenvironment of the storage box.

Sleeves with center seams should be avoided at all times, as they result in staining of the negatives should the adhesive age poorly. The "hygroscopic or moisture-reactive nature of some adhesives can result in greater physical and chemical activity along the seam, especially under humid conditions" [8]. This can result in irreparable damage to the negatives causing warping and distortion. If seamed sleeves are the only option, it is important to ensure that the seam runs down the side of the enclosure away from the emulsion. Both the sleeve and adhesives should meet the recommendations of the American National Standards Institute (ANSI). Sleeves with thumb cuts should be avoided at all times.

Although there is much debate over the merits of paper vs. plastic enclosures for the housing of large format cellulose acetate negatives, paper is suggested [8]. The static charge present in plastic sleeves can intensify deterioration of the negatives. Paper is preferred over plastic, as plastic enclosures also trap volatile breakdown products rather than allowing them to disperse into the atmosphere [8]. Smaller format negatives can be housed in plastic Mylar sleeves as well as in paper sleeves, thus providing a secondary layer of protection.

4.8.2 Storage

The current boxes utilized for housing the acetate negatives are adequate for long-term storage of negatives that display no signs of deterioration. All negatives should fit snugly, not tightly, into their desired box. The "boxes should have reinforced seams, be acid-free with high alpha-cellulose content, and meet ANSI Standards" [29]. Clamshell boxes with tight fitting lids are a possibility as well; vapour tight containers are an integral aspect in maintaining a proper level of relative humidity in film enclosures [30]. Materials fabricated of Zeolites "have been reported to have the advantage of trapping both acid vapours and moisture. Silica gel may also exhibit similar acid trapping properties and it is well known for absorbing moisture." [31]. The use of these absorbing materials, as well as micro chamber paper, which absorb environmental pollutants and off-gassed by-products, results in deceleration of the autocatalytic vinegar syndrome reaction [32].

Sheet film that displays no signs of degradation should be stacked flat in a drop front box. Negatives suffering from minor to advanced stages of vinegar syndrome should be stored vertically. Cellulose acetate negatives need to be grouped and stored according to size and level of deterioration. When varying sizes of cellulose acetate negatives are stored together, negatives will not receive equal support resulting in unbalanced pressure and weight on the negatives which may lead to physical damage.

Although the negatives do require protection from the outside world, it is imperative that they also have a level of protection from one another. Separate enclosures restrict interaction between neighbouring negatives. The individual housings also shield the negatives from scratches, adhesions, as well as environmental dust and dirt [33]. Overcrowding of paper enclosures can result in tearing and ripping of the paper sleeve, thus limiting the level of protection for the artifact. It is highly recommended that all the cellulose acetate negatives be re-housed into appropriate housings to ensure the appropriate amount of protection. While purchasing of flour-flap enclosures and re-housing of negatives can be expensive, it is highly recommended as one of the primary methods of limiting the deterioration of these artifacts and to sustain them for the future.

4.8.3 Physical Damage: Handling

Physical damage to the cellulose acetate negatives can be avoided with the use of proper storage and care. Further damage can be controlled and avoided through the use of appropriate handling methods. Improper handling of these photographic artifacts is a governing cause of their physical decline. Cellulose acetate negatives are extremely delicate and fragile objects that are at risk of damage each and every time they are handled.

The present physical state of the cellulose acetate negatives exhibits dirt, finger oils, tears/rips and scratches as a result of inappropriate handling. Prior to viewing the negatives, it is imperative that the viewing surface be clean, dry and flat. Lint-less or nylon gloves should be worn at all times when handling cellulose acetate negatives, thus eliminating the possibility of transferring finger oils onto the negatives [7].

Due to the delicate nature of cellulose acetate negatives, the film should be handled along the edges making sure not to touch the image. Only one negative should be handled at a time and negatives not being viewed should be re-housed. When removing a negative from its enclosure, it is vital not to press directly onto the negative and pull the negative out. The negatives should always be placed emulsion side up, thus avoiding interaction of the emulsion with the viewing surface. When viewing the negatives, pressure should not be applied to the negative nor should one lean, press or write on top of the negative. Cellulose acetate negatives should never be left unprotected nor should they be folded.

4.8.4 Mixing of Negatives

It is imperative that all negative types be housed separately from one another as various forms of degradation create a hazardous microenvironment, which in turn accelerates the rate of negative decomposition. As previously noted, vinegar syndrome is contagious, thus accelerating the rate of deterioration of the negatives in the Toronto Telegram fonds. The separation of cellulose acetate negatives from other negative bases is therefore essential. As the plastic base degrades, it off-gases and can induce deterioration of otherwise stable objects including photographs and negatives that are housed within close proximity [32].

4.8.5 Clippings, Loose Papers and Photographs

As previously noted, many sleeves house cellulose acetate negatives, corresponding notes and paper clippings as well as colour photographs. These informative papers can be housed temporarily with their pairing negatives, however it is essential to eliminate direct contact between the papers and the negatives. Loose papers are acidic and long-term housing with the negatives will create a damaging microenvironment. It is recommended that these paper additives be removed and housed in Mylar sleeves separately from the negatives. It is also important to note that, as stated above, coloured paper subject dividers and index cards are housed within the same boxes as the negatives. It is recommended that these dividers and index cards be replaced with archival paper suitable for negative storage.

The small colour photographs, which depict their pairing negatives, should also be removed from their current housings and re-housed in appropriate storage materials. Negatives and prints have different housing requirements, which should be followed. As negatives and prints degrade differently, the acidity released by the decomposing negatives can greatly affect the preservation and well being of the prints. Acids can also cause changes in colour dyes, which may discolour prints.

4.8.6 Staples, Paperclips and Elastic Bands

All paper clips and staples sharing sleeves with the cellulose negatives should be discarded as they cause permanent damage to the negatives. The removal of paper clips and staples will reduce physical damage to the negatives. Elastic bands also serve to induce physical damage and should be immediately removed.

4.8.7 Environment

The life span of cellulose acetate negatives is in direct correlation to the details of their storage environment. High temperatures and high relative humidity accelerate the deterioration process of cellulose acetate film. Unsuitable temperature, combined with a high relative humidity and poor ventilation creates a detrimental environment for the preservation of this type of film [6]. Even with the implementation of quality archival storage material, under conditions of high temperature and high relative humidity, the increase in moisture levels increases the rate of degradation. Rapid fluctuation in temperature and in humidity will hasten the decomposition of cellulose acetate negatives. The current storage room environment for the fonds is climate controlled with a temperature of 23.2° Celsius and 42% relative humidity.

The temperature in the storage area for cellulose acetate negatives is an essential component in controlling the rate of deterioration of the negatives. A higher temperature results in more available energy, thus promoting chemicals reactions. These chemical reactions include negative degradation and colour dye fading [19]. Lowering the temperature reduces the rate of chemical deterioration of the negatives. A cold storage temperature of -18° Celsius is recommended for permanent storage of cellulose acetate negatives that are suffering from minor to advanced stages of vinegar syndrome. However, if cold storage is not an option based on resources and other factors, a cool temperature of 20° Celsius is recommended. The current temperature of 23.2° Celsius in the Toronto Telegram fonds does not meet this requirement. A cool to cold temperature in the storage environment will significantly decelerate the chemical reaction of vinegar syndrome [31].

