SCIENCE APPLICATION

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A STUDY OF THE PRESERVATION AND RESTORATION OF HISTORIC PHOTOGRAPHS AT THE NATIONAL ARCHIVES*

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Abstract

A full scale investigation was undertaken into the nature and causes of deterioration of plates and prints which had been stored for about 100 years in the hot and humid Throne Hall in Bangkok's National Museum. The early glass plates and prints were stored in teakwood boxes. They had developed yellow and brown stains and some of them had faded from black to yellow. The stained and faded images were partly caused by oxidising gases released from teakwood boxes. The presence of oxidising gases in the box was confirmed by an experiment with the help of the Agfa yellow test film, which showed that the yellow and brown stains were composed of soluble silver salts. The envelope, cream-colour mounting board, brown paper board and Sa-paper† were tested for acidity and alkalinity and found to have pH 5.8, 5.0, 7.15 and 7.3 respectively.

A newly developed method was used to make quality modern prints from extremely high contrast negative plates by overexposing the grade 1 paper for 10 times the normal exposure and then bleaching them in a 0.4% (by wt.) potassium dichromate solution for 60 seconds prior to normal developing and fixing. The resulting scale index became 2.21. Plates and prints having overall yellow image were restored by photographing them on a blue sensitive film. The details of the faded image were enhanced by producing a highlight mask which was registered to negative when producing the final print. The restored photographic images were satisfactory.

†Sa-paper is made from bark and trunk of a local tree "Sa", commonly used for kite-making.

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Standards for storage conditions and enclosures for films, prints, and plates according to International Organisation for Standardisation (ISO), American National Standards Institute (ANSI) and archival suppliers recommendations have been presented to the National Archives of Thailand as part of present study.

Introduction

There has been a great deal of interest in old photographs in recent years on the part of archives, museums, galleries, historical societies and individual collectors. This has caused many to realize that insufficient attention has been paid to determining the best methods to care for them, or to restore those that have already begun to deteriorate.

All photographs are made of potentially unstable silver halide and gelatin which have varying resistance to time, temperature, humidity, light, and storage enclosure. If conditions are bad they may disintegrate, stain, fade or discolour.

The potential instability of photographs has been recognized from earliest times. In 1858, when photography was only about 20 years old, the Journal of Photographic Society in London wrote: "Much has been said and done about the fading of photographs. Committees have been appointed, large sums have been offered to those who may bring to light the hidden secret, but still the defect remains. Durability may be termed the keystone of photography."

Some interesting research works in the past on conservation of old photographs of Ostroff[1] Eaton[2] and Weyde[3] can be used as references. However, there are still other conservation problems which occur in tropical countries such as Thailand.

During the reign of King Rama IV, French missionaries Pallegoix and Lanodi taught a number of people how to take pictures using the process invented by Daguerre. A portrait of King Rama IV in a Daguerreotype silver plate is now in the Smithsonian but none of the others have been discovered in Thailand. In 1866, an Englishman Sagler introduced the wet-plate process to Thailand. Photography has become very popular since then among the upper classes, and many of the glass plates and prints made during this period were stored in the National Museum and now in the National Archives.

Clearly, storage of old plates and prints for more than a century in conditions of high temperature and humidity have damaged them severely. The deterioration of silver images in the National Archives in Bangkok was the concern that inspired the present work.

The study is divided into three parts:

- Examination to determine the nature of storage conditions and materials involved and the causes of deterioration and alteration.
- Restoration for repairing or correcting deterioration and alteration.
- Preservation with a view to retarding further deterioration.

Materials and Methods

Examination

Examination of environmental conditions of storage rooms : The temperature and relative humidity in the old and new storage rooms were measured by using a Thermohydrograph.

Examination of the nature of plates and prints : The method described by Canadian archivist, Siegfried Rempel[4], was used.

