THE DEMISE OF SAFETY FILM
A REVIEW OF THE CELLULOSE ACETATE BASED NEGATIVES
IN THE COLLECTION OF THE KODAK CANADA ARCHIVE

by

Megan Lena Harris
Bachelor of Science in Photography, Drexel University, 2003

A Thesis Project

presented to Ryerson University

in partial fulfillment of the

requirements for the degree of

Master of Fine Arts

in the Program of

Photographic Preservation and Collections Management

Toronto, Ontario, Canada, 2006

© Megan Lena Harris 2006

UMI Number: EC53509

INFORMATION TO USERS

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleed-through, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

UMI Microform EC53509
Copyright 2009 by ProQuest LLC
All rights reserved. This microform edition is protected against
unauthorized copying under Title 17, United States Code.

ProQuest LLC
789 East Eisenhower Parkway
P.O. Box 1346
Ann Arbor, MI 48106-1346

I hereby declare that I am the sole author of this thesis.

I authorize Ryerson University and George Eastman House International Museum of Photography and Film to lend this thesis to other institutions or individuals for the purpose of scholarly research.

✓
I further authorize Ryerson University and George Eastman House International Museum of Photography and Film to reproduce this thesis by photocopying or by other means, in total or in part, at the request of other institutions or individuals for the purpose of scholarly research.

✓

The Demise of Safety Film
A Review of the Cellulose Acetate Based Negatives
in the Collection of the Kodak Canada Archive

Megan Harris

Master of Arts 2006
Photographic Preservation and Collections Management
Ryerson University

The vinegar syndrome, a process in which cellulose acetate based films deteriorate, is becoming a prominent problem within collections worldwide. To understand this phenomenon one must look at the history and make up of cellulose acetate, the chemistry of the degradation process and the steps institutions are taking to stabilize objects to allow future access. With this knowledge, preservation strategies need to be applied to promote longevity. To illustrate this idea, a collection of forty degrading negatives from the Kodak Canada Archive at Ryerson University Library have been used as a case study in which research on cellulose acetate, the chemistry of this material, the vinegar syndrome, and present recommendations for storage have been taken into consideration and used as a basis for a re-housing project. All information and objects are used to argue for the preservation of such objects and the understanding of the importance of the object itself.

I would like to thank the following individuals for their guidance, aid, and support:

Chris Evans, Thesis Adviser

Susan Patrick, Ryerson University Library

Bruce Horsburgh, Director of Corporate Communications at Kodak Canada

Table of Contents

Introduction - 1

1. Cellulose Acetate Film Base - 3

2. Chemistry of Cellulose Acetate and the Vinegar Syndrome - 5

3. Present Actions - 8

4. Importance of the Original Object - 11

5. Case Study

History of Kodak Canada and its Collections - 14

Previous Housing and Storage - 16

Current Housing and Storage - 19

Conclusion - 22

Appendices

1: Significant Dates in the History of Cellulose Acetate - 23

2: Structure of Contemporary Film - 24

Taken from K.B. Hendriks' *Fundamentals of Photograph Conservation*.

3: Stages of Deterioration - 25

Taken from Bertrand Lavedrine's *A Guide to the Preventative Conservation of Photograph Collections*.

4a–4c: Previous Storage of the Kodak Corporate Archive - 26

5a–5d: Present Storage of the Kodak Corporate Archive and Heritage Collection - 29

6a–6b: Box 1 and 2 Inventories - 33

7a–7t: Box 1 Negative Reports - 35

8a–8t: Box 2 Negative Reports - 55

Notes - 75

Bibliography - 77

Introduction

When black-and-white negatives on acetate or polyester film are processed properly, and are protected in storage from the effects of heat, moisture, oxidizing gases, and reactive storage materials, they are extremely stable articles. They will outlast most other photographic records and, since they can be duplicated with very little loss of quality by a comparatively simple process they constitute the best material for archival purpose.¹

In 1979, this was the popular conception, but within three decades it has been proven to be false. Negatives produced on a cellulose acetate base are no longer considered stable, nor are they considered the best material for archival purposes; the belief is now quite the reverse. Objects of this nature have been proven to inevitably deteriorate through the process known as the vinegar syndrome.

Vinegar syndrome, the phenomenon identified and documented within the past twenty years, is ravaging photographic collections of cellulose acetate worldwide.² Cellulose acetate was widely used from the 1920s through the 1980s. The relatively inexpensive and easily produced base became the substrate of choice after cellulose nitrate based films were found to be hazardous. Because cellulose acetate was so widely used in the production of motion pictures, home movies, and photographic negatives there are decades worth of images in museums, archives, and homes, which if not properly identified and preserved will disappear forever.

A collection of such deteriorating objects is located within the Kodak Canada Archives at the Ryerson University Library. Among a large collection of objects donated in 2005, these cellulose acetate based negatives are exhibiting signs of various stages of the vinegar syndrome deterioration process. These vinegaring negatives are a preservation concern and had to be dealt with to prevent them from reacting with other objects in the collection. A re-housing project was

begun based upon research of current guidelines and the opinions of those with extensive knowledge and experience of the subject.

The first chapter presents an overview of the history of cellulose acetate based film and a general description of what it is. The second chapter goes into further detail on the chemistry of cellulose acetate plastics and their inherent deterioration problems. A background and description of the vinegar syndrome is also laid out in detail in this second chapter. Chapter three contains information on the present actions being taken by institutions and researchers worldwide. Professional opinions and recommendations are stated for the preservation of objects that are experiencing the vinegar syndrome. The fourth chapter includes opinions on why objects of this nature should be preserved; defending the importance of the original object in the ever-evolving digital era. Finally the last chapter includes a case study of objects located within the holdings of the Kodak Canada Archive at Ryerson University Library. A collection of forty cellulose acetate based negatives, in different stages of the vinegar syndrome, are used as an example to promote the importance of preservation and to provide a visual illustration of the vinegar syndrome's ability to severely degrade objects.

1. Cellulose Acetate Based Films

Cellulose acetate based films took over the motion picture and photographic industries in the mid-twentieth century (see Appendix 1). It took time for the acceptance of the acetate base in both industries, but finally the conscientious decision to move from nitrate to acetate was made. The shift was initially made more so for the prevention of fire than any other reason. The inherent dangers of cellulose nitrate based films to self-combust and cause unstoppable fires had become a liability in cinemas, and the danger could not be brought into homes. Much effort was placed in finding a stable photographic base that was not as dangerous as nitrate. The emphasis on a non-flammable base was imperative, but the new base left much to be desired. "Acetate bases are less flexible, more brittle, and do not wear as well as their nitrate counterparts."³

The shift of base materials can be linked to George Eastman and his company, Kodak, who were establishing an ever-growing 16mm home movie industry. With the popularity of such technology, Kodak knew they could not introduce cellulose nitrate based motion picture film to the general public. Eastman Kodak's "safety film" was the answer; this non-flammable cellulose acetate motion picture film became popular in the 1920s.⁴ It took several years after its inception for acetate to become the base of choice for the motion picture industry outside of the home. It took some time for the base to be embraced within the still photographic world as well.

