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Glass Plate Negatives

Preservation and Restoration

by MARTINE GILLET, CHANTAL GARNIER & FRANÇOISE FLIEDER

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0. INTRODUCTION

On account of its transparency, glass was used as a photographic base shortly after the inventions of W. H. Fox Talbot, to replace the oiled or waxed papers the calotypes were made up of. During the second half of the nineteenth century its use was very widespread, especially for the production of negatives. From the twenties onwards, the plastic based materials gradually replaced glass which is, however, still used nowadays for a few rare processes requiring rigidity and stability.

Various processes to obtain a negative picture have been used successively: the rarely used albumen process, wet and dry collodion processes, the manufac-

turing of which was universal for some 30 years before it was abandoned for the gelatin process.

As soon as 1850, photography made great strides. The present-day French collections therefore contain several hundred thousand glass negatives stored in museums, archives, public or private photographic libraries as well as private collections. Many of the negatives are the works of unknown photographers, but a great number of renowned artists, among them G. Le Gray, Ch. Negre, F. Nadar, E. Atget ... have left a very rich heritage.

A large part of the glass plate negatives have not been damaged though some deteriorations can be detected which are chiefly due to unstable components, faulty workmanship, inappropriate use, or poor storage conditions.

It is therefore necessary to start a research in order to experiment with restoration treatments. But before any attempts are made in this field, it seems necessary to epitomize the works carried out on the international level.

1. Manufacturing Processes[1-12]

1.1. Selection and preparation of glass plates

The choice of the glass is determined by the qualities required by the photograph: transparency, no defects (bubbles, scratches, unevenness, streaks, striations), a uniform thickness and a plane surface. The better suited mirror glass was therefore preferred to window glass as a base.

To ensure correct adhesion of the sensitive layer, the glass is cleaned very thoroughly and then polished. New glass must be freed from all types of grease, fingerprints and other impurities. They only have to be dipped in a diluted aqueous solution of ammonium of potassium hydroxide for a few minutes. Reused glass from old negatives must be put through an extra cleaning operation in order to remove every trace of chemicals. For this purpose they are dipped in a 10% solution of potassium cyanide or in a water bath strongly acidified with nitric acid or in a chromic sulphuric acid. After that they must be rinsed thoroughly, and the glass must be treated with a solution of potassium carbonate or sodium carbonate to neutralize the acidity of the cleaning.

After being cleaned, the glass has to be polished thoroughly. The glass surface must be rubbed vigorously in circles with a large wad of cotton after spreading a mixture of alcohol and powdered chalk, or a thick paste of Spanish white* mixed with a drop of water, or with a very fine powder of tripoli**

* Spanish white: crumbly chalk.
** tripoli: siliceous stone.

mixed with a little water and a few drops of nitric acid. The drying process is concluded with a wad of clean cotton to remove all paste particles. Then the plate is polished with a wash leather which has previously been degreased in a boiling sodium carbonate solution and then thoroughly rinsed.

In order to get rid of the electrostatic properties gained during the rubbing, which promote the accumulation of dust, it is necessary to clean the glass plates several hours to the application of the sensitive layer. When the negative is manufactured, the glass surface has to be dusted with a soft brush before the application of the photo-sensitive substance.

1.2. The albumen process

Nicephore Niepce's nephew, Niepce de Saint-Victor, was looking for a way of making a sensitive layer of starch or gelatin on a glass plate. In 1847 he succeeded in obtaining pictures which were not perfect, but which demonstrated the possibility of fixing them onto glass. On continuing his studies, he discovered, the following year, a type of coating – albumen from eggs – which possessed photographic properties and which resulted in the albumen process producing negatives of extreme fineness and particular gloss.

The albumen used in photography comes from fresh hen's eggs. Each egg contains 25 to 30 g albumen. In order to break the large cells keeping the albumen enclosed, the egg whites are beaten stiff and left to rest for 12 h. After being decanted, the liquid part constituting the albumen can be used. Another effective process is to use acetic acid. After this treatment, a 10% aqueous solution of ammonium iodide, potassium bromide and iodine is added to the albumen. The addition of a mucilagenous substance, like gum arabic, makes the albumen unctuous, increases its adhesive properties on glass, and prevents it from crackling during drying. The photographic albumen is spread in a thin, regular layer on the glass with a pipette: the glass is tilted lightly in all directions to ensure an even distribution. Any excess liquid is poured away from a corner. As the drying of the albumen has to be even, the plate should be heated slightly. When protected from dust, well-dried glass can be stored almost indefinitely.

The albumen layer is sensitized in a solution of silver nitrate and acetic acid.

Exposure to light must take place within a maximum of three to four days' time. The exposure may vary from 5 to 30 min. The picture is developed in a 1/1000 gallic acid solution into which a few drops of pyrogallol alcoholic solution may be added. When the picture becomes visible, a 3% silver nitrate aqueous solution is added. The development must be carried out very slowly; that is the condition for obtaining the best possible albumen negatives. After rinsing,

the picture is fixed in a 12–15% solution of sodium thiosulphate (sodium hyposulphite). Potassium cyanide must not be used as a fixative, as the albumen layer may then peel off. To increase the sensitivity of the albumen process, some photographers (G. Sella and E. Bacot) have changed the doses of bromide and iodide, so the exposure time has become twice as short.