Examination of the nature of storage materials : Suspected oxidising gases released from teakwood boxes were detected by using Agfa yellow test films containing fine-grain colloidal silver particles. Agfa diamond trademarks are normally printed with a colourless lacquer at given intervals on the yellow film and can be detected very faintly against the light. When the test film is new, the parts of the film that are free from lacquer will become discoloured if oxidising gases are present in the teakwood boxes. In this event, the Agfa diamonds should stand out clearly, being lighter than the surrounding area. An Agfa yellow test film was left in a teakwood box where the maximum day-time temperature was 58°C.

The pH of album paper, envelopes and mounting papers was tested by using Ionanalyzer model 407[A].

Examination of causes for the deterioration of photographic images : Negative glass plates from the National Archives with many yellow spots were pressed on a paper treated with zinc sulphide which was moistened with ammonia. If there were soluble silver salts contained in the yellow and brown spot, the patterns of those spots should be reproduced on the treated paper as light brown dots.

The side-reversed or mirror image on the opposite page of a black-and-white print in the album was tested for its nature by using potassium bromide solution. If the side-reversed image was a silver one, it would react with potassium bromide solution and form a colourless silver bromide.

Restoration

Prints from extremely high-contrast negative plates : were made by extending the exposure range of grade 1 paper. A newly developed method was used to extend the scale index or exposure range of grade 1 paper by varying its exposure and bleaching time as well as the concentration of bleaching bath, potassium dichromate, prior to the normal developing and fixing processes.

Plates and prints having overall yellow and low contrast images : were restored by photographing them on a blue sensitive Agfa N 31 p. sheet film. A vacuum contact printer equipped with a tungsten point lamp and a process camera equipped with a xenon lamp were used.

Stained images : were restored by copying them on a Kodak panchromatic colour separation film type 1 using a Wratten filter no. 25, which matches the colour of the stain. A process camera was used.

Details of the faded image of an old print : were enhanced by producing a highlight mask which was then registered to its negative when producing a final print. The Lith film was used for producing a highlight mask. The maximum density of 0.3 was required by the experiment.

Preservation

Storage enclosures and conditions according to recommendations of International Organisation for Standardisation[5], American National Standards Institute[6], Document Conservation Center[7], and Archival suppliers such as the Light Impressions[8] were searched and presented in this paper.

Results and Discussion

Results of Examination

Historically significant photographs were stored for about a century in the Issararesrajanusorn Throne Hall in the compound of the National Museum in Bangkok. The Throne Hall was very hot and humid and in recent years industrial pollutants have aggravated the problem. In December 1982, the temperature and relative himidity in the Throne Hall were found to be 37°C and 90 percent respectively when measured by a Thermohydrograph. Storage conditions were so bad that the collection was moved to the National Archives in 1977. The temperature and relative humidity in the new store room are maintained at 20°C and 62 percent respectively. There are at present 20,000 gelatin silver prints, albumen prints and an equal number of collodion wet plates and gelatin dry plates as evaluated by the Siegfield Rempels method. The collection also includes modern materials. More than a century of Thai life is depicted in this collection.

The early glass plates and prints were stored in teakwood boxes. They had developed yellow and brown stains, marks and spots. Some of them had lost their original colours and had faded from black to yellow.

It was found in an experiment with the help of the Agfa yellow test film (Plate 1) that there were some oxidising gases released from teakwood boxes after the film had been in the box for 4 months. This discolouration was due to a change in grain size of yellow colloidal silvers. These results conform with the discovery made by Sandermann and Simmatupang[9], who found that deoxylapachol, an oxidising agent, was released from teakwood at 58-59°C. The test method proved to be very useful in the clarification of the mechanism of image destruction as follows :

Silver image + oxidising gas ⟶ Soluble silver salt
(black image) (fading of yellow spot image)

Experiments using the zinc sulphide/ammonia test confirmed the above mehanism, since the pattern of yellow spots were reproduced as light brown dots pattern on moistured

paper, indicating that soluble silver salts, contained in the spots of plates, had migrated into the zinc sulphide layer where they precipitated as brown silver sulphides (Plate 2).