Relative humidity is intrinsically tied to the rise and fall of temperature and is an essential component in the stabilization of cellulose acetate negatives. A fluctuation of no more than 3% relative humidity within the storage room is acceptable for the stabilization of the negatives [31]. "Regardless of what the temperature is, it's the RH that is going to govern how much water remains in the film after the equilibrium is attained" [16]. With a change in temperature, relative humidity will adjust and compensate for the moisture in the air, thus a constant relative humidity is imperative. As water is a direct reactant in vinegar syndrome, a low level of relative humidity lowers the amount of water being absorbed by the film, which in turn limits the reaction [16]. Currently, the relative humidity in the storage room is 42%, which is considered to be elevated for adequate permanence of cellulose acetate negatives. A high relative humidity also promotes stickiness in the gelatin layer and the possibility of mould growth. A relative humidity lower than 20% results in brittleness, shrinkage and drying of the base; thus, a relative humidity between 20% to 30% is desirable[19]. It is strongly recommended that the current relative humidity be adjusted to meet the optimum standards.

As previously mentioned, cold storage facilities are optimal for the preservation of cellulose acetate negatives. Climate controlled cold storage vaults for large collections or a frost-free refrigerator or freezer for smaller collections are suggested for maintaining cellulose acetate negatives suffering from advanced stages of degradation [31]. Cold storage vaults are essentially microenvironments that provide a climate controlled space with protection from external temperatures, dust and pollutants. Freezing temperatures decelerate the chemical degradation of the acetate negatives [34].

4.8.8 Conservation Treatments

As mentioned in the previous chapter, negative duplication is a viable option for negatives suffering from minimal signs of degradation. Scanning of cellulose acetate negatives suffering from advanced stages of vinegar syndrome, where the image is still accessible, was conducted for the negatives in the Toronto Telegram fonds. In the summer of 2006, this project commenced with the scanning of approximately two hundred negatives. As previously stated, 44 % of the cellulose acetate negatives in this fonds are at the autocatalytic point of decomposition. If immediate action is not taken all image quality of deteriorating negatives will be lost forever. Thus, it is imperative that decisions regarding the future of the negatives in this fonds be finalized.

Negatives displaying minimal to moderate signs of deterioration are ideal candidates for duplication. Negatives exhibiting extreme deterioration cannot be duplicated as they are disfigured and image visibility is lost. It is recommended that all duplications be made onto polyester based film. Camera duplication is the most cost effective form of duplication and the option to hire a professional is always recommended depending on the level of negative decay. All duplicated negatives should be cut to size and housed in buffered envelopes [6].

Scanning and photographic duplication are conservation options for the deteriorated acetate negatives. Another option to explore is the dissolving of the emulsion away from its shrunken base. This is a delicate process to preserve the image, as the gelatin usually stays intact during decomposition. After the emulsion has been removed, it can be re-photographed or transferred to a new support [19]. A photographic conservator should complete this conservation treatment, as its success is dependent upon extensive experience when working with these delicate photographic objects.

4.9 Summation

The effects of vinegar syndrome and the subsequent deterioration of cellulose acetate films are a significant issue for the negatives within the Toronto Telegram fonds. The deterioration caused by vinegar syndrome is irreversible and highly contagious. This syndrome is a debilitating reality for cellulose acetate films and may impact other collection material as well. Creating conditions to limit vinegar syndrome requires a significant commitment of time and resources.

5 Conclusion

This case study investigates the declining negatives in the Toronto Telegram fonds. Evaluations were based on the current condition of the negatives, causes of deterioration and recommendations. The major contributors to the deterioration of the negatives in the Toronto Telegram fonds include poor environmental conditions, chemical deterioration, substandard storage conditions and inappropriate handling of the negatives. The negatives demonstrate significant signs of chemical and physical degradation. Conclusions and recommendations to stabilize and decelerate the deterioration process were suggested. Three sets of A-D Strip tests provided an accurate understanding of the level of degradation of the cellulose acetate negatives. The employment of proper negative handling, storage, removal of unnecessary additives and a controlled environment were recommended. The implementation of recommendations will aid in sustaining long-term stability and condition of the imagery.

The Clara Thomas Archives and Special Collections at York University houses 830,000 negatives dating from 1876 to 1971. These negatives document the daily news events from both the Canadian and international arenas. The intrinsic value this fonds has to support research and teaching at the Clara Thomas Archives and Special Collections, York University Libraries and York University must also be recognized. The photographic objects must be treated with the utmost respect and care to ensure their longevity. As stated in the above case study, precautions need to be implemented to ensure the deceleration of the negatives' deterioration. It is also essential that the negatives in this fonds be accessible to the public for viewing and research purposes, thus safety measures must be employed to ensure the sustainability of this fonds. The Toronto Telegram fonds is a remarkable visual documentation that deserves financial and professional support to ensure sustainability and prevent the loss of these invaluable artifacts .

Appendix A: Polyester Negatives

Polyester negatives were not identified during the examination of the negatives in the Toronto Telegram fonds. However, it is likely that polyester negatives make up a component of this fonds as polyester negatives were being produced as early as 1955. As the Toronto Telegram ceased its publication in 1971, there is a high probability that polyester negatives were utilized. The following briefly outlines the history, identification and environment of polyester negatives.

A.1 Brief History: Polyester Negatives

Polyester film replaced acetate film supports during the 1960s and 1970s. "Polyester film base is inherently more chemically stable than either cellulose nitrate or cellulose acetate film bases because it is a completely synthetic polymer" [3]. Polyester is a generic term, which describes two types of film supports, Polyethylene terephthalate and Polyethylene naphthalene. After World War II, polyethylene terephthalate was commercially produced and in 1996, under the brand name Advantix, Eastman Kodak sold Polyethylene naphthalene film [3].

Polyester film is the most chemically stable of the film bases and has the longest lifespan of all the plastic film bases. This is due to the fact that polyester film is "cast from the molten polymer it does not contain solvents or plasticizer" [3] which are known to degrade with age.

A.2 Identification

At times, the identification of polyester film can be challenging as the edge printing for the film may display 'SAFETY' which is a reference to its film counterpart [3]. Commonly the edge printing depicted on polyester film includes 'Estar' and/or 'Cronar' [35]. To confirm the nature of the film base, a simple polarization test can be conducted [3]. Polyester film has a higher birefringence than its film equivalents. When placed between two polarizing filters and backlit, if the interference colours produced include red and green the film base polyester. When this test is completed on cellulose nitrate and acetate film bases, no colours are visible [16].

A.3 Storage

If polyester negatives are identified within the Toronto Telegram fonds, the negatives should be appropriately stored. A frozen storage environment is suggested for polyester colour negatives as they have a tendency to experience colour image decay over time. A frozen temperature of 0° Celsius is optimal for colour polyester film, otherwise a cold to cool temperature should be implemented. The warmest recommended temperature is 2° Celsius with a 30% relative humidity [4]. For black and white film, a cold to frozen temperature is also recommended but a cool environment is sufficient. A maximum of 18° Celsius with a relative humidity between 30% and 40% is advised [3].