The albumen process involves a lot of difficulties; the perfect cleaning of the glass, the albumen's attraction of dust, the slowness of the process and the strong contrast of its pictures. When the wet collodion process therefore appeared and solved these problems, all the photographers set about using this new and fast technique.

The albumen was, however, still used in cases where the wet collodion was unworkable, e.g. for tourist photographers. It was reserved for scientific reproductions, stereoscopic views and presentation. We only have knowledge of very few albumen negatives.

1.3. The wet collodion process

We are acquainted with the first use of collodion-treated glass for photographic use from F. Scott Archer who published the results of his studies in 1851, although G. Le Gray erroneously laid claim to an earlier publication. The wet collodion process gives pictures whose fineness of design competes with that of the albumen process without having its strong contrast.

Photographic collodion spread on a scrupulously clean glass plate is based on ordinary collodion with ammonium, cadmium or potassium iodide and bromide. It must be liquid, fast-working, adhesive and as permanent as possible. Ordinary collodion is a complete and concentrated guncotton dissolution in a mixture of ethyl ether and ethyl alcohol. Guncotton, known under the names of pyroxylin or nitrocellulose, consists of cellulose nitrate obtained through the reaction of nascent nitric acid on carded cotton. The photographers usually bought the ordinary collodion ready for use in order to obtain reproducibility.

The sensitizing silver bath of the iodide-bromide collodion layer is a weakly acid silver nitrate solution of varying concentration, depending on the work to be done.

Exposure must take place immediately after the sensitization while the emulsion is still wet, hence the name of the process, 'wet collodion'. The sensitivity is reduced when the plate is dry. Exposure time is from 2 to 60 seconds.

Development of the negative has to take place very soon after exposure to avoid stains caused by the drying of the collodion. There are two main procedures for developing the picture:

- developement with pyrogallic acid in an acetic solution, the use of which is ascribed to V. Regnault: the picture emerges slowly and progressively, and can easily be stopped at the correct moment; the tones are strong without being harsh;
- development with ferric ammonium sulphate in alcoholic or acetic-acid solution; the picture emerges quickly, almost suddenly and, contrary to the former process, the negative is more harmonious and blended now and then with too little contrast.

Some operators have mixed both processes to obtain a plate combining the special properties of the two developing baths. The fixing of the picture is carried out either with a 2% aqueous solution of potassium cyanide, or with a 40% solution of sodium thiosulphate. Then the negative must be rinsed thoroughly and dried. In this process the picture does not penetrate the collodion layer; it remains in relief.

The development rarely gives the plate the required strength; it is almost always necessary to intensify it. Many procedures have been used; we will only mention a few of them: intensification with silver, copper and silver, lead, mercury, etc. Retouchings are performed with a pencil, and all parts required to be unaffected by actinic rays must be covered by a solution of fuchsine or carmine mixed with rubber. Collodion plates are not as durable as albumen plates. When they are to be used for many copies, they must be protected against chafing and scratches by covering them with a rather hard and transparent varnish. Many products have been used for this purpose: varnish with gum arabic, albumen, benzole, benzoin gum, yellow or white shellac, amber, yellow or red dyed collodion based varnishes, etc ... (Appendix A).

The greatest inconvenience of the wet collodion process is the necessity to expose it immediately after making the sensitive layer; this makes outdoor photography problematic. For this reason, many attempts have been made to use a dry collodion.

1.4. The dry collodion process

This process has been used by professional photographers, but not quite as much as the wet collodion process, on account of its weak sensitivity. The dry sensitive layers can be exposed long after being made, and may be developed a few days later. The slowness of the development compels us to reinforce the adhesion of collodion to the glass plate by interposing a dry layer of albumen or rubber varnish dissolved in chloroform.

The principle in this process is the same as for wet collodion. A protective agent has to be added after the sensitization to make the dry layer durable, and

plete list gives one a general idea of the many substances used to develop gelatin negatives.

It should be mentioned that the development should always be carried out in an alkaline buffer and with sodium sulphite which enhances the effect of the developer. Moreover, sodium sulphite acts as a preservative for the bath. After being developed, the glass plate is immersed in a 5% of potassium or chrome alum solution which hardens the gelatin. The fixing is made with sodium thiosulphate exclusively.

It very often happens that the negative has to be intensified or reduced. Many formulas are described in the literature: intensification with mercuric-ammonium chloride, mercuric iodide, cuprous bromide, reduction with potassium cyanide, copper salts, thiosulphate, potassium ferricyanide, permanganate, etc.

The negatives are protected with a varnish as is described in the wet collodion process. It should be mentioned, however, that the strength of gelatin plates is increased by an alum treatment.

In Appendix B we show some prescriptions for the manufacture of negatives.