The envelope, cream-colour mounting board, brown paper board and Sa-paper were cut into small pieces and left in distilled water for one hour. The water was then tested for pH by using Ionanalyzer, with the result that the pHs of the above papers were 5.8, 5.0, 7.15 and 7.3 respectively. Acid vapours evaporated from those papers had damaged silver images in the same maner as the oxidising gas did.

The results of the potassium bromide test showed that the side-reversed or mirror image on the opposite page of black-and-white print in the album (Plate 3) was a silver image. The hot and humid storage conditions had caused a considerable amount of colloidal silver to be transferred from the original image to the opposite blank page in the album.

Results of Restoration

Modern prints were first made from negative plates held in the National Archives. As is well known, modern printing paper is not well suited to the making of prints from old negative plates which have density ranges over 1.8. Even the lowest contrast grade will not yield a good quality print. Printing-out paper which was suitable for print-making from old negatives is not available in Thailand and it is understood that they are also becoming very difficult to obtain in United States.

This problem has been solved by lowering the effective grade of grade 1 paper. The scale index was extended by overexposing and bleaching the paper prior to normal developing and fixing.

Many experiments have been conducted by varying the exposure and bleach times as well as the concentration of bleaching bath. Finally, it was found that when the illuminance at the film plane was 20 luxes, an exposure time of 70 seconds or 10 times overexposure, must be used. The bleach times should be between 30-90 seconds in a 0.4%(by wt.) potassium dichromate solution. The bleached paper was then developed in D-72 (diluted 1 : 4) for 3 minutes and fixed normally. The resulting scale index was extended to over 2.07 (Fig.1), so that more highlight contrast and details were obtained (Fig.2).

The overexposed and bleached prints are compared with the normal print as shown in Plates 4 and 5 respectively. This experiment might be considered as a breakthrough in the making of a quality print from an extremely high contrast negative plate by overexposing and bleaching modern photographic paper.

Satisfactory results were obtained in the restoration of plates and prints having overall yellow and low contrast images by photographing them for 18 seconds at f/ 22 on a blue sensitive Agfa N 31 p sheet film and developing the film in a DK-50 developer (diluted 1 : 1) for 3 minutes at 20°C. Prints made from those negatives have normal contrast and tonal density as shown in plate 6, compares to the original photograph shown in plate 7.

The conventional method used to restore stained images by photographing them

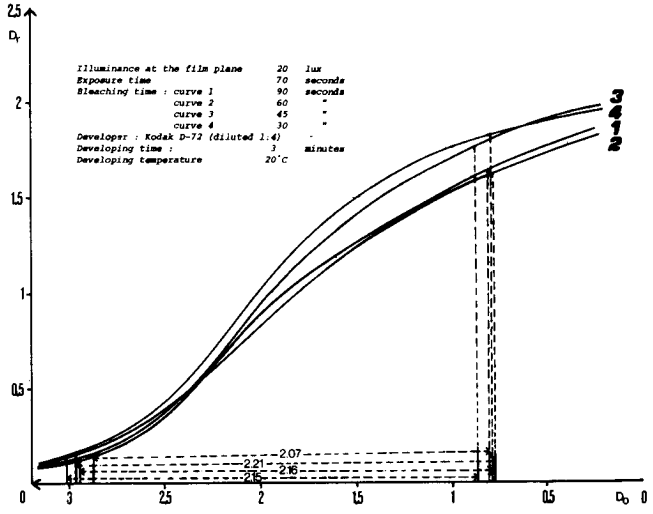

Figure 1 Curves 1, 2, 3 and 4 show characteristic curves of grade 1 paper exposed for 70 seconds (10 time overexposed) and then bleached in 0.4%(by wt.) of potassium dichromate for 90, 60, 40 and 30 seconds respectively. The scale index are 2.07, 2.21, 2.16 and 2.15 respectively