Appendix B: Glossary of Terms

Acetate: A transparent plastic base for photographic film made by treading cellulose with acetic acid. This term is used for various modifications of cellulose acetate [4].

Acetate Decay: Vinegar syndrome. Degradation of cellulose acetate film base that, causes distortion, shrinkage, and brittleness, often detected by a vinegar odour. The severity of decomposition can be determined using A-D Strips [4].

Acid Free: A commercial term used to describe archival materials whose pH is equal to or greater than 7. Acid free does not guarantee that the materials are suitable for photographic objects [16].

A-D Strips: Indicator papers, manufactured by IPI (Image Permanence Institute), which change colour when acetic acid is produced by degrading cellulose acetate film base [4].

Alkaline: Describes materials that have a pH above 7 on a scale of 1 (very acidic) to 14 (very alkaline) [22].

Anti-Curl Layer: Layer of gelatin on the back of a film substrate that limits curling caused by the emulsion [16].

Autocatalytic: A process in which products formed in a degradation reaction accelerate the degradation reaction [27].

Binder: Thin, transparent layer containing the image substance [3].

Birefringence: Colour formation observed in a polarization test [19].

Buffered: Describes materials that have been made with or provided with some alkalinity to counteract acidity in the environment or in the manufacturing process [22].

Dry Plate: A glass plate negative, containing a silver image on a gelatin binder [3].

Emulsion: A suspension of light-sensitive silver halide salts in a viscous medium forming a coating on photographic plates, film or paper [3].

Glassine: An acidic, hygroscopic waxy paper that can adhere to emulsion surfaces under conditions of high humidity or if wet. Glassine has a short life expectancy and becomes brittle and yellow with age. Glassine is a transparent or semitransparent paper often utilized to make envelopes and sleeves for housing photographic objects [8].

Hygroscopic: A material that has the property of adsorbing moisture from the air [16].

Lignin: Organic fibre that forms an essential part (approx. 16-34%) of woody fibre, responsible for rigidity in plants. A major cause of acidity in paper, lignin is largely removed during chemical pulping but not during mechanical pulping. Lignin-free implies ≤1% concentration of lignin. [8].

Micro Chamber paper: A registered trademark for a line of lignin-free, sulphur-free archival papers that contain an alkaline reserve and an interior layer of zeolites. Available as interleaving, mat boards, containers, and the Micro Chamber is designed to absorb airborne pollutants and off-gassed by products of degradation [32].

Mould: Fungus that grows on polymers or organic materials exposed to high humidity; causes material degradation [4].

Mylar: A brand name for a clear, chemically inert and stable polyester material used for storage. [22].

Nitrate: A transparent plastic base that was used for photographic film. Obtained from the treatment of cellulose with nitric acid [4].

pH: "Potential of hydrogen." pH defines the alkaline or acidic nature of a solution. A pH below 7 corresponds to an acidic solution, a pH greater than 7 corresponds to an alkaline solution, and a pH of 7 corresponds to a neutral solution. When the pH increases by one unit, the alkalinity of the solution is multiplied by 10. The pH scale ranges from 0 to 14 [16].

Photographic Activity Test (P.A.T): A worldwide standard for archival quality in photographic enclosures that predicts possible interactions between photographic images and the enclosures in which they are stored. The PAT test is also used to test the components of enclosures, such as adhesives, inks, paints, labels, and tapes [22].

Polyester: A transparent plastic base for photographic film and magnetic tape that is composed of a polymer of ethylene glycol and terephthalic acid. It is very strong and stable [4].

Polymer: A large molecule made of linked smaller molecular units called monomers [3].

Re-housing: In preservation, this term refers to putting materials into envelopes or other protective containers [22].

Relative Humidity: The amount of water vapour in the air, expressed as a percentage of the maximum amount of water that the air could hold at a given temperature [22].

Silver Mirroring: Chemical deterioration of the silver image that leads to the formation of bluish silver deposits on the surface of the binder [3].

Subbing Layer: An extremely thin, transparent layer that adheres the binder to the negative support [3].

Zeolites: A group of naturally occurring minerals that readily absorb liquids and gasses. Also known as molecular sieves, zeolites are used to trap potentially harmful off-gassing or pollutants [32].

Appendix C: Suppliers

Canadian Conservation Institute
Rental of environmental monitoring system
25 De Villebois
Gatineau QC K1A 0M5
Tel: 819-243-4990
Website: http://www.cci-icc.gc.ca

Carr McLean
Library and Archival Supplies
461 Horner Avenue
Toronto, Ontario M8W 4X2
Tel: 1-800-268-2123
Website: http://www.carrmclean.ca

Epson Canada Ltd.
Paper and Ink
3771 Victoria Park Avenue
Toronto, Ontario M1W 3Z5
Tel: 1- 800-463-7766
Website: http://www.epson.ca

Image Permanence Institute
Preservation Research and Supplies: AD Strips
70 Lomb Memorial Drive
Rochester, NY 14623-5604
Tel: 585-475-5199
Website: http://www.imagepermanenceinstitute.org/

James Dawson Enterprises
Storage Supplies
178 Pennsylvania Ave, Unit 5
Concord, Ontario L4K 4B1
Tel: 905- 738-6959
Website: http://www.jamesdawson.com

Light Impressions
Archival Product Suppliers
Light Impressions
P.O. Box 787, Brea, CA 92822-0787
Tel: 800 828-6216
Website: http://www.lightimpressionsdirect.com

Metal Edge
Archival Storage Materials
Metal Edge Inc.
Conventional freezer storage bags/CMI indicators
6340 Bandini Ave
Commerce, Ca 90040
Tel: 800-862-2228
Website: http://www.metaledgeinc.com

Print-File
Archival Storage and Presentation Supplies
Print File, Inc
P.O. Box 607638 Orlando, FL 32860
Tell: 800-508-8539
Website: http:// www.printfile.com

Vistek
Digital Printing Supplies
496 Queen Street East
Toronto, Ontario M5A 4G8
Tel: 416-365-1777
Email: www.vistek.ca

Woolfitt's
Museum Boards and Archival Supplies
1153 Queen St. West
Toronto, Ontario M6J 1J4
Tel: 1-800-490-3567
Website: http://www.woofitts.com