Acetate sheet films were also introduced during the early twentieth century, although they would not be produced in mass amounts until a decade later in the 1930s.⁵ Also around this time all x-ray film production followed suit and began to use acetate based films instead of nitrate due to the large numbers of holdings within institutions such as hospitals.⁶ It wasn't until the 1950s that all nitrate based film production and use ceased.⁷

It is important to understand the great effort that was put into establishing a base that would not have a high flammability rate. The main goal was to reduce liability, while maintaining the structure of the base (see Appendix 2). The first cellulose acetate bases did not live up to their nitrate counterparts in terms of wear and tear. Kodak invested a great deal of time and money into the research and creation of a better “safety film,” one that would eventually be deemed fit to replace all cellulose nitrate.

2. Chemistry of Cellulose Acetate Based Films and the Vinegar Syndrome

Cellulose acetate “is obtained by the action under rigidly controlled conditions, of acetic acid and acetic anhydride on purified cellulose usually obtained from cotton linters. All three available hydroxyl groups in each glucose unit of the cellulose can be acetylated”.⁸ In other words; cellulose, an organic compound found in forms of cotton, can be combined with acids such as acetic acid or nitric acid to create a plastic.

“Polymeric substances like cellulose are composed of long chains of repeating individual units. In the case of cellulose, chains of 500-2000 units are typical, and each individual unit has 3 possible sites where it can be chemically modified.”⁹ The three sites of each unit on the chain are where the acetic acid reacts with the cellulose, creating cellulose acetate. These side units are also where the cellulose acetate vinegar syndrome deterioration takes place.

One of the largest problems in the housing and storage of cellulose acetate based films is the presence of moisture in the environment. When moisture is introduced to the cellulose acetate the units experience the chemical reaction known as hydrolysis, the “chemical decomposition of a substance involving the addition of water.”¹⁰

When the acetyl side groups are hydrolysed, acetic acid is released. This moment of release of acetic acid is the point at which the vinegar syndrome begins. Once this reaction begins there is no stopping it. “The side groups in all the cellulosic plastics are acids after they have been hydrolyzed from the cellulose backbone.”¹¹ The now free acids continue to react with other side groups along the cellulosic chain; they act as catalysts for further hydrolysis, which in turn leads to a continuation of the release of more acid.¹²

The deterioration that occurs during this vinegar syndrome process ranges from a vinegar odour to complete destruction of the negative substrate. There are five stages that are used to

categorize the level of deterioration that a negative has reached (see Appendix 3). They range from the slight appearance of the vinegar odour in the first stage to the shrinkage, wrinkled gelatin and brittleness of the fifth stage.

Release of acetic acid is the first step in the detrimental process negatives will go through, this is the point at which a vinegar odour becomes evident; the definitive vinegar smell is the scent of acetic acid being released. From this stage the deterioration evolves to the visible manifestations of the deterioration problem.

The second stage of deterioration sees the vinegar odour becoming stronger and the film becoming brittle. From here the third stage begins and damage to the base becomes visible. Buckling of the base begins. This is the first evidence of the loss of the side groups and the breaking of the bonds between the units of cellulose acetate in the base.

The fourth stage is at which point the plasticizers break free from their ties with the base, emanating in a frost or bubbles on the surface of the negative.¹³ Plasticizer is the flame retardant additive used in safety films to keep them from burning at a dangerous rate. Plasticizers also play a role in controlling film flexibility.¹⁴

The fifth stage, being the most severe, includes base shrinkage, wrinkled gelatin, and channelling. The units on the polymer chain of cellulose acetate continue to break apart from each other and advance shrinkage of the cellulose base occurs. The gelatin emulsion of the negative does not experience any loss in photographic density but it begins to wrinkle as it loses its bond with the cellulose base. As the base shrinkage continues, the gelatin emulsion remains the same size but there is less and less base for the emulsion to adhere to. The visual manifestation of this is clear as the emulsion begins to form wrinkles as well as buckling up, or channelling.¹⁵

Once base loss, and buckling and wrinkling of the emulsion have occurred the negative is not printable anymore. It is important to take actions to preserve these objects when the slight vinegar odour of stage one is noticed. The autocatalytic nature of the degradation means that deterioration will only continue and strengthen rapidly. Retardation of the vinegar syndrome at the earliest stage is imperative in promoting longevity of such objects.

3. Present Actions

When re-housing negatives it is important to put into perspective both the micro and macro environments. Present knowledge and research recommends storage and housing in terms of both the overall environment and the specific materials in contact with the objects. It is suggested by researchers working with objects affected by the vinegar syndrome to keep the objects in cold storage with a low relative humidity.¹⁶ This overall environmental recommendation is proven to be effective and is implemented in collections worldwide.¹⁷ Once the deterioration of the vinegar syndrome begins it can never be stopped, but the rate of deterioration can be dramatically retarded when precautions are put into play.

There are two basic preservation strategies that are used in institutions that are dealing with degrading objects. The first is controlling the macro environment of the storage area by maintaining a reasonable temperature and relative humidity. The second is the microenvironment, using specific housings that come in direct contact with the objects.

Relative humidity is an “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.”¹⁸ Controlling the amount of moisture in the air in the storage environment is essential for the preservation of photographic objects. A relative humidity of 20-30% is the most recommended RH for the storage of cellulose acetate negatives. Any higher and the amount of moisture in the air can be detrimental to the negatives by promoting the hydrolysis can lead to the vinegar syndrome.

Cold storage is the best strategy for the preservation of cellulose acetate films.¹⁹ Chemical reactions, including the hydrolysis reaction responsible for vinegar syndrome, are extremely temperature sensitive. Lowering the temperature can slow the vinegar syndrome dramatically. When objects are placed in cold storage the ability to keep the environment at a

controlled constant temperature and relative humidity are great advantages. It is possible for an institution to purchase a cold storage vault system, but this is an expensive endeavour. A cold storage alternative to a vault is to purchase a commercial frost-free freezer. Inexpensive and space efficient, these freezers run at around zero degrees Fahrenheit. This temperature is ideal for the cold storage of photographic objects such as safety film.²⁰

While commercial freezers are at an optimal temperature for storage, the control of relative humidity leaves much to be desired. The frost-free option of the freezers is an option institutions should take into consideration. This feature however, cannot stand alone in the fight for moisture control in the macro environment. A good microenvironment is also essential when combating moisture in cold storage situations.²¹

Microenvironments are the housings that surround objects and come in direct contact with them. The most important of these housings, when dealing with cold storage in a commercial freezer, is the polyethylene bag. The housed object is placed inside zip loc style polyethylene bags. It is recommended that two bags be used on the same object; this offers a double barrier from the moisture of the outside environment. If one bag isn't securely closed or a tear appears, there is another bag as a back up to create another barrier for moisture.

Though polyethylene bags are important to the longevity of the objects housed in freezers, there are other housings that are included in the microenvironment, which are imperative for preservation. Every institution has its own way of housing objects that may differ from others but there is a tendency to have the same general understanding of what materials are beneficial.

The paper envelope is another housing important to the preservation of negatives. When a negative is housed in cold storage it should be placed within an envelope. These paper

enclosures offer a three closed side sleeve to place the negative in. Acid free and opaque, it is believed that for direct contact with the negative these are best. Once in breathable envelopes, which prevent moisture and acetic acid vapour build up, the package can be placed in another paper enclosure. A folder acts as a secondary barrier from the outside environment.