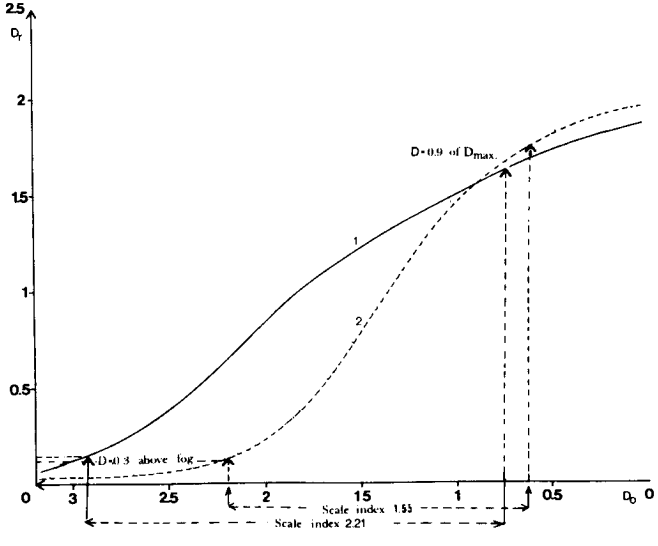

Figure 2 Curve 1 shows the characteristic curve of 10 times overexposed and bleached grade 1 paper, in comparison to curve 2 made by normal exposure of grade 1 paper. Both sheets of paper were developed in a developer D-72 (diluted 1 :4). Curve 1 shows more highlight contrast and more density in the middle tone area but lesser density in the shadow area.

on a Kodak panchromatic colour separation film type 1 through a Wratten filter no. 25 for 13 second at f / 22 and developing the film in a DK-50 developer (diluted 1:1) for 4.5 minutes at 20°C, proved to be successful. A print made from the negative is shown in Plate 8 and the original is shown in Plate 9.

The enhancement of details in faded images was performed as follows. A faded image was photographed with a yellow filter no. 12 on a Kodak separation negative type II film for 3 8 seconds at f / 22 and the film was then developed in a Kodak DK-50 developer (diluted 1 :1.5) for 4 minutes at 20°C. The faded image was again photographed on a Kodalith orthochromatic film for 6 seconds at f/22. The exposed film was then developed in a lith developer (part A : part B = 1:1) for 2 minutes, then fixed and washed as normal. The film which had undergone this process was not called "negative" but "highlight mask". The highlight mask was registered to the negative from the first process ; the combined negative was now called "mask negative". A final print was then made from the resulting mask negative.

Details of faded images were successfully enhanced in their final prints. The restored image had details in the highlights, and overall tone reproduction was normal. The characteristic curves of the highlight mask, negative and masked negative are shown in Figure 3. The restored photograph and the original are shown in Plates 10 and 11 respectively. The rephophotographic technique was, for the first time, used in the restoration of old photographs.

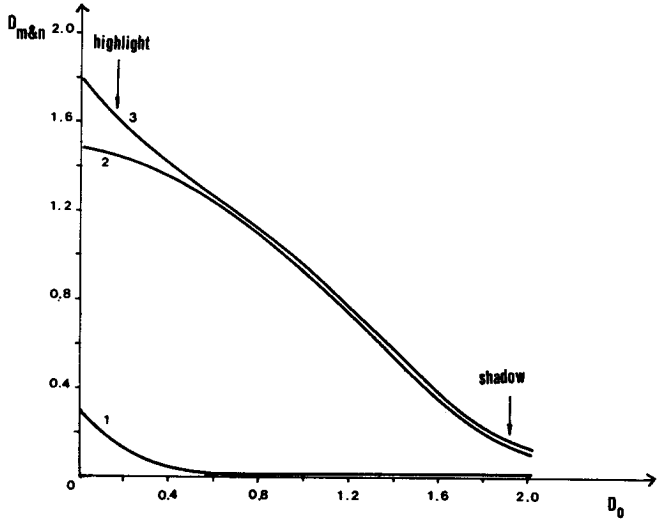

Figure 3 Characteristic curves of highlight mask (1), negative (2), and masked negative (3). The masked negative curve shows higher highlight contrast.