Appendix D: Data From A-D Strips Tests

Table 5.1: A-D Strip Tests Results

Accession no.	July 17-18, 06	January 2-3, 07	July 11-12, 07
1974-002/001	1	1	1
1974-002/002	1	1	1
1974-002/003	1	1	1
1974-002/004	1	1	1
1974-002/005	2	2	2
1974-002/006	2	2	2
1974-002/007	3	3	3
1974-002/008	2	2	2.5
1974-002/009	2	2	2
1974-002/010	3	3	3
1974-002/011	1	1	1
1974-002/012	0.5	0.5	0.5
1974-002/013	1	1	1
1974-002/014	1	1.5	1.5
1974-002/015	0.5	0.5	0.5
1974-002/016	0.5	0.5	0.5
1974-002/017	2	2	2
1974-002/018	3	3	3
1974-002/019	1	1	1
1974-002/020	1	1.5	1.5
1974-002/021	1	1	1
1974-002/022	0.5	0.5	0.5
1974-002/023	1	1.5	1.5
1974-002/024	1	1.5	1.5
1974-002/025	0.5	0.5	0.5
1974-002/026	0.5	0.5	0.5
1974-002/027	1	1	1
1974-002/028	0.5	1	1
1974-002/029	1.5	1.5	1.5
1974-002/030	0.5	0.5	0.5
1974-002/031	0.5	0.5	0.5
1974-002/032	0.5	0.5	0.5
1974-002/033	1	1	1

1974-002/034	1	1	1
1974-002/035	1	1	1
1974-002/036	0.5	0.5	0.5
1974-002/037	0.5	0.5	0.5
1974-002/038	0.5	0.5	0.5
1974-002/039	0.5	0.5	0.5
1974-002/040	1	1	1
1974-002/041	1	1	1.5
1974-002/042	1.5	1.5	1.5
1974-002/043	1	1	1
1974-002/044	0.5	0.5	0.5
1974-002/045	1.5	1.5	1.5
1974-002/046	1.5	1.5	1.5
1974-002/047	0.5	0.5	0.5
1974-002/048	3	3	3
1974-002/049	0.5	0.5	0.5
1974-002/050	0.5	0.5	0.5
1974-002/051	1	1	1
1974-002/052	1	1	1
1974-002/053	2	2	2
1974-002/054	2.5	2.5	2.5
1974-002/055	1.5	1.5	1.5
1974-002/056	1	1	1.5
1974-002/057	0.5	0.5	0.5
1974-002/058	1.5	1.5	2
1974-002/059	1.5	1.5	1.5
1974-002/060	1.5	2	2
1974-002/061	1	1	1
1974-002/062	1.5	1.5	2.5
1974-002/063	1	1	1
1974-002/064	1	1.5	2
1974-002/065	1	1	1
1974-002/066	1	1	1
1974-002/067	0.5	0.5	0.5
1974-002/068	0.5	0.5	0.5
1974-002/069	1	1	1
1974-002/070	1.5	1.5	1.5
1974-002/071	0.5	0.5	0.5
1974-002/072	0.5	0.5	0.5
1974-002/073	0.5	0.5	0.5
1974-002/074	0.5	0.5	0.5

1974-002/075	0.5	0.5	0.5
1974-002/076	0.5	0.5	0.5
1974-002/077	0.5	0.5	0.5
1974-002/078	1	1	1
1974-002/079	1	1	1
1974-002/080	1	1	1
1974-002/081	0.5	0.5	0.5
1974-002/082	1.5	1.5	1.5
1974-002/083	3	3	3
1974-002/084	1.5	1.5	2
1974-002/085	1.5	1.5	1.5
1974-002/086	1.5	1.5	1.5
1974-002/087	1	1	1
1974-002/088	2	2	2.5
1974-002/089	1.5	1.5	2
1974-002/090	1	1	1
1974-002/091	2	2	2
1974-002/092	1	1	1
1974-002/093	3	3	3
1974-002/094	1.5	1.5	1.5
1974-002/095	1.5	1.5	1.5
1974-002/096	2	2	2
1974-002/097	1.5	1.5	2
1974-002/098	0.5	0.5	0.5
1974-002/099	2	2	2
1974-002/100	3	3	3
1974-002/101	2	2	2
1974-002/102	1	1	1
1974-002/103	2	2.5	2.5
1974-002/104	2	2.5	2.5
1974-002/105	0.5	0.5	0.5
1974-002/106	0.5	0.5	0.5
1974-002/107	0.5	0.5	0.5
1974-002/108	1	1	1
1974-002/109	1	1	1
1974-002/110	1	1	1
1974-002/111	2	2	2
1974-002/112	1	1	1
1974-002/113	1	1	1
1974-002/114	1.5	2	2
1974-002/115	2	2.5	2.5

1974-002/116	1.5	1.5	2
1974-002/117	2	2.5	2.5
1974-002/118	2	2.5	2.5
1974-002/119	2.5	3	3
1974-002/120	1	1	1.5
1974-002/121	0.5	0.5	0.5
1974-002/122	1	1	1
1974-002/123	1	1	1
1974-002/124	1.5	1.5	1.5
1974-002/125	1	1	1
1974-002/126	1	1	1
1974-002/127	1	1	1
1974-002/128	1	1	1
1974-002/129	0.5	0.5	0.5
1974-002/130	2.5	2.5	2.5
1974-002/131	1	1	1
1974-002/132	1	1	1
1974-002/133	2	2	2.5
1974-002/134	2	2	2.5
1974-002/135	1.5	1.5	1.5
1974-002/136	0.5	0.5	0.5
1974-002/137	1	1	1
1974-002/138	1.5	1.5	1.5
1974-002/139	1.5	1.5	1.5
1974-002/140	1	1	1
1974-002/141	0.5	0.5	0.5
1974-002/142	0.5	0.5	0.5
1974-002/143	1	1	1
1974-002/144	1	1	1
1974-002/145	1	1	1
1974-002/146	3	3	3
1974-002/147	1.5	1.5	2
1974-002/148	0.5	0.5	0.5
1974-002/149	0.5	0.5	0.5
1974-002/150	0.5	0.5	0.5
1974-002/151	0.5	0.5	0.5
1974-002/152	0.5	0.5	0.5
1974-002/153	0.5	0.5	0.5
1974-002/154	0.5	0.5	0.5
1974-002/155	0.5	0.5	0.5
1974-002/156	1	1	1

1974-002/157	1	1	1
1974-002/158	1	1	1
1974-002/159	1	1	1
1974-002/160	2	2	2.5
1974-002/161	1	1	1
1974-002/162	1	1	1
1974-002/163	1	1	1
1974-002/164	2.5	3	3
1974-002/165	1	1	1
1974-002/166	3	3	3
1974-002/167	1.5	1.5	2.5
1974-002/168	0.5	0.5	0.5
1974-002/169	3	3	3
1974-002/170	1	1	1
1974-002/171	2	2	2.5
1974-002/172	0.5	0.5	0.5
1974-002/173	3	3	3
1974-002/174	3	3	3
1974-002/175	2.5	2.5	2.5
1974-002/176	1	1	1
1974-002/177	3	3	3
1974-002/178	3	3	3
1974-002/179	0.5	0.5	0.5
1974-002/180	0.5	0.5	0.5
1974-002/181	0.5	0.5	0.5
1974-002/182	3	3	3
1974-002/183	2.5	2.5	3
1974-002/184	1	1	1
1974-002/185	3	3	3
1974-002/186	0.5	0.5	0.5
1974-002/187	1	1	1
1974-002/188	0.5	0.5	0.5
1974-002/189	1.5	1.5	1.5
1974-002/190	2.5	2.5	2.5
1974-002/191	2.5	2.5	3
1974-002/192	2	2	2
1974-002/193	2	2.5	3
1974-002/194	2	2	2
1974-002/195	2.5	2.5	2.5
1974-002/196	2	3	3
1974-002/197	2.5	2.5	2.5