2. Preservation: Bibliographic Survey

2.1. Deteriorations

Although most glass plate negatives are well preserved, various kinds of deterioration will be noted, physical, chemical or biological, which are caused either by the manufacturing treatment or by attacks from the surrounding agents.

Physical deteriorations

The glass implies fragility in the handling because of its properties. Therefore one often encounters cracked negatives and even negatives which have been broken into many pieces. Old negatives are always more or less dusty and marked with finger-prints, either on the glass or on the emulsion. Frequently, there are scratches, more or less deep, on the image surface. If the negative is varnished, the scratches have not destroyed the emulsion and the picture is untouched under the protective coating. It happens that gelatin plates stored next one to another without anything to separate them stick together. This happens when plates are stored at high humidity or when protective varnish or the gelatin have become sticky because of decomposition.

Finally, the peeling of the image on some negatives may have various causes. The first photographers using glass negatives have stressed the importance of the cleaning and polishing processes required to ensure adhesion of the emul-

sion to the glass[26,36]. In connection with the gelatin method, fluctuating humidity may also cause peeling; gelatin, which is very hygroscopic, swells at high humidity and shrinks when the air dries up. As the glass is dimensionally stable, some tensions arise between the gelatin and its base which may end in a separation of the materials. In the collodion processes, excessive concentration of the solvents used for the manufacture results in deteriorations: as ether is very volatile, it favours fast drying and results in the shrinkage of the collodion which causes the reticulation of the image[58,26]; addition of too much alcohol will give a thin and brittle collodion film without any resistance[36].

Chemical deteriorations

The chemical deteriorations can be seen on the different components of the negative, except on glass which is considered to be rather stable. The protective varnish laid on the image may decompose: it becomes yellow or sticky and peels off. The collodion or cellulose nitrate is an unstable product, especially at high humidity[18,26,36]. It sets nitrogen oxides free which attack the cellulose chain and the silver of the image. It becomes yellow and gradually crumbles. For the varnished negatives the decomposition is accelerated because the protective layer prevents the gases from volatilizing.

The yellowing and fading of the image is often caused by residual salts coming from a too old fixing bath or poor rinsing. The sulphurous products based on thiosulphate react with the silver of the image and produce silver sulphide; the negative then turns brown-yellow, or may be full of spots of the same colour[15,18,21,36,46,58]. Air pollution in the form of sulphur dioxide and nitrogen dioxide and all other oxidizing agents being in contact with the negatives (adhesives, envelopes, paints and varnishes of storage cabinets, etc ...) cause an oxidation of the silver and a fading of the image. Silver stains often appear on the edges of old glass plate negatives. They are called dichroic on account of their many different colours depending on the way they are seen: they may look grey or metallic in reflected light, but yellow or sometimes red or brown-green in transmitted light. They consist of a thin layer of colloidal silver created around the silver sulphide molecules.

In the old collections, the existence of small craters may also be noted, the origin and formation of which are unknown.

Biological deteriorations

The gelatin and collodion negatives are excellent fungus and bacteria culture media that thrive best, when the humidity at the storage place is high and exceeds 60% R.H.[26,46,54]. They go through deteriorations, now and again irreversible: white filaments on the surface, coloured spots caused by pigments re-

leased by spores, decomposition of the gelatin which has become sticky and water-soluble.

2.2. Storage

In order to limit the deteriorations we have just been describing, it is necessary to observe strict storage conditions for glass plate negatives. The plates must be stored in the dark, in air-conditioned rooms where the air is purified by means of mechanical filters with strong filtering elements, the effectivity of which is monitored[35].

On account of the unstable collodion, the plates must be placed in a specially ventilated room reserved for this purpose[26,42]. The storage temperature is relatively low: 0°C, and the RH between 20 and 30%.

For gelatin plates, the conditions are less rigid: Kodak[46] recommends temperatures between 10 and 16°C, with a RH between 30 and 45%. A. Swan[56] and J. Orraca[41] are even less strict: they believe that a temperature of 18–20°C and a RH of 50% can do. The plates must be stored upright in metal cabinets, preferably made of anodized aluminium or stainless steel[13,14,41,44,56,57].

As to the materials, the wood, paints, fresh varnishes capable of releasing solvents or oxidizing agents should be avoided in connection with the storage furniture. Each plate must be placed in its own envelope which is designed for vertical storage. Neutral paper with a pH value between 6.5 and 7.5 and an alpha-cellulose content above 87% is recommended[13,14,26,42,44,56]. The envelopes should be glued with a 15–20% polyvinyl acetate resin dispersion[13,25,44]. If the curator wishes to use transparent envelopes, glassine paper should not be used. Besides its getting acidic with age, this paper contains substances that may volatilize and affect the image[62]. T. F. Collings tested this and confirms that this paper is unsuitable. Envelopes made of cellulose acetate without any surface treatment and containing less than 15 parts of plasticizer for 100 parts of ester or of polyethylene terephtalate without surface treatment should be preferred[13,44].

The envelopes must not press too hard on the plate. The emulsion should be placed opposite to the side where the envelope is sealed[13,44], as the joining may leave marks on it. When envelopes of neutral paper are used which require the use of glue, it must be checked that this adhesive does not go beyond the point of joining, thereby entering into direct contact with the image.