Once the negative is packaged in these paper enclosures it should be placed within an archival box. For degrading cellulose acetate negatives it is best to store them on their edges, if stored flat they have the ability to weigh down on one another. With the negatives securely placed upright in archival quality boxes, all that is needed to complete the microenvironment package is the aforementioned polyethylene bags.²²

If the negatives have not entered extreme stages of deterioration, scans can be made of the images. Once the negatives become brittle and the gelatin begins to wrinkle, due to the loss of base, it becomes impossible to place the objects on a flat bed scanner safely. The fragility and three dimensionality of the object restrict duplication.

Extensive research is still being performed on the vinegar syndrome problem and into the precautions, which must be considered when preserving such objects. The best thing to do presently is to try to slow down the chemical reaction as much as possible, ensuring added years to the lifespan of the negatives. All experiments and research are done in the hopes that in the future a treatment for the stoppage of complete deterioration will be found.

4. Importance of the Original Object

Many people may question the importance of preserving objects such as negatives. Their argument is that digital scans can be made from the originals. That as long as there is a surrogate image the original degrading object doesn't need to be protected. Preservation of objects can be costly and many feel that creating digital surrogates is an inexpensive answer to the problem. Some believe that the negative is not as important as the prints created from it, and that if already existing, there is no need to keep the negative or worry about its preservation. While these arguments make sense to some, others believe the original object is what is important. Physical and theoretical points can be made in the defence of the importance of the negative.

John Loengard states "Ansel Adams signed more than 800 prints of his *Moonrise, Hernandez, N. Mex.*, during his lifetime, but his negative is unique."²³ Without the negative, photographic prints could not be produced; it is the first object in the photographic process. Acting as a basis from which to reproduce an image, the negative is an object that enables imagery to be produced and viewed by many. With this being stated, how can one deny such an object its importance and preservation? The easy route isn't always the best route in regards to collections.

John Szarkowski argues that "a photographic negative generally contains much more information than a print made from it, because the negative is a transparency, and thus can have a much longer scale of relative values, in exactly the same way that a stained-glass window has a longer scale of values than a painting on a panel or a canvas."²⁴ While Ansel Adams compares the negative to the "writing of a musical score, or the preparation of architectural designs and plans for a structure."²⁵ John Loengard also makes a similar statement when referring to making a print from a negative as "a bit like translating a novel from French to English. Such translation

is an art, and it is wise to remember that what is translated is the original work of art.”²⁶ These three views cannot be overlooked in the argument for the preservation of negatives.

The acquisition of negatives has not been a common practice among institutions and private collectors. Objects such as paper negatives produced by William Henry Fox Talbot have been considered valuable and worth collecting due to the historical importance of the process, while negatives on other bases have not. With the phasing out of photographic film and the inherent changes of the medium it can be argued that negatives will become viewed as objects of historical importance. As time passes objects overlooked become desired due to the change in society and technology.

The founding director of the International Center of Photography, Cornell Capa said “I don’t want collectors to collect negatives. They’d destroy the negative so the print they own would be more valuable.”²⁷ This statement points towards the shift in the thinking behind the negative.

The advent of digital photography has not only changed the world of photography, but also in the preservation of photographic objects. Preservation methods and technology have evolved in such an extreme way that many are not thinking about the long-term effects of this technology. Creating digital files of objects is something that should be done, but one cannot place all their trust in an image readable only by machines. Digital images demand constant changing file formats and currently there is a lack of knowledge on the longevity of common storage media like CDs and hard drives. With the present technological environment no one can guarantee the life of a digital file. To create digital files and disregard the original is a common, yet risky decision.

Along with the risk involved with longevity of digital files, there is also the quality to take into consideration. It is inevitable that platforms of technology change and that the migration of digital information take place. With this migration comes the loss of information within the image. Every time an image is transferred from one platform to another, whether it is from disk to CD or from one database to another, there is a definitive loss of information in all the transfers that are made.²⁸

5. Case Study

History of Kodak Canada and its Collections

Kodak Canada Limited has been a staple in the Toronto, Ontario area since 1899. Presently located on the west side of Toronto, the massive complex of white buildings stands as a reminder of the years of production and the hundreds of thousands of Canadians that passed through the gates for work. Organized in 1899 by orders of Kodak founder, George Eastman, Kodak's presence in Canada is an example of the worldwide demand for Eastman's photographic equipment and supplies at the time and the keen business sense of Eastman.

The Canadian division of Kodak manufactured products from 1899 to 1913 at its original downtown Toronto location. Quickly outgrowing the original space at 41 Colborne Street, production moved to its home of almost a century at Weston Road and Eglinton Avenue in Toronto. With space to build and expand the new facility became the permanent home for Kodak Canada Limited.²⁹

Throughout its decades of existence in Toronto, Kodak Canada Limited visually documented all the buildings and events at Kodak Heights, as the manufacturing site would become known. All information dealing with the company, from photographs to textual files, was saved and placed in storage in the company's corporate archive. Accessed on a regular basis, this corporate archive was originally arranged by subject heading. All information, photographs, negatives, and textual material, relating to a certain subject were placed together in a folder and filed away. Also in this space were located publications and handwritten historical books. These were stored on metal shelving units.

For the one hundredth anniversary of Kodak in Canada a Centennial Project was established in 1999. The creation of what is called the Kodak Canada Heritage Collection

Museum was established to exhibit cameras, equipment, photographs, and other Kodak ephemera from the company's history. The Heritage Collection Museum was the last thing to be removed when the Kodak Heights site closed in 2006.

Now housed at the Ryerson University Library, the Kodak Heritage Collection Museum contents have been kept in chronological order, as it had been displayed at Kodak. Also, the labels used in the Kodak Heritage Collection Museum have been kept with the objects. Previously housed in glass cases, the collection is now housed in archival storage and is accessible to anyone who wishes to view the objects.

The collection was donated to the Ryerson University Library in the year 2005 after the announcement of the impending closure of the Canadian site. With the ever-growing technological advances in digital photography technology and the decrease in demand for photographic supplies, Eastman Kodak Company began to shut down Kodak sites around the world. For Kodak to create digital photography technology and supplies there was no need for massive amounts of employees. Cut backs and downsizing have lead to the closing of such plants as Kodak Canada Limited. With the plant closing the corporate archives and Heritage Collection needed a new home.

Ryerson University has had connections with Kodak Canada for years. A Kodak lecture series had been set up at Ryerson and there was a Kodak Canada chair within the well-known Images Arts department at the university. The presence of such a wide collection, ranging from the chronological structure and display of the Heritage Collection to the massive amounts of historical data held within the corporate archives, at an institution like Ryerson University ensures future use from the holdings. The range of information the collection holds is useful to a number of academic programs at the university.

Case Study

Previous Housing and Storage

When located in Building 9 at Kodak Heights, housing concerns were not a priority for the Kodak Corporate Archive. The objects included in the archive were used on a regular basis. Placed within hanging file folders located in a number of filing cabinets, the importance of accessibility and usability is clearly illustrated by the original order created by Kodak.