1974-002/198	1	1	1
1974-002/199	1.5	1.5	1.5
1974-002/200	2	2	2
1974-002/201	1.5	2.5	2.5
1974-002/202	1	1	1
1974-002/203	1	1	1
1974-002/204	2	2	2
1974-002/205	0.5	0.5	0.5
1974-002/206	0.5	1	1
1974-002/207	0.5	0.5	0.5
1974-002/208	1	1	1
1974-002/209	0.5	0.5	0.5
1974-002/210	1	1	0.5
1974-002/211	0.5	0.5	0.5
1974-002/212	0.5	0.5	0.5
1974-002/213	0.5	0.5	0.5
1974-002/214	1	1	1
1974-002/215	0.5	0.5	0.5
1974-002/216	0.5	0.5	0.5
1974-002/217	0.5	0.5	0.5
1974-002/218	0.5	0.5	0.5
1974-002/219	0.5	0.5	0.5
1974-002/220	0.5	0.5	0.5
1974-002/221	0.5	0.5	0.5
1974-002/222	0.5	0.5	0.5
1974-002/223	0.5	0.5	0.5
1974-002/224	0.5	0.5	0.5
1974-002/225	0.5	0.5	0.5
1974-002/226	0.5	0.5	0.5
1974-002/227	1	1	1
1974-002/228	1	1	1
1974-002/229	1	1	1
1974-002/230	1	1	1
1974-002/231	3	3	3
1974-002/232	1	1	1
1974-002/233	1	1	1
1974-002/234	1	1	1
1974-002/235	0.5	0.5	0.5
1974-002/236	1	1	1
1974-002/237	0.5	0.5	0.5
1974-002/238	2	2	2

1974-002/239	3	3	3
1974-002/240	2	2	2
1974-002/241	1	1	1
1974-002/242	0.5	0.5	0.5
1974-002/243	2.5	2.5	2.5
1974-002/244	2.5	2.5	2.5
1974-002/245	1.5	1.5	2
1974-002/246	0.5	0.5	0.5
1974-002/247	0.5	0.5	0.5
1974-002/248	2	2	2
1974-002/249	1.5	2	2
1974-002/250	1.5	1.5	1.5
1974-002/251	3	3	3
1974-002/252	3	3	3
1974-002/253	3	3	3
1974-002/254	3	3	3
1974-002/255	3	3	3
1974-002/256	3	3	3
1974-002/257	2	2.5	2.5
1974-002/258	3	3	3
1974-002/259	1.5	1.5	1.5
1974-002/260	1.5	1.5	1.5
1974-002/261	2	2.5	2.5
1974-002/262	1	1	1
1974-002/263	1	1.5	1.5
1974-002/264	0.5	0.5	0.5
1974-002/265	1.5	1.5	2
1974-002/266	0.5	0.5	0.5
1974-002/267	0.5	0.5	0.5
1974-002/268	1.5	0.5	1.5
1974-002/269	2.5	2.5	2.5
1974-002/270	0.5	1	1
1974-002/271	1.5	2	2.5
1974-002/272	0.5	0.5	0.5
1974-002/273	1.5	1.5	2
1974-002/274	3	3	3
1974-002/275	0.5	0.5	0.5
1974-002/276	0.5	0.5	0.5
1974-002/277	2	2	2
1974-002/278	2	2	2.5
1974-002/279	0.5	0.5	0.5

1974-002/280	0.5	0.5	0.5
1974-002/281	0.5	0.5	0.5
1974-002/282	0.5	0.5	0.5
1974-002/283	1.5	1.5	1.5
1974-002/284	0.5	0.5	0.5
1974-002/285	1.5	2	2.5
1974-002/286	0.5	0.5	0.5
1974-002/287	0.5	0.5	0.5
1974-002/288	2.5	2.5	2.5
1974-002/289	2.5	2.5	2.5
1974-002/290	2.5	3	3
1974-002/291	1.5	2	2
1974-002/292	3	3	3
1974-002/293	0.5	0.5	0.5
1974-002/294	0.5	0.5	0.5
1974-002/295	0.5	0.5	0.5
1974-002/296	0.5	1	1.5
1974-002/297	1.5	1.5	1.5
1974-002/298	0.5	0.5	0.5
1974-002/299	0.5	0.5	0.5
1974-002/300	0.5	0.5	0.5
1974-002/301	0.5	0.5	0.5
1974-002/302	0	0	0
1974-002/303	0	0	0
1974-002/304	0.5	0.5	0.5
1974-002/305	0	0	0
1974-002/306	0	0	0
1974-002/307	0	0	0
1974-002/308	0	0	0
1974-002/309	0	0	0
1974-002/310	0	0	0
1974-002/311	0	0	0
1974-002/312	0	0	0
1974-002/313	0	0	0
1974-002/314	0	0	0
1974-002/315	0	0	0
1974-002/316	0	0	0
1974-002/317	2	2.5	2.5
1974-002/318	2.5	2.5	2.5
1974-002/319	1.5	1.5	2
1974-002/320	3	3	3

1974-002/321	2.5	2.5	2.5
1974-002/322	1	1	1
1974-002/323	1	1	1
1974-002/324	2	2	2
1974-002/325	3	3	3
1974-002/326	3	3	3
1974-002/327	1.5	1.5	1.5
1974-002/328	1.5	1.5	1.5
1974-002/329	1.5	1.5	1.5
1974-002/330	2.5	2.5	2.5
1974-002/331	2.5	3	3
1974-002/332	3	3	3
1974-002/333	1.5	1.5	1.5
1974-002/334	0.5	0.5	0.5
1974-002/335	3	3	3
1974-002/336	1	1	1
1974-002/337	2	2	2
1974-002/338	2.5	2.5	2.5
1974-002/339	0.5	0.5	1
1974-002/340	1.5	1.5	1.5
1974-002/341	0.5	0.5	0.5
1974-002/342	0.5	0.5	0.5
1974-002/343	0.5	0.5	0.5
1974-002/344	2.5	2.5	2.5
1974-002/345	1	1	1
1974-002/346	3	3	3
1974-002/347	2	2.5	2.5
1974-002/348	2.5	2.5	2.5
1974-002/349	0.5	0.5	0.5
1974-002/350	1	1	1
1974-002/351	2.5	2.5	2.5
1974-002/352	1	1	1
1974-002/353	1	1	1
1974-002/354	1	1	1
1974-002/355	1	1	1
1974-002/356	1.5	1.5	1.5
1974-002/357	3	3	3
1974-002/358	2.5	2.5	2.5
1974-002/359	0.5	0.5	0.5
1974-002/360	1.5	1.5	1.5
1974-002/361	1	1	1.5