When the plates have been stored, they should be checked regularly every two years, so that any deteriorations may be discovered.

2.3. Restoration

2.3.1. Cleaning of glass plate negatives

In most cases the only required treatment is to remove dust and grease (fingerprints). The methods to be used must necessarily be different in accordance to the surface to be cleaned. Whatever the manufacturing process may be (collodion or gelatin), the glass side can be cleaned with ethyl alcohol or with water to which a wetting agent has been added. The smallest possible amount of solution should be used to moisten the rag, so that no fluff is left on the glass plate. Cleaning of the glass side must take place quickly and be followed by wiping to avoid the swelling of the emulsion[26,50,56,62]. The emulsion side is wiped carefully with a soft sable brush and contact with the surface must be as light as possible. The brush should also be cleaned very often to avoid accumulated particles which can be drawn on the surface and cause scratches[49].

For the gelatin glass plates, A. Swan[56], A. D. Bensusan[15] and S. Rempel[49] then recommend wiping the emulsion side with a cotton rag moistened with a film cleaning solution (Kodak film cleaner)*. This product evaporates quickly and does not penetrate into the emulsion. The use of aqueous solutions should be avoided as much as possible. However, J. Scott[52] recommends dipping the plate into water for 1 min. E. Ostroff[42] and F. Garztecki[26] recommend removing grease from the collodion negatives by a quick wash (max. 5–10 sec) in water mixed with a wetting agent. A quick rinse in cold water should follow this operation.

Due to lack of information concerning the cleaning methods for glass plate negatives we have extended our bibliographical studies to the cleaning techniques for films and microfilms. To avoid scratches caused by dust, films must not be cleaned with a dry rag. Organic solvent properties have been tested to find the most suitable[24,28,54]. The solvent has to remove all impurities (dust and grease) from the film. It must leave no residue. Its boiling point must be rather low (max. 70–85°C), it must have a low evaporation speed, no electrostatic properties and a good lubricating capacity. For safety reasons, it must be flameproof and non-toxic. Its price, finally, is the last criterion. Among the recommended solutions, we could mention freon 113 (or 1,2,2-trichloro-1,2,2-trifluoroethane), the mixture 1/1 n-heptane and freon 113, 1,1,1-trichloroethane (or methyl chloroform), and the Kodak cleaning solution (Kodak film cleaner). It should be mentioned that most 1,1,1-trichloroethanes on the market contain reaction inhibitors with metals. These inhibitors of the dioxan type, 2-methylfuran or nitromethane, are damaging to the films[28]: they may dissolve

* product based on 1,1,1-trichloroethane.

the base and set the plasticizer to migrate: they have a tendency to concentrate in the cleaning bath as they are less volatile than the solvent. So the use of 1,1,1-trichloroethane without inhibitor is recommended.

The ultrasonic method is generally used for the cleaning of films[29,34,39,61]. A high-frequency generator gives an electric impulse to a transducer converting it into mechanical energy dissipated into the cleaning liquid where a cavitation phenomenon takes place. Thousands of small unstable bursting bubbles create shock waves and clean the film immersed in the solvent. The frequency used is 25 KHz, and the recommended average energy level per surface unit of transducer is between 1.5 and 2.0 E/cm^2. The temperature in the cleaning bath must be between 37 and 43°C. The most difficult process is the drying of the film which must not be left to dry off as there is a risk of leaving impurities suspended in the solvent. The film must be dried between two sheets to remove the drops of solvent, while the temperature is kept stable at 49°C. There must be a certain humidity (50 to 60% RH) in the drying chamber to reduce the electrostatic charges.

The glass plate negatives may also be overgrown with fungus. A disinfection serves to kill the living microorganisms, but it does not remove the unsightly traces covering the picture. The traces must be removed to recreate the transparency of the negative required for printing. The cleaning of the surface may be carried out with a film cleaner soaked cotton rag. If the gelatin or the collodion has been attacked and decomposed by microorganisms, restoration is no longer possible[46,47,54].

2.3.2. Adhesion of emulsion to glass

The peeling of the gelatin is a conspicuous deterioration of glass plate negatives. Unfortunately there are no satisfactory methods of glueing the emulsion on again. E. Ostroff suggests to flatten the emulsion layer with a glass plate, and duplicate the negative. Some gelatin-based adhesives are, however, recommended:

- A 15% aqueous solution of photographic gelatin to which a few drops of "photoflo" have been added[41].
- A 10% aqueous solution of photographic gelatin containing 0.5 g chrome alum and 5 ml "photoflo" dissolved to 1/200[62]. This formula constitutes one of the substratum used for the production of old negatives;
- An aqueous solution of gelatin containing ammonium hydroxide[62].

In connection with the collodion process, I. Moor[36] describes a gaseous procedure of filling in the cracks, made either in the reticulated varnish or in the

collodion. The plate is exposed to the vapours from a mixture of ether (60%) and alcohol (40%) to which 2 ml essential camphor oil is added.