The room located on the third floor of Building 9 was not an ideal environment for the collection (see Appendices 4a and 4b). One of the only rooms that never received any air conditioning, the room was very warm and musty. Two walls of the room were lined with large windows; the amount of direct sunlight within the room is evident in the deterioration of many objects. Fading of imagery and objects is not the only degradation resulting from sunlight. The immense heat from the sunlight also contributed to the deterioration of collection objects.

Dust, dirt, and mould were also problems within the room. Just looking at the air vent raises a red flag for any collection manager (see Appendix 4c). The dust and dirt stains on the wall around the air vent are a reminder of the lack of care provided to the objects themselves. Mould is a common problem among the many albums and record books Kodak had kept throughout the years. It is evident that the state of the room aided in the production of this of mould.

Once donated to the Ryerson University Library, the archive was kept in a small room on the third floor of the Ryerson University Library building. The collection remained in the filing cabinets and boxes in which it was packaged and moved in. In this small room the temperature is controlled as much as possible. The air conditioning is on at all times, but fluctuates as the

seasons change. As the room was not originally built for collection purposes, but as a meeting room for library staff, it does not offer an optimal housing environment.

A collection wide inventory was begun once the collection had been moved to Ryerson from Kodak. Beginning with materials located in filing cabinets, a detailed count was created. An initiative to separate objects was started. The original order of the collection has been kept in an intellectual sense, but not retained physically due to preservation issues. The small space of the room allows for only a small number of objects to be worked with at one time. Inventorying has been a lengthy process and re-housing was being done at the same time to save time and create a better environment for the materials.

It was decided that the objects in the filing cabinets were more at risk than the boxes of textual material and publications. These textual documents and publications did not create as great a preservation concern as the mixed materials in the filing cabinets.

First nitrate negatives were identified and immediately removed from the files. The nitrate negatives within the archive are an extreme risk to the collection as well as the building in which the collection is located. To significantly reduce the inherent fire dangers of nitrate, these negatives were individually housed in negative sleeves and placed inside a Kenmore Frost Free freezer that was purchased in June 2005 specifically for the cold storage of such objects within the Kodak Archive.

After the nitrate negatives were separated and re-housed all the acetate-based negatives that were beginning to vinegar out were removed and treated in the same manner. Each negative was placed in a print envelope; as many were buckling and curling, they needed housing that offered more space. Then the envelopes were placed in drop front Hollinger boxes and stored in the freezer.

In February of 2006, the Kodak Canada Archive at Ryerson University Library was moved from the third to the first floor of the Ryerson University library building (see Appendix 5a). During a remodelling project space was set aside for the storage of the Kodak collection and other special collections located at the library. This space is double the size of the previous room, and environmental concerns were taken into consideration. This room is air conditioned and easily controlled, although it too fluctuates over the year. Metal shelves were installed in the space for storage of the collection.

Case Study

Present Housing and Storage

After much research was done on the advised storage and housing of safety film, acetate based negatives, a re-housing project was begun within the Kodak Canada Archive at the Ryerson University Library. Decisions about proper storage and housing were based on information from such respectable research laboratories as the Image Permanence Institute at the Rochester Institute of Technology and archival standards from the National Archives in Washington D.C. and the Canadian National Archives in Ottawa.

With the proper guidance and suggestions the storage and housing of the negatives also had to fit into the constraints with which the Ryerson University Library had placed on the archive. Such constraints as space and money needed to be considered. With the archive already containing a commercial frost-free freezer, cold storage of the objects had to be planned accordingly. Having a limited amount of space within the freezer for acetate based negatives, the decision of which objects to store in the freezer had to be made.

It was decided to house these objects within Hollinger boxes that were then placed in the frost-free freezer. Each individual negative is stored inside an acid free un-buffered 8 x 10 paper envelope. The envelopes are then placed inside acid free map folder stock folders, which are then housed inside Hollinger document boxes. Since the negatives are fragile and have a tendency to crack and break, they were moved from Hollinger drop front print boxes to upright Hollinger document boxes to keep them from weighing down on each other (see Appendices 5b and 5c).

To ensure the best possible storage of the objects inside the freezer each Hollinger document box is placed in two polyethylene zip lock bags (see Appendix 5d). The double

bagging method offers an extra layer of protection from moisture that may build up. If one of the bags has a tear, or the closure opens, the second polyethylene bag offers a back up barrier from the outside environment.

Each Hollinger box in the freezer contains twenty negatives. Inventories for each box were made including existing information and descriptions (see Appendices 6a and 6b). Reports were made for each individual negative (see Appendices 7a–7t and 8a–8t). Any information regarding a negative is included in these reports such and information stated is the condition of the negative and stage of deterioration, and original negative numbers and dates that were included with the original objects.

The detailed reports provide documentation of specific deterioration for each negative. Many of the negatives are only experiencing early stage degradation such as a vinegar odour, while others are in the later stages of deterioration. Detail images of curling, buckling, wrinkled gelatin, and base loss are included in the reports. These reports are able to act as surrogate images of the negatives, while also acting as visual documentation of the vinegar syndrome deterioration process. This is important to not only researchers but also to the collections manager of the archive; the ability to access the negatives at a later date and compare them to their previous states is valuable to the preservation of the objects. The ability to compare and note changes in the stability of an object also allows institutions to assess their housing and storage practices.

The new housing and storage plan implemented at the Kodak Canada Archive is a preservation action. The negatives will be accessed as little as possible to ensure their longevity. To allow researchers the ability to view the imagery on the objects, surrogate copies of the negatives were made. Unable to be scanned, the negatives are too brittle and there is too much

shrinkage to allow their placement on a flat bed scanner, they were placed on a light table and photographed with a digital camera. Photocopies of the prints from the original negatives already in the collection were made as another copy for researchers to view.

Access to the negatives is still available. If a researcher needs to see the original negative, they need to prove the necessity of viewing it and allow the archive the proper amount of time to acclimatize the object. If the researcher does not need to see the actual negative, the digital images, photocopies, and prints from the negatives within the collection all offer the information found on the negative.

Conclusion

The vinegar syndrome is detrimental to institutions holding collections of cellulose acetate based film everywhere. Whether it is still photographic, motion picture, or x-ray film, these objects will all experience the inevitable degradation that occurs within all cellulose acetate collections.

The documentation of the Kodak Canada Archive at Ryerson University Library has been presented to the viewer and offers visuals of the deterioration and the inherent dangers in the storage environment that have resulted in the state in which the collection is currently in. Previous and present housing and storage has been described to illustrate the importance of such specifications and the lengths that researchers and institutions have gone to preserve such objects.

While many may think the original negative object is not important, arguments have been made for the opposite. The argument of the original photographic object can't be denied. Not only are such objects important to the history of photography and the institutions in which they are collected, but also they can be used for further research and experiments in the longevity of housing and storage standards. The ability to be able to access to the negatives in years to come, while having a visual documentation from before re-housing, allows visual comparison, which in turn can be used to assess the storage and housing procedures.

Research has proven that years can be added to the life of these films if they are stored and housed properly. It is possible that with the extensive research and experiments focused on the vinegar syndrome resulting in new and more effective approaches, that these added years could be dramatically extended, preserving such negatives for much longer than is presently possible.