Studies on Preservation

Storage enclosures : Storage enclosures for photographic prints and negatives are available in a variety of materials and formats. To choose the proper enclosure requires a knowledge of the possible alternatives.

Paper enclosures are opaque, protecting an object from light. However, this makes viewing difficult, requiring the removal of the prints and negatives from the enclosure before they can be looked at. This increases the handling and subsequent abrasion and fingerprinting of the image. Paper enclosures are porous, protecting the object from accumulated moisture and detrimental gases. Paper enclosures are easy to write on and generally less expensive than plastic enclosures.

Although processed prints are usually acidic (with pH of about 5.5) it would be desirable for storage papers to have a pH of 7 and above. "Museumboard", sold as 100 percent rag, acid-free mount (or matt) board, has demonstrated long-term stability.

Plastic enclosures have the great advantage of allowing an image to be viewed without being removed from the enclosure. This greatly reduces the chance of abrading, scratching, and fingerprinting the photograph. Plastic enclosures seal the object from the atmosphere. Since most chemical deterioration in a photograph is catalyzed by the presence of moisture and sulphides in the atmosphere, such protection will prolong the life of the image. Plastic enclosures can trap moisture and cause ferrotyping of the image making it very difficult to write on.

Containers : Films and prints should be stored in closed cabinets of drawers or on open shelves in vented containers of anodized aluminium, steel with baked-on nonplasticized synthetic resin lacquer or stainless steel. The use of wood, particleboard or pressboard is not recommended, because they can produce detrimental fumes. Interiors of these cabinets should have vents to permit a free circulation of air so that humidity and temperature conditions can be uniformly maintained and the accumulation of undesirable gases can be prevented.

Preservation of negatives, prints and colour slides : Negatives should be preserved and indexed in acid free paper, mylar, polyester or polyethylene or polypropylene folders or jackets or sleeves to protect them from dust, dirt and other pollutants. PVC and epoxy plastic should be avoided, because they emit harmful fumes.

Like all photographic materials, slides have their own particular storage requirement. Any storage system should fit in with one's work habits and needs. Slides should be preserved in slide guard pages made of polypropylene or polyester, polyethylene and triacetate. Slide guard pages can be kept in binders or filing drawers.

Mylar folders are recommended for archival protection of negatives and transparencies, sheet films and also unmounted prints. Sheet films and unmounted prints should be preserved in storage boxes made of acid-free paper, and acid-free glues such as methyl

cellulose, polyvinylacetate are recommended. If the sides of the boxes are wood-reinforced, the boxes must be lined with white, acid-free buffer paper or Tyvek to protect the contents from acid migration.

To protect and arrange family history photographs, the three-ring binder or album should be used. Protective sheets for both sides of the page in an album should be made of polypropylene sheets. Mounting corners should be made of polyester with a self-adhesive backing. Double-sided tapes of 3M code 415 and Filmoplast are recommended.

To laminate a print by spraying lacquer on its surface affords a good protection. However, since lacquer usually consists of liquid polymer dissolved in an organic solvent, care should be taken to avoid such harmful solvents as butylalcohol, ethylacetate and methylisobutyl ketone.

In the display of valuable photographs, a key ingredient is the board used for mounting and matting. Acid-free paper board is recommended.

The best method of mounting is dry mounting with thermoplastic sheets such as Kodak dry mounting tissue. Cold mounting with the use of 3M's Positionable Mounting Adhesive works well only with RC paper which is sensitive to high heat. Rubber cement or white glue should not be used for mounting because they are harmful to photographs. Methyl cellulose glue or Photo-mount adhesive of Scotch brand is recommended.