2.3.3. Glueing of broken or cracked plates

Among the types of damage the fragile glass base is exposed to, two cases should be noted which are described by R. A. Weinstein & L. Booth[62]:

- Cracked glass. Generally the emulsion remains undamaged. After cleaning the glass side, it is sufficient to put on it another very clean plate, held in place by means of an acrylic self adhesive tape (3 M No. 850). This method allows to keep the cracked glass in position, and therefore reduces possible marks from the cracks. To save the picture, the negative may be duplicated or contact printed.
- Broken glass. The previous method may be used in about half the cases. But if the glass has been broken in too many pieces, it would be expedient to use an adhesive for glass of the cyanacrylic type (instant glue Eastman Kodak No. 910) or epoxy (e.g. Hydrosol 0.0151), whose refractive index resembles that of glass. The harmlessness of these adhesives to the negatives has not been proved, and T. J. Collings[20] prefers not to use them. He describes a system with a frame of neutral paper where the fragments of glass may be wedged at intervals of about 1 cm, and where the negative can in this way be assembled. This mounting keeps the glass fragments into position, so that they do not overlap and further deteriorate the picture. This is not a restoration technique; it is more like a storage method.

2.3.4. The transfer of the emulsion to another base

is a solution proposed by I. Galambos[25], when a gelatin negative, whose glass base is broken, has to be restored. The fragments are placed on a glass plate coated with vaseline, so that the picture may be assembled. The cracks are filled with a 3% aqueous gelatin solution. After drying, the plate is immersed in a 0.5% sodium fluoride and 1% concentrate sulphuric acid solution. The separated emulsion is transferred to the new base, prepared beforehand; the process must be carried out under water. The new base is a thoroughly cleaned reused glass plate from a damaged negative on which two layers are placed successively. The first layer is obtained after immersion in an aqueous solution with 20% gelatin and 1% potassium chromate; the second consists of a 4% aqueous gelatin solution applied with a pipette. The so-prepared base is dried prior to the transfer which is carried out in water. Several experiments have been carried out with transfers of emulsions for plastic based negatives to solve

the problems concerning the base shrinkage. V. Reed[48] uses 2-butanol for dissolving either the substratum in the case of a cellulose diacetate base or both substratum and base in the case of cellulose nitrate base[38,43,51]. L. Gear[27] separates the emulsion by immersing the negatives in a mixture of acetone (50%), methanol (40%) and water (10%). According to the authors, these transfers are relatively easy.

2.3.5. Chemical restoration

Before a chemical restoration is made of a faded or stained image, one must be aware of the risks involved: worsening of the damage and irreversibility of the process. Some methods have been tested, however, but all of them on gelatin negatives. J. L. Enyart[23] has started restoration of 2,000 glass plate negatives selected from the large collection of 60,000 negatives at the University of Kansas Library. After cleaning with a wad of cotton moistened first with water, then alcohol and finally diluted ammonium hydroxide, the plate is immersed in an acid thiourea solution which reduces the silver oxides (especially the silver sulphide). If the gelatin appears delicate, the thiourea solution is applied with a cotton wad. The plate must subsequently be rinsed thoroughly. This technique has often been used for cleaning daguerrotypes[60]; though the picture is in most cases brightened up, thorough studies have revealed a change of the silver grain structure and the coming out of small red spots (the measles of daguerrotypes). In the case of thiourea treated glass plate negatives, the problem of a later deterioration has not been approached. Stains of silver sulphide or dichroic silver may be reduced or eliminated either through treatment in a 2% potassium cyanide solution[30] or in a thiosulphate-ammonia fixing bath acidified with citric acid[2,30,31,46,59]. The latter solution preferentially acts on the spots, but also attacks the silver of the image. The treatment must be watched closely, and subsequently the plate must be rinsed thoroughly in order to remove all the thiosulphate, which is itself a picture deteriorating substance. It is also possible to erase these stains by using a 0.5 to 1% alcoholic iodine solution[63].

Finally, faded or yellowed pictures may be freshened up by using the bleaching redevelopment process. Many experiments have been made with this technique on plastic based negatives[16,22,33,46,59], but there are no publications describing its use on the glass plates. At a preliminary stage, this technique requires a treatment in a hardener to strengthen the gelatin. In the case of glass plate negatives, this treatment may cause the peeling of the gelatin during drying. A lot of care is required. Bleaching is performed in an acid potassium permanganate solution. After exposure, the picture is developed in Dektol or D 72-Kodak solution.

As mentioned in the chapter on the technology of negatives, intensification or reduction techniques were used to obtain the desired contrast. These methods can be used for restoring the silver images.

2.3.6. Duplication

The authors agree recommending a duplication of the negatives before any treatment. Some think it is the only way to restorate, others think it is a guarantee against altering the picture completely through a chemical treatment.

Non-stained negatives can be duplicated directly on Kodak Professional Direct Duplicating film SO-015 (thick base in Estar) without any loss of quality or resolution of the image compared to the originals[17,37,38,46]. The obtained duplicate is inverted from left to right on account of the emulsion to emulsion exposure.