Appendix 1

Significant Dates in the History of Cellulose Acetate Based Films

1884 - Eastman Kodak Company's first commercially produced flexible roll film system is introduced³⁰

1908 – Eastman Kodak Company develops a non-flammable acetate safety film³¹

1920s – Acetate based sheet film introduced³²

1923 – Cine-Kodak film introduced, 16mm reversal film³³

1929 – All X-ray film production changed from nitrate to acetate base³⁴

1930 – Active cellulose acetate research program initiated at Eastman Kodak Company³⁵

1940 – All sheet film produced on acetate base³⁶

1948 – Cellulose triacetate replaced nitrate in the production of 35mm motion picture film³⁷

1948 – First account of acetate degradation reported to Eastman Kodak Company³⁸

1950 – Kodak ceased use of nitrate film base for its roll films, acetate replaces nitrate³⁹

1950 – Kodak wins an “Oscar” for its 35mm triacetate motion picture film⁴⁰

1960 – ESTAR base introduced, polyester film base⁴¹

1980s – Polyester film bases begin to replace acetate⁴²

Appendix 2

Structure of Contemporary Film

Taken from K.B. Hendriks' *Fundamentals of Photograph Conservation*.

From top to bottom the layers of film are:

- A. Gelatin Supercoat: This is a protective layer of gelatin. Silver grains are sensitive to light, but also to abrasion. Without this layer, any abrasion received during manufacture or handling of the unexposed film would show up after development as black abrasion marks.
- B. Emulsion: The silver gelatin emulsion consists of the gelatin binding medium and the light-sensitive silver halide crystals and may be made up of several layers, depending on the characteristics of the film type. (In some modern black-and-white films, the emulsions may contain layers of black-and-white chromogenic dyes.)
- C. Subbing (Substratum) Layer: A binding layer on a photographic support to provide better adhesion between the emulsion and the base.
- D. Support/Film Base: Most contemporary roll films use cellulose triacetate as the support. Unlike the early plastic bases (including cellulose nitrate and cellulose diacetate), cellulose triacetate is very stable chemically and dimensionally. Most modern sheet films have a polyester base for even greater stability. These modern bases are transparent, grainless, and virtually colorless.
- E. Gelatin Anti-Curl, Anti-Halation Layer: This layer is designed to match the thickness of the emulsion plus supercoat, to counteract the effect of humidity on the emulsion layer that may cause contraction and expansion. This layer usually contains an anti-halation dye, designed to absorb light when the film is exposed. Without it, light passing through the emulsion can be reflected back to the emulsion, forming “halos” – unwanted secondary exposure caused by stray light – around image highlights.

Appendix 3

Stages of Deterioration of Cellulose Acetate Bases

Taken from Bertrand Lavedrine's *A Guide to Preventative Conservation of Photograph Collections*.

1. The film is in good condition. There is a noticeable slight odour of acetic acid.
2. The film is in good condition. There is a strong odour of acetic acid.
3. The edges curl. The film is slightly brittle.
4. The film deforms. A deposit of plasticizer appears on the surface. The film becomes fragile.
5. The gelatin layer wrinkles. The film is brittle.

Appendix 4a

Storage room for Kodak Canada Corporate Archive at Kodak Canada, Building 9

Appendix 4b

Storage room for Kodak Canada Corporate Archive at Kodak Canada, Building 9

Appendix 4c

Storage room for Kodak Canada Corporate Archive at Kodak Canada, Building 9

Appendix 5a

Current Storage of Kodak Canada Archive at
Ryerson University Library

Appendix 5b

Housing of Vinegaring Safety Film at Kodak Canada Archive
at Ryerson University Library, Previous to Re-housing Project

Appendix 5c

Current Housing at Kodak Canada Archive at
Ryerson University Library
Hollinger Document Box with Folders and Envelopes

Appendix 5d

Current Storage at Kodak Canada Archive at
Ryerson University Library
Hollinger Document Boxes in Polyethylene Bags in Frost-Free Freezer

Appendix 6a

Box 1

Folder

1. Gymnasium
2. Cafeteria
3. Library
4. Cafeteria
5. Exterior of Building
6. Building Interior – Lobby of Building #9
7. Cafeteria Kitchen
8. Fire Hall
9. Addition to Building #5 – June 19, 1947
10. Addition to Building #5 – June 19, 1947
11. Fire Hall
12. Building Interior – April 1951
13. Cafeteria – Dining Area
14. Cafeteria – Dining Area
15. Addition to Building #5 – June 19, 1947
16. Exterior of Building and Water Tower
17. Addition to Building #5 – June 19, 1947
18. Exterior of Building and Water Tower
19. Exterior of Building and Water Tower
20. Front Gate and Exterior of Building and Water Tower – Original Number 1083

Appendix 6b

Box 2

Folder

21. Interior of Building – Lobby in Building #9
22. Perforator Recd. – 1937 – Original Number 206
23. Semi-automatic Spooling Lathe – 1935 – Original Number 203
24. Boxing and Wrapping Machine – 1936 – Original Number 199
25. Semi-automatic Spooling Lathe – 1935 – Original Number 202
26. Boxing and Wrapping Machine – 1936 – Original Number 200
27. Welding Machine – 1937 – Original Number 218
28. Welding Machine – 1937 – Original Number 217
29. Boxing and Wrapping Machine – 1936 – Original Number 201
30. Machinery – Original Number 103
31. Original Number 108
32. Machinery – Original Number 124
33. Machinery – Original Number 120
34. Machinery – Original Number 105
35. Machinery – Original Number 104
36. Machinery – Original Number 106
37. Machinery – Original Number 107
38. Machinery – Original Number 101
39. Machinery – Original Number 102
40. Man Running Machinery – Original Number 109

Appendix 7a

Current Location – Box 1 Folder 1 (In Freezer)

Previous ID –

Negative Number –

Description of Image – Building 9 Gymnasium

Date – Unknown

Stage of Deterioration– 3

Notes – Curling, Strong Vinegar Odor

Condition Of Negative

Bottom Left Corner of Negative

Appendix 7b

Current Location – Box 1 Folder 2 (In Freezer)

Previous ID –

Negative Number –

Description of Image – Building 9 Cafeteria

Date – Unknown

Stage of Deterioration– 3

Notes – Curling, Strong Vinegar Odour

Condition Of Negative

View From Left Side of Negative

Appendix 7c

Current Location – Box 1 Folder 3 (In Freezer)

Previous ID –

Negative Number –

Description of Image – Library

Date – Unknown

Stage of Deterioration- 3

Notes -Curling, Strong Vinegar Odour

Condition Of Negative

Curling of Right Side of Negative

Appendix 7d

Current Location – Box 1 Folder 4 (In Freezer)

Previous ID –

Negative Number –

Description of Image – Building 9 Cafeteria

Date – Unknown

Stage of Deterioration– 3

Notes - Curling, Strong Vinegar Odour

Condition Of Negative

Curling of Left Side of Negative

Appendix 7e

Current Location – Box 1 Folder 5 (In Freezer)

Previous ID –

Negative Number –

Description of Image – Exterior of Building

Date – Unknown

Stage of Deterioration– 3

Notes – Curling, Strong Vinegar Odour

Condition Of Negative

Curling of Right Side of Negative

Appendix 7f

Current Location – Box 1 Folder 6 (In Freezer)