To display photographs permanently in frames, aluminium frames meets the high visual and preservation standards of the museum, archives and galleries. UV absorbing plastic should be placed in front of the photograph and humidity non-absorbing plastic should be placed at the back of the photograph.

The light emitted by a 150 Watt tungsten lamp (or by four 40 Watt deluxe cool white fluorescent lamps covered with UV absorbing sleeve) and located six feet or more from prints will be of such intensity and colour quality as to minimize light fading while providing enough illumination of satisfactory colour distribution for proper appreciation of colour and tone quality.

Storage rooms should have temperature below 18 °C and relative humidity between 40-50 percent. Storage rooms should be free from chemical materials and air pollutants.

The results of this work indicate that storage enclosures and conditions in the National Archives should be immediately improved. This would involve transferring the glass plates and prints from teakwood boxes to metal boxes, inserting the negatives in acetate sleeves and ensuring that proper temperature and humidity conditions are maintained as recommended earlier. Furthermore, the stability of colour prints and slides and their preservation and restoration should be further investigated.

Plate 1 An original Agfa yellow test film (right) and the yellow test film after reacting to oxidising gases (left) ; the latter becomes discoloured and the Agfa diamond trademark stands out clearly.

Plate 2 Brown silver sulphide pattern resulting from the reaction between soluble silver salts in brown spots of plates and zinc sulphide in ammonium hydroxide.

Plate 3 A side-reversed silver image on the opposite page of a black-and-white print in an album.

Plate 4 An overexposed and bleached print which shows better highlight details and contrast.

Plate 5 A normally exposed and developed print which shows a loss of highlight details and contrast.

Plate 6 A restored print through the process of rephotographing on a blue sensitive film.

Plate 7 Its original print having overall yellow and low contrast before restoration

Plate 8 A stained image after restoration

Plate 9 A stained image before restoration

Plate 10 A restored print shows enhancement of highlight details and contrast.

Plate 11 An original faded print which has poor highlight details.