For the stained negatives, an optical restoration is required to reduce or even get rid of the stains. For this purpose a panchromatic film and a filter of the same colour as the stain only are needed. Kodak separation negative film 4131 – type 1 – is recommended, together with the below-mentioned filters:

KODAK[46]			
Stain color	Filter color	Kodak Wratten filter n°	Filter factor (Tungsten)
Yellow	yellow	15	1.5
red, amber	red	25	4
orange			
green	green	58	8
blue-green	blue	47	20
blue			

(for a 64 ASA film, exposure has to be multiplied by the factor stated above).

When a panchromatic sensitivity is not required, the Kodak commercial films 6127 and 4127 (thick base in estar) are more economic. L. Booth[16], director of the 'Museum and Historical Library Title Insurance and Trust Company' in San Diego, California, where more than 100,000 glass plate negatives are stored, duplicates on Kodak Film 6127. He produces his intermediate positives on Kodak Ektapan 4162.

When the plates are cracked or broken, it is sufficient to keep the fragments in place between two glass plates.

To avoid any manipulations, J. R. Scott[53] recommends the microfilming of the entire Archives collection in Toronto, i.e. 15,000 negatives. For the accomplishment of this work, he uses the following equipment: Kodak camera MRD-2/ Recordak 35 mm AHU microfilm/ 3M-P 74 treatment using Kodak chemistry; the ratio of reduction is five.

In the case of faded negatives where the picture is almost invisible, the disclosure technique for faded inks with ultra-violet or infrared rays has been attempted without much success[55]. On the other hand using duplicating processes with autoradiography give intensified images with X-ray sensitive films, provided that the original still contains silver particles. The principle of this process is to convert the silver in the picture into a radioactive component[40,61,64,65,66,67], and this can be done according to the three below-mentioned reactions:

- irradiation of the picture with a neutron flow transforms silver (^{107}Ag) into radioactive silver (^{108}Ag). In this case, the time of radiation must be limited to avoid the gelatin decomposition;
- the silver of the image reacts with a component containing a "labelled" element, like sulphur-35 or iodine-131;
- the isotopic exchange of the surface silver is carried out with atoms of ^{110}Ag or ^{111}Ag dissolved in the negative immersion bath.

Combinations of these three processes may also be used.

These methods open up prospects for information and duplication, but the picture stability of the original document is threatened. This technique should therefore be reserved for very damaged negatives which may be regarded as ruined.

Conclusion

If the preservation conditions for glass plate negatives have been defined quite well, then the restoration treatment of deteriorated negatives has scarcely been studied and is, above all, used for the gelatin processes.

The cleaning of dusty plates must be carried out manually with a soft brush or cotton moistened with 1,1,1-trichloroethane. This treatment is recommended by most authors who emphasize the necessity of a very careful treatment of the negative.

The possibility of repairing both cracked and broken glass plates and peeling gelatin has not been subject to very specific studies. Only one scientist has proposed to transfer the emulsion to a new base, others recommend adhesives of

the epoxy type or a cyanacrylic resin for the glass, or an aqueous gelatin solution for glueing the emulsion to the base.

The chemical restoration to reduce brown and dichroic stains or to intensify faded pictures, has been described for plastic based negatives, but experiments with glass plates have not been made yet.

No studies have been carried out to prove the harmlessness of these restoration treatments.

This bibliographical summary constitutes a source of information, on the basis of which research into the restoration of glass plate negatives may be started. It has given us the possibility of underlining the lack of interest for peeling emulsions and cracked or broken glass plates. It seems important to start experimentation in this field.

3. Experimentation

French conservators are faced with many problems to preserve glass plate negatives. As various manufacturing processes have been used, we have defined the scope of our studies to gelatin negatives and have first perfected a method to identify the image components of the altered negatives. Then we have approached the restoration treatments. Once the cleaning processes of the glass and the emulsion had been tested, we have developed a technique for transferring the image layer onto a new base.

3.1. Identification of the glass plate negative manufacturing process

Most of the time, the process can be identified on a visual investigation alone. As for the collodion process, the glass base is thick and the edges of the hand-applied sensitive layer are uneven. Scanned in transparency, the image is black-grey, but in reflected light, it is brown-black in the high densities and cream-coloured in the highlights. As for gelatin glass plates, the glass is thinner and shows sharp edges leading the emulsion to peel off. Either in transmitted or reflected light, the shades range from grey to black according to their densities. Even if an expert collector may sometimes doubt the precise nature of a plate, he must then resort to more significant tests. They are destructive and must be put into practise only if one is compelled to.

The first analysis consists in putting a drop of water on a corner of the image and then in examining the behaviour of the moistened area under the binocular magnifier.

Other chemical methods rely on the reactions peculiar to the proteins and only require a small sampling from the image (20 µg or 0.5 mm^2).

- The Biuret test shows gelatin when a part of the emulsion treated with an alkaline cupric sulphate solution turns purple.
- The Ehrlich reactive gives a pink colour in the presence of hydroxiproline which is characteristic of gelatin. The latter is the more reliable. To indicate the nitrate function of collodion, a phenylamin acid solution may be used as it makes nitrates turn dark blue.