Previous ID –

Negative Number –

Description of Image – Building 9 Lobby

Date – Unknown

Stage of Deterioration– 3

Notes - Curling, Strong Vinegar Odour

Condition Of Negative

Curling of Bottom of Negative

Appendix 7g

Current Location – Box 1 Folder 7 (In Freezer)

Previous ID –

Negative Number –

Description of Image – Cafeteria Kitchen

Date – Unknown

Stage of Deterioration– 3

Notes - Curling, Strong Vinegar Odour

Condition Of Negative

Curling of Left Side of Negative

Appendix 7h

Current Location – Box 1 Folder 8 (In Freezer)

Previous ID –

Negative Number –

Description of Image – Fire Hall

Date – Unknown

Stage of Deterioration– 2

Notes - Strong Vinegar Odour

Condition Of Negative

Appendix 7i

Current Location – Box 1 Folder 9 (In Freezer)

Previous ID – Addition to Building 5

Negative Number –

Description of Image – Addition to Building 5

Date – June 19, 1947

Stage of Deterioration– 2

Notes - Strong Vinegar Odour

Condition Of Negative

Appendix 7j

Current Location – Box 1 Folder 10 (In Freezer)

Previous ID – Addition to Building 5

Negative Number –

Description of Image – Addition to Building 5 Construction

Date – June 19, 1947

Stage of Deterioration– 2

Notes - Strong Vinegar Odour

Condition Of Negative

Appendix 7k

Current Location – Box 1 Folder 11 (In Freezer)

Previous ID –

Negative Number –

Description of Image – Fire Hall

Date –

Stage of Deterioration– 2

Notes - Strong Vinegar Odour

Condition Of Negative

Appendix 7I

Current Location – Box 1 Folder 12 (In Freezer)

Previous ID –

Negative Number –

Description of Image – Building Interior

Date – April 1951

Stage of Deterioration– 2

Notes -Strong Vinegar Odour

Condition Of Negative

Appendix 7m

Current Location – Box 1 Folder 13 (In Freezer)

Previous ID –

Negative Number –

Description of Image – Cafeteria – Dining Area

Date –

Stage of Deterioration– 2

Notes - Strong Vinegar Odour

Condition Of Negative

Appendix 7n

Current Location – Box 1 Folder 14 (In Freezer)

Previous ID –

Negative Number –

Description of Image – Cafeteria – Dining Area

Date – Unknown

Stage of Deterioration– 2

Notes - Strong Vinegar Odour

Condition Of Negative

Appendix 7o

Current Location – Box 1 Folder 15 (In Freezer)

Previous ID – Addition to Building 5

Negative Number –

Description of Image – Addition to Building 5 Construction

Date – June 19, 1947

Stage of Deterioration– 3

Notes - Curling, Strong Vinegar Odour

Condition Of Negative

Curling of Left Side of Negative

Appendix 7p

Current Location – Box 1 Folder 16 (In Freezer)

Previous ID –

Negative Number –

Description of Image – Exterior of Building and Water Tower

Date – Unknown

Stage of Deterioration– 2

Notes -Strong Vinegar Odour

Condition Of Negative

Appendix 7q

Current Location – Box 1 Folder 17 (In Freezer)

Previous ID – Addition to Building 5

Negative Number –

Description of Image – Addition to Building 5 Construction

Date – June 19, 1947

Stage of Deterioration– 2

Notes -Strong Vinegar Odour

Condition Of Negative

Appendix 7r

Current Location – Box 1 Folder 18 (In Freezer)

Previous ID –

Negative Number –

Description of Image – Exterior of Building and Water Tower

Date – Unknown

Stage of Deterioration– 2

Notes -Strong Vinegar Odour

Condition Of Negative

Appendix 7s

Current Location – Box 1 Folder 19 (In Freezer)

Previous ID –

Negative Number –

Description of Image – Exterior of Building and Water Tower

Date – Unknown

Stage of Deterioration– 2

Notes -Strong Vinegar Odour

Condition Of Negative

Appendix 7t

Current Location – Box 1 Folder 20 (In Freezer)

Previous ID –

Negative Number – 1083

Description of Image – Front Gate and Exterior of Building and Water Tower

Date –

Stage of Deterioration– 2

Notes -Strong Vinegar Odour

Condition Of Negative

Appendix 8a

Current Location – Box 2 Folder 21 (In Freezer)

Previous ID –

Negative Number –

Description of Image – Building #9 Lobby

Date –

Stage of Deterioration– 2

Notes - Strong Vinegar Odour

Condition Of Negative

Appendix 8b

Current Location – Box 2 Folder 22 (In Freezer)

Previous ID –

Negative Number – 206

Description of Image – Perforator Recd.

Date – 1937

Stage of Deterioration– 2

Notes -Strong Vinegar Odour

Condition Of Negative

Appendix 8c

Current Location – Box 2 Folder 23 (In Freezer)

Previous ID –

Negative Number – 203

Description of Image – Semi-automatic Spooling Lathe

Date – 1935

Stage of Deterioration– 4

Notes -Strong Vinegar Odour, Buckling

Condition Of Negative

Buckling of Right Side of Negative

Appendix 8d

Current Location – Box 2 Folder 24 (In Freezer)

Previous ID –

Negative Number – 199

Description of Image – Boxing and Wrapping Machine

Date – 1936

Stage of Deterioration– 5

Notes -Strong Vinegar Odour, Shrinkage, Brittle, Wrinkled Gelatin

Condition Of Negative

Shrinkage and Wrinkled Gelatin of Negative

Appendix 8e

Current Location – Box 2 Folder 25 (In Freezer)

Previous ID –

Negative Number – 202

Description of Image – Semi-automatic Spooling Lathe

Date – 1935

Stage of Deterioration– 4

Notes -Strong Vinegar Odour, Buckling

Condition Of Negative

Buckling of Right Side of Negative

Appendix 8f

Current Location – Box 2 Folder 26 (In Freezer)

Previous ID –

Negative Number – 200

Description of Image – Boxing and Wrapping Machine

Date – 1936

Stage of Deterioration– 5

Notes -Strong Vinegar Odour, Shrinkage, Wrinkled Gelatin, Yellow Discoloration

Condition Of Negative

Shrinkage and Wrinkled Gelatin of Negative

Top Edge of Negative

Appendix 8g

Current Location – Box 2 Folder 27 (In Freezer)

Previous ID –

Negative Number – 218

Description of Image – Welding Machine

Date – 1937

Stage of Deterioration– 3

Notes -Strong Vinegar Odour, Curling

Condition Of Negative

Appendix 8h

Current Location – Box 2 Folder 28 (In Freezer)

Previous ID –

Negative Number – 217

Description of Image – Welding Machine

Date – 1937

Stage of Deterioration– 3

Notes -Strong Vinegar Odour, Curling

Condition Of Negative

Appendix 8i

Current Location – Box 2 Folder 29

Previous ID –

Negative Number – 201

Description of Image – Boxing and Wrapping Machine

Date – 1936

Stage of Deterioration– 5

Notes -Strong Vinegar Odour, Shrinkage, Brittle, Wrinkled Gelatin

Condition Of Negative

Shrinkage and Wrinkled Gelatin of Negative

Top Edge of Negative

Appendix 8j

Current Location – Box 2 Folder 30 (In Freezer)