1974-002/362	0.5	0.5	1
1974-002/363	1	1	1
1974-002/364	1	1	1
1974-002/365	1	1	1
1974-002/366	1	1	1
1974-002/367	3	3	3
1974-002/368	2.5	3	3
1974-002/369	2.5	2.5	2.5
1974-002/370	1.5	1.5	1.5
1974-002/371	1.5	1.5	1.5
1974-002/372	0.5	0.5	0.5
1974-002/373	2.5	2.5	2.5
1974-002/374	1	1	1
1974-002/375	0.5	0.5	0.5
1974-002/376	0.5	0.5	0.5
1974-002/377	0.5	0.5	0.5
1974-002/378	0.5	0.5	0.5
1974-002/379	0.5	0.5	0.5
1974-002/380	3	3	3
1974-002/381	1	1	1
1974-002/382	2.5	2.5	2.5
1974-002/383	0.5	0.5	0.5
1974-002/384	0.5	0.5	1.5
1974-002/385	1.5	1.5	1.5
1974-002/386	2.5	2.5	2.5
1974-002/387	2.5	2.5	2.5
1974-002/388	2.5	2.5	2.5
1974-002/389	2.5	3	3
1974-002/390	1.5	1.5	1.5
1974-002/391	0.5	0.5	0.5
1974-002/392	1.5	1.5	1.5
1974-002/393	1.5	1.5	1.5
1974-002/394	3	3	3
1974-002/395	2.5	2.5	2.5
1974-002/396	3	3	3
1974-002/397	2	2	2.5
1974-002/398	0.5	0.5	0.5
1974-002/399	2	2	3
1974-002/400	1.5	1.5	1.5
1974-002/401	0.5	0.5	0.5
1974-002/402	0.5	0.5	0.5

1974-002/403	1.5	1.5	1.5
1974-002/404	3	3	3
1974-002/405	2	2.5	2.5
1974-002/406	1.5	1.5	1.5
1974-002/407	3	3	3
1974-002/408	1.5	2	2
1974-002/409	0.5	0.5	0.5
1974-002/410	0.5	0.5	0.5
1974-002/411	1	1	1
1974-002/412	0.5	0.5	0.5
1974-002/413	1.5	1.5	1.5
1974-002/414	0.5	0.5	0.5
1974-002/415	1.5	1.5	1.5
1974-002/416	2	2	2.5
1974-002/417	3	3	3
1974-002/418	1.5	1.5	1.5
1974-002/419	1.5	1.5	2
1974-002/420	0.5	0.5	0.5
1974-002/421	1	1	1
1974-002/422	1.5	1.5	1.5
1974-002/423	1.5	1.5	1.5
1974-002/424	1	1	1
1974-002/425	1	1	1
1974-002/426	2.5	2.5	2.5
1974-002/427	1	1	1
1974-002/428	1	1	1
1974-002/429	1	1	1
1974-002/430	1	1	1
1974-002/431	1.5	1.5	1.5
1974-002/432	1	1	1
1974-002/433	1	1	1
1974-002/434	2	2	2
1974-002/435	3	3	3
1974-002/436	1	1	1
1974-002/437	1	1	1
1974-002/438	3	3	3
1974-002/439	1	1	1
1974-002/440	2.5	2.5	2.5
1974-002/441	1.5	2	2.5
1974-002/442	2.5	3	3
1974-002/443	2	2	2

1974-002/444	1	1	1
1974-002/445	2	2	2
1974-002/446	1	1	1
1974-002/447	2.5	2.5	2.5
1974-002/448	2	2	2.5
1974-002/449	2.5	3	3
1974-002/450	2.5	2.5	3
1974-002/451	2.5	2.5	2.5
1974-002/452	2.5	2.5	2.5
1974-002/453	0	0	0
1974-002/454	0	0	0
1974-002/455	0	0	0
1974-002/456	0	0	0
1974-002/457	0	0	0
1974-002/458	0	0	0
1974-002/459	0	0	0
1974-002/460	0	0	0
1974-002/461	0	0	0
1974-002/462	0	0	0
1974-002/463	0	0	0
1974-002/464	0	0	0
1974-002/465	0	0	0
1974-002/466	0	0	0
1974-002/467	0	0	0
1974-002/468	0	0	0
1974-002/469	0	0	0
1974-002/470	0	0	0
1974-002/471	0	0	0
1974-002/472	0	0	0
1974-002/473	0	0	0
1974-002/474	0	0	0
1974-002/475	0	0	0
1974-002/476	0	0	0
1974-002/477	0	0	0
1974-002/478	0	0	0
1974-002/0S	0	0	0
1974-002/0S-box 1	0	0	0
1974-002/0S-	0.5	0.5	0.5
box 6 of 6	1.5	1.5	1.5
box 4 of 6	1.5	1.5	1.5

no label	3	3	3
no label	3	3	3

	Jul-06	Jan-07	Jul-07
Total	1.265979381	1.306185567	1.35257732

Level of Acidity/Degradation

	Jul-06	Jan-07	Jul-07
0	42	42	42
0.5	126	123	120
1	114	112	108
1.5	70	66	59
2	46	42	40
2.5	42	46	57
3	45	54	59

Table 5.2: A-D Strip Percentage Change

Jul-06	Jan-07		Change
9%	9%	0.0:	0.0%
26%	25%	0.5:	-2.4%
24%	23%	1.0:	-1.8%
14%	14%	1.5:	-5.7%
9%	9%	2.0:	-8.7%
9%	9%	2.5:	9.5%
9%	11%	3.0:	20.0%

Jan-07	Jul-07		Change
9%	9%	0.0:	0.0%
26%	25%	0.5:	-2.4%
24%	23%	1.0:	-3.6%
14%	14%	1.5:	-10.6%
9%	9%	2.0:	-4.8%
9%	9%	2.5:	23.9%
9%	11%	3.0:	9.3%

Jul-06	Jul-07		Change
9%	9%	0.0:	0.0%
26%	25%	0.5:	-4.8%
24%	23%	1.0:	-5.3%
14%	14%	1.5:	-15.7%
9%	9%	2.0:	-13.0%
9%	9%	2.5:	35.7%
9%	11%	3.0:	31.1%

Bibliography

Adelstein, P.Z. *IPI Media Storage Quick Reference.* Rochester, New York: Image Permanence Institute, 2004.

Adelstein, P.Z., Douglas W. Nishimura and James M. Reilly. *Preservation of Safety Film.* Rochester, NY: Image Permanence Institute, 1991.

Adelstein, P.Z., Jean-Louis Bigourdan and James M. Reilly. *Moisture Relationships of Photographic Film.* Journal of the American Institute for Conservation, 36 Fall/Winter 1997.

Albright, Gary. *Conserve O Gram 14/2: Storage Enclosures for Photographic Prints.* Andover, Massachusetts: Northeast Document Conservation Center, July 1993.

Bahnemann, Greta. WebJunction. 'The Preservation of Glass Plate Negatives.' *http://webjunction.org/do/DisplayContent?id=12112.* Volume 1/Issue 3, December 2, 2005.

Balloffet, Nelly and Jenny Hille. *Preservation and Conservation for Libraries and Archives.* Chicago: American Library Association, 2005.

Bennett, Karen L. and Jessica S. Johnson. *Identification of Film-Based Photographic Material 14/9.* Washington, DC: Conserve O Gram, September 1999.