3.2. Cleaning of the gelatin glass plates

In most cases, the cleaning of the gelatin glass plate negatives can be restricted to a dust removal. Great care must be taken to avoid the scratching and peeling of the emulsion or of the covering varnish. An "air bulb" and a soft sable brush are used to dust the plates. The brush should always be very clean to avoid drawing particles on the surface and damaging it. We suggest using several brushes and having them regularly changed. Providing there are no retouches, the glass side can be efficiently cleaned with a cotton rag moistened with ethyl alcohol. Then, the solvent will be removed by wiping with a dry cloth. This simple and careful process is not sufficient when the stains are stuck to the emulsion. Therefore we have tested an ultrasonic process, currently used for motion picture films. Samples of glass plates have been immersed in various organic solvents and put through ultrasonic waves in a Bransonic B 220 tank. Among the products which have been tested (1,1,1-trichloroethane, dichloromethane, carbon tetrachloride, hexane) known for their efficiency and safety to the images of the films, the 1,1,1-trichloroethane appears to be most satisfactory. We had the solvent temperature (from 20° to 36°C) and the running time of the ultra sounds (1 to 30 min) to vary according to the negatives' condition.

In most cases, the cleaning of the plate is carried out after a 5 min ultrasonic treatment under a temperature of 25°C, on average. Though this process is harmless to well preserved plates, it is prohibited for those already damaged because, in that case, pieces of gelatin peel off from the glass. Therefore this process must not be systematic. When the whole image is masked by stains, it is then difficult to determine exactly the extent of the deterioration. Then the plate should be carefully hand-cleaned with a cotton rag moistened with 1,1,1-trichloroethane. As for the varnished plates, the ultrasonic process completely dissolves the protecting film and leaves a clean but vulnerable image. Thus, in this case, the process must not be carried out and the plate should be hand-cleaned and great care taken not to dissolve the varnish.

3.3. Restoration of the peeling glass plate negatives

The partial or complete peeling of the emulsion is one of the most serious deteriorations for gelatin glass plates.

The simplest solution is to glue together the pieces of the peeling emulsion with a gelatin-based adhesive similar to the one used for the manufacturing of the glass plate. But the effect of this process is short-lived. As a matter of fact, the glass cannot locally be thoroughly cleaned to get the smooth surface a good adhesion requires. Moreover, the aqueous adhesive brings moisture and causes a swelling of the emulsion followed by a shrinkage when drying. The picture undergoes tensions causing much more peeling than before the treatment. Because of this, we have thought the problem could be solved by transferring the image layer onto a new glass base.

This process is divided into several stages:

- The preparation of the new glass base is required to ensure a good adhesion of the transferred emulsion. The glass surface has to be smooth and free from any impurities. It will be immersed in a chromic sulphuric acid solution for 18 h to be cleaned; then thoroughly rinsed out in water, before being soaked in an aqueous 5% sodium carbonate solution to neutralize the acidity of the previous bath. It is rinsed again in distilled water. After drying, a 1% aqueous sodium silicate solution is applied with a pipette on one side of the glass to allow a better fixation of the adhesive. The plate, once vertically dried to remove the excess liquid, is ready for use. A 1% gelatin and 0.1% chrome alum aqueous solution may be used in place of the sodium silicate solution. Both chemicals generate the same effects.
- The hardening of the emulsion is needed to limit the swelling of the gelatin in the aqueous and acid baths. Our first transferring experiments showed that the picture underwent an important enlargement, up to 10%. To avoid it, several gelatin hardeners were tested: alum based solution, chrome alum or formaline ones. We had the concentration and time immersion to vary for each of them. The best results were got when the plates had been soaked for 3 min in a 2% formaline aqueous solution. Then the dimensional enlargement was almost non-existent.

The varnished plates cannot be treated in the hardening bath because the coating film becomes opaque or crystallises in the formaline solution. Various solvents were tested to dissolve the varnish: methylalcohol, acetone, toluol, benzene, ether and chlorinated solvents. In most cases, ethylalcohol is effective. Spot-tests are necessary before any treatment to select the most appropriate solvent. Then the gelatin will be hardened as described above.

- The total peeling of the emulsion is achieved by dipping the plate in a diluted

aqueous fluorhydric acid solution. As it attacks the glass, this product allows the peeling of the whole emulsion. We have determined the lowest acid concentration and the shortest dipping time required for an effective action: the plate must be dipped for 30 sec in the 1% acid solution. The emulsion so separated will then be thoroughly rinsed at least in three distilled water baths successively to eliminate the residual acid. It will be transferred onto the new base while it is still wet.

We have experimented with another method which had been used at the beginning of the century for stripping the emulsion from glass negatives*. This technique unites the two previous steps of the transfer: the hardening and the peeling of the emulsion. Thus the treatment only requires a 30 min dipping in a 2% formaline and 2% glycerol solution and no enlargement occurs. Though this method is easily applied to strongly damaged emulsions, almost separated from their base, it seems less effective to less deteriorated negatives. The last ones require the former treatment: hardening with formaline followed by a peeling of the picture by means of the acid solution.