Previous ID –

Negative Number – 103

Description of Image – Machinery

Date –

Stage of Deterioration– 1

Notes -Slight Vinegar Odour

Condition Of Negative

Appendix 8k

Current Location – Box 2 Folder 31 (In Freezer)

Previous ID –

Negative Number – 108

Description of Image – Machinery

Date –

Stage of Deterioration– 3

Notes -Strong Vinegar Odour, Buckling

Condition Of Negative

Buckling of Right Side of Negative

Appendix 8I

Current Location – Box 2 Folder 32 (In Freezer)

Previous ID –

Negative Number – 124

Description of Image – Machinery

Date –

Stage of Deterioration– 1

Notes -Slight Vinegar Odour

Condition Of Negative

Appendix 8m

Current Location – Box 2 Folder 33 (In Freezer)

Previous ID –

Negative Number – 120

Description of Image – Machinery

Date –

Stage of Deterioration– 5

Notes -Strong Vinegar Odour, Shrinkage, Brittle, Wrinkled Gelatin

Condition Of Negative

Shrinkage and Wrinkled Gelatin of Negative

Top Edge of Negative

Appendix 8n

Current Location – Box 2 Folder 34 (In Freezer)

Previous ID –

Negative Number – 105

Description of Image – Machinery

Date –

Stage of Deterioration – 3

Notes – Vinegar Odour, Curling

Condition of Negative

Appendix 8o

Current Location – Box 2 Folder 35

Previous ID –

Negative Number – 104

Description of Image – Machinery

Date –

Stage of Deterioration– 1

Notes -Slight Vinegar Odour

Condition Of Negative

Appendix 8p

Current Location – Box 2 Folder 36 (In Freezer)

Previous ID –

Negative Number – 106

Description of Image – Machinery

Date –

Stage of Deterioration– 3

Notes -Strong Vinegar Odour, Curling

Condition Of Negative

Appendix 8q

Current Location – Box 2 Folder 37 (In Freezer)

Previous ID –

Negative Number – 107

Description of Image – Machinery

Date –

Stage of Deterioration– 3

Notes -Strong Vinegar Odour, Curling

Condition Of Negative

Appendix 8r

Current Location – Box 2 Folder 38 (In Freezer)

Previous ID –

Negative Number – 101

Description of Image – Machinery

Date –

Stage of Deterioration– 4

Notes -Strong Vinegar Odour, Buckling

Condition Of Negative

Curling of Top Edge of Negative

Appendix 8s

Current Location – Box 2 Folder 39 (In Freezer)

Previous ID –

Negative Number – 102

Description of Image – Machinery

Date –

Stage of Deterioration– 3

Notes -Strong Vinegar Odour, Curling

Condition Of Negative

Appendix 8t

Current Location – Box 2 Folder 40 (In Freezer)

Previous ID –

Negative Number – 109

Description of Image – Man Running Machinery

Date –

Stage of Deterioration – 4

Notes – Strong Vinegar Odour, Buckling, Brown Discoloration

Condition of Negative

Buckling of Left Side of Negative

End Notes

-
- ¹ Angels Arribas. *Preservation of Photographs* (1997), 32.
- ² J.L. Bigourdan. "Vinegar Syndrome: An Action Plan." *The Vinegar Syndrome: A Handbook, Prevention, Remedies, and the Use of New Technologies* (Bologna: The GAMMA Group, 2000).
- ³ Leslie Stroebel. *Photographic Material and Processes* (Boston, MA: Focal Press, 1996), 254.
- ⁴ Ibid.
- ⁵ James M. Reilly. *IPI Storage Guide for Acetate Film: Instructions for Using the Wheel, Graphs, and Tables: Basic Strategy for Film Preservation* (Rochester, NY: Image Permanence Institute, Rochester Institute of Technology, 1993).
- ⁶ C.E. Kenneth Mees. *From Dry Plates to Ektachrome Film* (New York, NY: Ziff-Davis Publishing Company, 1961).
- ⁷ James M. Reilly. *IPI Storage Guide for Acetate Film*.
- ⁸ Phillips Petroleum Company. Plastics Division. *Glossary of Plastics Terms* (Bartlesville, OK: Phillips Petroleum Company, 1966), 7.
- ⁹ James M. Reilly, Peter Z. Adelstein, and Douglas W. Nishimura. *Preservation of Safety Film: A Final Report to the Office of Preservation National Endowment for the Humanities* (Rochester, NY: Image Permanence Institute, Rochester Institute of Technology, 1991), 3.
- ¹⁰ Phillips Petroleum Company. Plastics Division. *Glossary of Plastics Terms*, 20.
- ¹¹ James M. Reilly, Peter Z. Adelstein, and Douglas W. Nishimura. *Preservation of Safety Film*, 15.
- ¹² Ibid.
- ¹³ James M. Reilly. *IPI Storage Guide for Acetate Film*.
- ¹⁴ James M. Reilly, Peter Z. Adelstein, and Douglas W. Nishimura. *Preservation of Safety Film*.
- ¹⁵ James M. Reilly. *IPI Storage Guide for Acetate Film*.
- ¹⁶ Ibid.
- ¹⁷ J.L. Bigourdan, P.Z. Adelstein, and J.M. Reilly. "Use of Microenvironments for the Preservation of Cellulose Triacetate Photographic Film," *Journal of Imaging Science and Technology*, Vol. 42, No. 2, March/April 1998, pp. 155-162.
- ¹⁸ Nelly Balloffet. *Preservation and Conservation for Libraries and Archives* (Chicago, IL: American Library Association, 2005), 187.
- ¹⁹ J.L. Bigourdan, P.Z. Adelstein, and J.M. Reilly. "Use of Microenvironments", 155-162.
- ²⁰ E. Sapwater. "Images On Ice." PEI (April 1999): 36-43.
<http://wilhelm-research.com/subzero/sapwater0499.pdf>
- ²¹ Nelly Balloffet. *Preservation and Conservation*.
- ²² Ibid.
- ²³ John Loengard. *Celebrating the Negative* (New York, NY: Arcade Publishing, 1994), 5.
- ²⁴ John Szarkowski. *Ansel Adams at 100* (Boston, MA: Little, Brown and Company, 2003), 21.
- ²⁵ Ansel Adams. *The Negative* (Boston, MA: Little, Brown and Company, 1981), ix.
- ²⁶ John Loengard. *Celebrating the Negative*, 5.
- ²⁷ Ibid, 7.
- ²⁸ E. Sapwater. "Images On Ice."
- ²⁹ Jessica McDonald, Denise Psaila, Kelly Thielen, and Siobhan Creem. *The Kodak Canada Archive and Heritage Collection at Ryerson University*, Report for Ryerson University, (Toronto: 2005).
- ³⁰ Christopher James. *The Book of Alternative Processes* (Albany: Delmar, 2002).