Bigelow, Sue. *Cold Storage of Photographs at the City of Vancouver.* Vancouver: Canadian Council of Archives Preservation Committee, March 2003.

Bigourdan, Jean-Louis, and James M. Reilly. *Environment and Enclosures in Film Preservation.* Rochester, NY: Image Permanence Institute, 1997.

Carr McLean. *http:// www.carrmclean.ca.* The Capris Group. Library, Archival and Museum Supplies, 2007.

Chapman, Stephen and Anne R. Kenney. *Digital Imaging For Libraries and Archives.* New York: Department of Preservation and Conservation Cornell University, 1996.

Compton, John, Ira Current, Leslie Stroebel and Richard Zakia. *Photographic Materials and Processes.* Boston: Focal Press, 1986.

Corbett, D. J. *Motion Picture & Television Film Image Control & Processing Techniques.* London: Focal Press, 1968.

Eastman Kodak Company. *'Safe Handling, Storage, and Destruction of Nitrate-Based Motion Picture Films.'* *http://www.kodak.com/global/en/corp/environment/kes/pubs/pdfs/H182.pdf.* Environment Information From Kodak, Kodak Environmental Services. Rochester, NY. 2006.

Film Forever *'The Film Preservation Guide.'* AMIA *http://www.filmforever.org.* June 2007.

Monique Fischer, '*A Short Guide to Film Base Photographic Materials: Identification, Care, and Duplication.'* Northeast Document Conservation Center. *http://www.nedcc.org/resources/leaflets/5Photogrpahs/01ShortGuide.php*, 2007 July 4th, 2007.

Gordon, Paul L. and Craig Jones. *The Book of Film Care.* Rochester, NY: Kodak Motion Picture and Audiovisual Markets Division, 1983.

Herskovitz, Robert. *Storage of Glass Plate Negatives.* Minnesota: Minnesota Historical Society, 1999.

Health & Safety Executive. *The Dangers of Cellulose Nitrate Film.* Crown Copyright. August 2003

Hendriks, Klaus B. *CCI Notes 16/2: Care of Black-and-White Photographic Negatives on Film.* Ottawa, Ontario: Canadian Heritage, 1996.

Hopkins, William L. *'Cold Storage for Glass Plate Negatives'* *http://palimpsest.stanford.edu/byform/mailing-lists/cdl/2002/0476.html.* Conservation Distlist Instance, Cool, April 2002. May 2007.

Kilby, Virginia. Conserve O Gram. *'Buffered and Unbuffered Storage Materials 4/9.'* *http://www.nps.gov/history/museum/publications/conserveogram/cons_toc.html.* Curatorial Service Division, National Park Services. Washington DC. July 1995.

Knapp, Tony. Conserve O Gram. *'Caring for Cellulose 14/8.'* *http://www.nps.gov/history/museum/publications/conserveogram/cons_toc.html.* Regional and Affiliated Archives Programs, National Archives and Records Administration. College Park, MD. August 2004.

Kodak Environmental Services, Publication No. H-182. *Safe Handling, Storage, and Destruction of Nitrate-Based Motion Picture Film.* Rochester, N. Y.: Eastman Kodak Company, 2006.

Lavedrine, Bertrand. *A Guide to the Preventive Conservation of Photograph Collections.* Los Angeles: The Getty Conservation Institute, 2003.

Martin, Miranda and Sarah S. Wagner. *'How Do I House Glass Plate Negatives?' http://www.archives.gov/preservation/storage/glass-plate-negatives.html.* National Archives and Records Administration. The U.S. National Archives and Records Administration 8601 Adelphi Road, College Park, MD. Revised June 18, 2001.

Mees, C. E. Kenneth. *From Dry Plates to Ekatchrome Film: A Story of Photographic Research.* New York: Ziff-Davis Publishing Company, 1961.

Messier, Paul. *'Preserving Your Collection of Film-Based Photographic Negatives.' http://palimpsest.stanford.edu/byauth/messier/negrmcc.html.* Conservators of Fine Arts and Material Culture Rocky Mountain Conservation Center 1993. Updated August 24, 2005.

Munson, Marit. *'Guidelines for The Care of Works on Paper with Cellulose Acetate Lamination.' http://www.nmnh.si.edu/anthro/conservation/lamination/lamination_guidelines.htm.* Getty Grant Program: National Museum of Natural History, Smithsonian Institution, no date. July 2007.

National Library of Australia. *Storage of Cellulose Acetate Collections: A Preliminary Survey of Issues and Options (pdf).* Australia: National Library of Australia, 2002.

National Museum of Photography Film & Television. '*Glass Negatives: Information Sheet 5.3.10.*' Bradford, West Yorkshire, NMPFT, 2000.

Nishimura W. Douglas, James M. Reilly and Edward Zinn. *New Tools for Preservation: Assessing Long Term Environmental Effects on Library and Archive Collections.* Rochester, NY: Image Permanence Institute, 1995.

Ogden, Sherelyn. Preservation Leaflet 4.1 *'Storage Methods and Handling Practices.' http://www.nedcc.org/resources/leaflets/4Storage_and_Handling/01StorageMethods.php.* Northeast Document Conservation Center Historical Society, 2007.

Paddock, Eric. *'Portrait of an Era: A History of Glass Plate Negative Photographs.' http://www.aspenhistory.org/poe.html.* Colorado Historical Society, 1995.

Reilly, James, M. *IPI Storage Guide For Acetate Film: Instructions for Using the Wheel, Graphs, and Table, Basic Strategy for Film Preservation.* Rochester, NY: Image Permanence Institute, 1993.

Reilly, James. M. *Care and Identification of 19th Century Photographic Prints.* Rochester, N. Y.: Silver Pixel Press, 2001.

Ritzenthaler, Mary-Lynn and Diane Vogt-O'Connor. *Photographs Archival Care andManagement.* Chicago: Society of American Archivists, 2006.

Selwitz, Charles. *Cellulose Nitrate In Conservation.* United States of America: J.Paul Getty Trust, 1988.

'Storage of Cellulose Acetate Collection: A Preliminary Survey of Issues and Options' (PDF). Australia: National Library of Australia, February 2002.

'The Big Picture: Rehousing the Library's Glass Negative Collection.' http://www.nla.gove.au/pres/conver/070296.html. National Library of Australia. Canberra Act 2601 Australia, March 22, 2007.

The Dangers of Cellulose Nitrate Film. Printed by the Health & Safety Executive Crown Copyright, August 2003.

Valverde, Maria Fernanda. *Photographic Negatives Nature and Evolution of Processes.* Rochester, New York: Advanced Residency Program in Photographic Preservation, Andrew W. Mellon Foundation, 2005.

'Vinegar Syndrome' Australia. *http://www.members.optusnet.com.au/picture/Vinegar%20Syndrome.html.* July 2007.

Wilhelm, Henry. *The Permanence and Care of Color Photographs: Traditional and Digital Color Prints, Color Negatives, Slides, and Motion Pictures.* Grinnell, Iowa: Preservation Publishing Company, 1993.