Plates

Plate 1

Plate 2

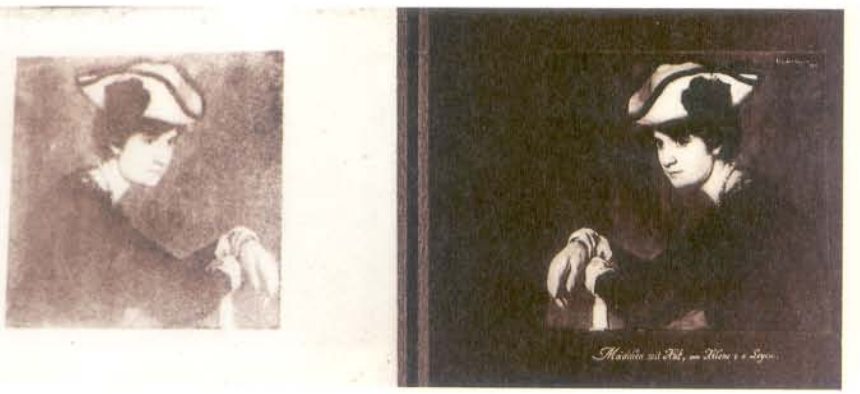

Plate 3

Plate 4

Plate 5

Plate 6

Plate 7

Plate 8

Plate 9

Plate 10

Plate 11

Acknowledgements

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บทคัดย่อ

การศึกษาค้นคว้าเกี่ยวกับสภาพและสาเหตุของการเสื่อมสภาพของฟิล์มกระจกและภาพถ่ายได้กระทำอย่างละเอียดและได้พบว่าภาพบนฟิล์มกระจกและภาพถ่ายซึ่งเดิมบรรจุไว้ในกล่องไม้สักเก็บไว้ ณ พระที่นั่งอิศเรศราชานุสรณ์ เป็นเวลา 100 ปีเศษ ปรากฏมีริ้วรอยและจุดสีเหลือง หรือน้ำตาล บางภาพซีดจาง และภาพเปลี่ยนจากสีดำเป็นสีเหลือง ริ้วรอยและจุดสีเหลืองหรือน้ำตาลมีสาเหตุส่วนหนึ่งเนื่องมาจากแกสอ๊อกซิไดซ์ที่ระเหยออกมาจากไม้สัก, จากซองบรรจุภาพและจากกระดาษผนึกภาพ ซึ่งไปทำปฏิกิริยากับภาพเงินในฟิล์มและภาพถ่ายนั้น การปรากฏของแกสอ๊อกซิไดซ์ในกล่องไม้สักได้รับการพิสูจน์โดยอาศัยฟิล์มทดสอบสีเหลืองของอั๊กฟ่า และจากการทดลองได้พบว่า องค์ประกอบของริ้วรอยและจุดสีเหลืองหรือน้ำตาลนั้นเป็นเกลือเงินที่ละลายน้ำได้ จากการทดสอบความเป็นกรดเป็นด่างของซองบรรจุภาพ และกระดาษผนึกภาพสีครีม กระดาษผนึกภาพสีน้ำตาล และกระดาษสา พบว่ามีค่า พีเอช 5.8 5.0 7.15 และ 7.3 ตามลำดับ

ได้มีการพัฒนาวิธีการใหม่เพื่อใช้ในการผลิตภาพถ่ายจากต้นฉบับฟิล์มกระจกที่มีความเปรียบต่างสูง โดยฉายแสงผ่านเนกาทีฟลงบนกระดาษขยายภาพเกรด 1 โดยใช้เวลาฉายแสงเป็น 10 เท่า ของเวลาฉายแสงปกติ แล้วนำกระดาษขยายภาพที่ได้รับการฉายแสงแล้วไปล้างในน้ำยาฟอกจาง ซึ่งประกอบด้วยโปตัสเซียมไดโครเมตเข้มข้น 0.4 เปอร์เซ็นต์ โดยน้ำหนักเป็นเวลา 60 วินาที ก่อนที่จะนำกระดาษขยายภาพไปล้างในน้ำยาสร้างภาพ และน้ำยาคงภาพตามปกติ ผลปรากฏว่าช่วงรับแสงของกระดาษขยายภาพเกรด 1 ขยายกว้างมีค่าเป็น 2.21 ภาพที่ได้มีความเปรียบต่างและรายละเอียดที่บริเวณสว่างดีมาก การบูรณะภาพถ่ายที่มีสีเหลืองโดยทั่วไปทำได้โดยถ่ายภาพนั้นลงบนฟิล์มที่ไวต่อแสงสีน้ำเงินสีเดียว ภาพถ่ายที่อัดขยายจากฟิล์มดังกล่าวมีคุณภาพดี ส่วนภาพที่ซีดจางและมีริ้วรอยได้บูรณะโดยถ่ายภาพนั้นผ่านฟิลเตอร์ที่มีสีเดียวกันกับสีของริ้วรอยนั้นลงบนฟิล์มแพนโครแมติกรายละเอียดของภาพที่ซีดจาง ได้ผลิตให้เห็นคมชัดขึ้นโดยการผลิตมาสก์ไฮไลต์และนำมาสก์นี้มาประกบกับเนกาทีฟในขณะขยายภาพสุดท้าย การบูรณะภาพได้ผลดี

ได้เสนอแนะหอจดหมายเหตุแห่งชาติเกี่ยวกับสภาพการเก็บรักษาและภาชนะบรรจุฟิล์มภาพถ่าย และฟิล์มกระจก ตามมาตรฐานสากลของ ไอเอสโอ ของ เอเอ็นเอสไอ และตามคำแนะนำของบริษัทที่จำหน่ายวัสดุอุปกรณ์สำหรับหอจดหมายเหตุ