-
- ³¹ Eastman Kodak Company. *Journey Into Imagination: The Kodak Story* (Rochester, NY: Eastman Kodak Company, 1988).
- ³² James M. Reilly, Peter Z. Adelstein, and Douglas W. Nishimura. *Preservation of Safety Film*.
- ³³ C.E. Kenneth Mees. *From Dry Plates*.
- ³⁴ Ibid.
- ³⁵ Eastman Kodak Company. *Journey Into Imagination*.
- ³⁶ James M. Reilly. *IPI Storage Guide for Acetate Film*.
- ³⁷ Eastman Kodak Company. *Journey Into Imagination*.
- ³⁸ James M. Reilly, Peter Z. Adelstein, and Douglas W. Nishimura. *Preservation of Safety Film*.
- ³⁹ James M. Reilly. *IPI Storage Guide for Acetate Film*.
- ⁴⁰ Eastman Kodak Company. *Journey Into Imagination*.
- ⁴¹ Ibid.
- ⁴² James M. Reilly. *IPI Storage Guide for Acetate Film*.

Bibliography

- Adams, Ansel. *The Negative*. Boston: Little, Brown and Company, 1981.
- Adelstein, P.Z., J.-L. Bigourdan, and J.M. Reilly, "Moisture Relationships of Photographic Film," *Journal of the American Institute for Conservation*, 36 Fall/Winter 1997, pp. 193-206.
- Arribas, Angels. *Preservation of Photographs*. 1997.
- Balloffet, Nelly. *Preservation and Conservation for Libraries and Archives*. Chicago: American Library Association, 2005.
- Bigourdan, J. -L., and J.M. Reilly, "Effectiveness of Storage Conditions in Controlling the Vinegar Syndrome: Preservation Strategies for Acetate Base Motion-Picture Film Collections," *Image and Sound Archiving and Access: the Challenges of the 3rd Millennium*, proceedings of the Joint Technical Symposium Paris 2000, M. Aubert and R. Billeaud, eds., (Paris: CNC, May 2000) pp. 14-34.
- Bigourdan, J.-L., P.Z. Adelstein, and J.M. Reilly, "Moisture and Temperature Equilibration: Behavior and Practical Significance in Photographic Film Preservation," *La Conservation: Une Science en Evolution, Bilans et Perspectives*, Actes des Troisiemes Journees Internationales d'Etudes de l'ARSAG, Paris, 21 au 25 Avril 1997, (Paris: Association pour la recherche scientifique sur les arts graphiques, 1997) pp. 154-164.
- Bigourdan, J. -L., P.Z. Adelstein, and J.M. Reilly, "Use of Microenvironments for the Preservation of Cellulose Triacetate Photographic Film," *Journal of Imaging Science and Technology*, Vol. 42, No. 2, March/April 1998, pp. 155-162.
- Bigourdan, J. -L., "Vinegar Syndrome: An Action Plan," *The Vinegar Syndrome: A Handbook, Prevention, Remedies, and the Use of New Technologies*, (Bologna: The GAMMA Group, 2000) pp. 45-59.
- Corbett, D.J. *Motion Picture and Television Film: Image Control and Processing Techniques*. London: Focal Press, 1968.
- Eastman Kodak Company. *Journey Into Imagination The Kodak Story*. Rochester, NY: Eastman Kodak Company, 1988.
- Eastman Kodak Company. *The Book of Film Care*. Rochester, NY: Eastman Kodak Company, 1983.
- Eastman Kodak Company. Motion Picture and Audiovisual Markets Division. *Eastman Professional Motion Picture Films*. Rochester, NY: Kodak, Motion Picture and Audiovisual Markets Division, 1992.

Eastman Kodak Company. Motion Picture and Education Markets Division. *Hazard in the Handling and Storage of Nitrate and Safety Motion Picture Film*. Rochester, N.Y.: Eastman Kodak Company, Motion Picture and Education Markets Division, 1966.

Fielding, Raymond. *A Technological History of Motion Pictures and Television: An Anthology from the Pages of the Journal of the Society of Motion Picture and Television Engineers*. Berkeley, California: University of California, 1967.

Fischer, Monique and Andrew Robb. "Identification of Film-Base Photographic Materials." *Conserve O Gram* 14/9 (September 1999): 1-4
<http://www.cr.nps.gov/museum/publications/conserveogram/14-09.pdf> (accessed

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

Goldberg, Lisa and Steven Weintraub. "Cobalt Indicating Silica Gel Health and Safety Update." *Conserve O Gram* 2/15 (June 2001): 1-3. (adapted from "Health and Safety News 26, no.1 (January 2001)) <http://www.cr.nps.gov/museum/publications/conserveogram/02-15.pdf>

Hendriks, K.B. *Fundamentals of Photograph Conservation*. Toronto: Lugus, 1991.

Horenstein, Henry. *Black & White Photography: A Basic Manual*. Boston: Little, Brown, 1983.

James, Christopher. *The Book of Alternative Photographic Processes*. Albany: Delmar, 2002.

Joesten, Melvin D., James L. Wood, and Mary E. Castellion. *World of Chemistry: Essentials 3rd Edition*. Toronto: Brooks/Cole – Thomson Learning, 2004.

Lavedrine, Bertrand. *A Guide to the Preventative Conservation of Photograph Collections*. Los Angeles, CA: Getty Publications, 2003.

Loengard, John. *Celebrating the Negative*. New York: Arcade Publishing, 1994.

McDonald, Jessica, Denise Psaila, Kelly Thielen, and Siobhan Creem. *The Kodak Canada Archive and Heritage Collection at Ryerson University*. Toronto: 2005.

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

Mees, C.E. Kenneth. "History of Professional Black-and-White Motion Picture Film." *Journal of the SMPTE*, v.63 (October, 1954).

Melville, Annette and Scott Simmon. *Redefining Film Preservation: A National Plan: Recommendations of the Librarian of Congress in Consultation with the National Film Preservation Board*. Washington, D.C.: Library of Congress, 1994.

Phillips Petroleum Company. Plastics Division. *Glossary of Plastics Terms*. Bartlesville, Oklahoma: Phillips Petroleum Company, 1966.

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, Rochester Institute of Technology, 1993.

Reilly, James M., Peter Z. Adelstein, and Douglas W. Nishimura. *Preservation of Safety Film: Final Report to the Office of Preservation, National Endowment for the Humanities*. Rochester, NY: Image Permanence Institute, Rochester Institute of Technology, 1991.

Robinson, Clark Norval. *Meet the Plastics*. : Macmillan, 1949.

Sapwater, E. "Images on Ice." PEI (April 1999): 36-43.
<http://wilhelm-research.com/subzero/sapwater0499.pdf>

Sargent, Ralph N. *Preserving the Moving Image*. Washington, D.C.: Corporation for Public Broadcasting and the National Endowment for the Arts, 1974.

Stroebel, Leslie D. *Photographic Materials and Processes*. Boston: Focal Press, 1986.

Szarkowski, John. *Ansel Adams at 100*. New York: Little, Brown and Company, 2003.

Wagner, Sarah S. "Cold Storage Handling Guidelines for Photographs." *U.S. National Archives and Records Administration* website. 26, April 2006.
<http://www.archives.gov/preservation/storage/cold-storage-photos.html>

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.

Wortman, William A. *Collection Management: Background and Principles*. Chicago: American Library Association, 1989.

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.