Yarsley, V. E., W. Flavell, P.S. Adamson and N.G. Perkins. *Cellulosic Plastics: Cellulose Acetate; Cellulose Ethers; Regenerated Cellulose; Cellulose Nitrate.* London: Iliffe Books Ltd., 1964.

References

[1] Carr McLean – Museum and Archival Supplies, *http://www.carrmclean.ca*, July 2nd 2007.

[2] *http://www.palimpset.stanford.edu/waac/wn/wn10/wn10-3/wn10-302.html*, May 2007.

[3] Valverde, Maria Fernanda. *Photographic Negatives Nature and Evolution of Processes.* Rochester, New York: Advanced Residency Program in Photographic Preservation, Andrew W. Mellon Foundation, 2005.

[4] Adelstein, Peter, Z. *IPI Media Storage Quick Reference.* Rochester, New York: Image Permanence Institute, 2004.

[5] Paddock, Eric. *'Portrait of an Era: A History of Glass Plate Negatives Photograph' http://www.aspenhistory.org/poe.html.* Colorado Historical Society, 1995. May 2007.

[6] Eggleton, Elizabeth (editor). *Conservation of Photographs.* Rochester, New York: Eastman Kodak Company, 1985, p 37,40, 91, 92, 134.

[7] Hendriks, Klaus B. *CCI Notes 16/2: Care of Black-and-White Photographic Negatives on Film. Ottawa, Ontario: Canadian Heritage, 1996.*

[8] Ritzenthaler, Mary- Lynn and Diane Vogt-O'Connor. *Photographs Archival Care and Management.* Chicago: Society of American Archivists, 2006, p 218, 226, 227, 228, 251, 253, 489.

[9] National Museum Photography Film & Television. *Glass Negatives: Information Sheet 5.3.10.* Bradford, West Yorkshire, NMPFT, 2000, p 2.

[10] Martin, Miranda and Sarah S. Wagner. *'How Do I House Glass Plate Negatives.'http://www.archives.gov/preservation/glass-negatives.html.* College Park, MD: National Archives and Records Administration, Revised June 2001. May 2007.

[11] Herskovitz, Robert. *Storage of Glass Plate Negatives.* Minnesota: Minnesota Historical Society, 1999, p 3.

[12] Wilhelm, Henry. *The Permanence and Care of Color Photographs: Traditional and Digital Color Prints, Color Negatives, Slides and Motion Pictures.* Grinnell, Iowa: Preservation Publishing Company, 1994, p 489.

[13] Reilly, James. M. *Care and Identification of 19th Century Photographic Prints.* Rochester, N. Y.: Silver Pixel Press, 2001, p 10, 92.

[14] *'The Big Picture: Rehousing the Library's Glass Negative Collection.' http://www.nla.gov.au/pres/conver/070296.html.* National Library of Australia. Canberra Act 2601 Australia, March 22, 2007. May 2007.

[15] Bahnemann, Greta *'The Preservation of Glass Plate Negatives' http://webjunction.org/do/DisplayContent?id=12112.* Web Junction, December 2005. May 2007.

[16] Lavedrine, Bertrand. *A Guide to the Preventive Conservation of Photograph Collections.* Loss Angeles: The Getty Conservation Institute, 2003, p 17- 19, 23, 89,247-255.

[17] Hopkins, William L. *'Cold Storage for Glass Plate Negatives' http://palimpsest.stanford.edu/byform/mailing-lists/cdl/2002/0476.html.* Conservation Distlist Instance, Cool, April 2002. May 2007.

[18] Ordgen, Sherelyn. Preservation Leaflet 4.1. *' Storage Methods and Handling Practices.' http:// www.nedcc.org/resources/leaflets/4Sotrage_Handling/01StorageMethods.php* Northeast Document Conservation Center Historical Society, 2007. June 2007.

[19] Reilly, James M. *IPI Storage Guide for Acetate Film: Instructions for Using the Wheel, Graphs and Table, Basic Strategy for Film Preservation.* Rochester, NY: Image Permanence Institute, 1993, p 10, 11, 13, 19, 20.

[20] Kodak Environmental Services, Publication No. H-182. *Safe Handling, Storage, and Destruction of Nitrate-Based Motion Picture Film.* Rochester, N. Y.: Eastman Kodak Company, 2006, p 1.

[21] *http://www.nps.gov/history/museum/publications/conserveogram/cons_toc.html* (o4-09 pdf).

[22] Balloffet, Nelly and Jenny Hille. *Preservation and Conservation for Libraries and Archives.* Chicago: American Library Association, 2005, p 187, 199-202.

[23] Health & Safety Executive. *The Dangers of Cellulose Nitrate Film.* Crown Copyright. August 2003, p 3.

[24] Eastman Kodak Company. *'Safe Handling, Storage, and Destruction of Nitrate-Based Motion Picture Films.' http://www.kodak.com/global/en/corp/environment/kes/pubs/pdfs/H182.pdf.* Rochester, NY. 2006. June 2007.

[25] Adelstein, Peter, Z, Douglas W. Nishimura and James M. Reilly. *Preservation of Safety Film.* Rochester: Image Permanence Institute, 1991, p 1, 3, 4, 13.

[26] *'Vinegar Syndrome'* Australia. *http://www.members.optusnet.com.au/picture/Vinegar%20Syndrome.html.* July 2007.

[27] Film Forever *'The Film Preservation Guide.'* AMIA *http://www.filmforever.org.* June 2007.

[28] Albright, Gary. *Conserve O Gram 14/2: Storage Enclosures for Photographic Prints.* Andover, Massachusetts: Northeast Document Conservation Center, July 1993.

[29] Messier, Paul. *'Preserving Your Collection of Film-Based Photographic Negatives.' http://palimpsest.standford.edu.byauth/messier/negrmcc.html.* Conservators of Fine Arts and Material Culture, Rocky Mountain Conservation Center, 1993 (updated August 24, 2005).

[30] Gordon, L. Paul. *The Book of Film Care.* Rochester: Eastman Kodak Company, 1983, p 33.

[31] National Library of Australia. *Storage of Cellulose Acetate Collections: A Preliminary Survey of Issues and Options (pdf).* Australia: National Library of Australia, 2002, p 9.

[32] Munson, Marit. *'Guidelines for the Care of Works on Paper with Cellulose Acetate Lamination.'http://www.nmh.si.edu/anthro/conservation/lamination/lamination_guidelines3.htm,* Artwork Preservation Project; Smithsonian Institute, July 10th 2007.

[33] Reilly, James. M. *Care and Identification of 19th Century Photographic Prints.* Rochester, N. Y.: Silver Pixel Press, 2001, p 92.

[34] Monique Fischer, *'A Short Guide to Film Base Photographic Materials: Identification, Care, and Duplication.'* Northeast Document Conservation Center. *http://www.nedcc.org/resources/leaflets/5Photogrpahs/01ShortGuide.php,* 2007. July 4th, 2007.

[35] Bennett, Karen L. and Jessica S. Johnson. *'Identification of Film-Based Photographic Material 14/9.'* Washington, DC: Conserve O Gram, September 1999.