- The image layer transferred onto the new base requires great skill. A gelatin-based adhesive has to be spread on the newly prepared glass plate. We used the one containing chrome alum recommended by Weinstein & Booth[5]. Trying to lay the parts of the picture directly onto the wet adhesive has not been successful. So we carried it out in water.

In spite of careful handling, cracking due to the gelatin shrinking during drying cannot be avoided. So this technique shouldn't be applied.

The best solution consists in putting together the parts of the picture back-side-up onto an intermediate wet base, and afterwards applying it on the new base covered with the still wet adhesive.

A polyester tissue has been successfully used for this purpose. After drying, the negative allows a good printing. Some small cracking however can still be seen. They can be cut off by retouching on the glass side.

Without this transfer the damaged negative would have been lost for good. A good adhesion of the transferred emulsion on the new base has been checked by artificial ageing at a high temperature. After three months at 50°C, no alteration has been noticed.

* The British Journal of Photographic Almanac and Photographer's Daily Companion. Ed. Arthur J. Dalladay, A. Inst. P., London, H. Greenwood & Co. Ltd, (1940).

CONCLUSION

Our experiments on the preservation of peeling emulsions lead us to elaborate a technique in which the silver image is transferred onto a new base. This process requires great care and skill. The conservator will have to duplicate the negative before processing. Our studies will be carried on to elaborate a technique allowing the restoration of the broken glass plate negatives. The most important choice of the adhesive used to put the parts together will be determined by its harmlessness to the image.

Appendix A

Protection of glass plates negatives.

	Varnishes formulas[8]	
Glossy varnishes		
1	Ethyl alcohol (95°)	900 cm^3
	Methyl alcohol	100 cm^3
	White shellac	85 g
2	Ethyl alcohol (95°)	950 cm^3
	Methyl alcohol	50 cm^3
	Castor oil	2 cm^3
	Sandarac resin	90 g
	Benzoin gum	60 g
Matt varnishes		
3	Ethyl alcohol (95°)	50 cm^3
	Ether	425 cm^3
	Benzol	225 cm^3
	Sandarac resin	10 à 35 g
4	Ether	225 cm^3
	Benzol	40 à 200 cm^3
	Sandarac resin	20 g
	Mastic	5 g
Durable varnishes		
5	Benzol	1000 cm^3
	Oil of lavander	5 cm^3
	Asphalt	100 g
	Gutta percha	10 g
	Rubber	1 g
Coloured varnishes		
	2% collodion + dye	
	red dyes: fuchsine, safranine, azo dye, eosin	
	yellow dyes: chrysoidine, azo dye	

Appendix B

Considering the numerous manufacturing processes, we mention below some currently used formulas.

	Albumen process		
Preparation of photographic albumen			
Solution 1: Gobert			
	water		10 ml
	fresh albumen		100 g
	ammonium iodide		1 g
	potassium bromide		0.25 g
	iodine		0.25 g
The two following mixtures increase the process sensitivity			
Solution 2: G. Sella			
	water		5 ml
	gum and sugar solution*		5 ml
	potassium iodide		1 g
	iodine		0.12 g
	potassium bromide		0.20 g
	albumen		100 ml
* gum and sugar solution:			
	water	48 ml	
	sugar	16 g	
	arabic gum	8 g	
Solution 3: E. Bacot			
	distilled water		45 ml
	dextrin		9 g
	potassium iodide		3 g
	potassium bromide		0.5 g
	albumen (6 whites of eggs)		
Sensitization			
Bath 1: Gobert			
	water to make		100 ml
	acetic acid		10 g
	silver nitrate		10 g
Bath 2:			
	distilled water to make		100 ml
	silver nitrate (fused)		8 g
	acetic acid		16 g
Bath 3: E. Bacot			
	distilled water		100 ml
	silver nitrate (fused)		10 g
	acetic acid		25 g

Developers

Bath 1: Gobert

water to make	1000 ml
gallic acid	1 g

then add a few drops of the following solution

pure alcohol	100 ml
pyrogallic acid	10 g

As soon as the image appears, add a few drops of this solution

water to make	100 ml
silver nitrate	3 g

Bath 2: E. Bacot

distilled water	400 ml
gallic acid	7 g
calcium acetate	3 g

Then add a few drops of the following solution

distilled water to make	100 ml
silver nitrate	6 g
acetic acid	20 g

Wet collodion process

Collodion

	Formulas			
	Davanne	Fabre	Bareswill	Codex
gun cotton (g)	11.3 to 14	22.6	11.25	52.6
ethyl ether (ml)	660	660	800	790
alcohol (40°) (ml)	340	340	200	210

Photographic collodion

	Formulas			Vienne's Geographic Institute
	Bayard	Perrot de Chaumeux	V. Monckhosen	
gun cotton (g)	8 to 10	1	1	15.5
ether (ml)	600	50	50	500
alcohol (ml)	400	50	50	400
ammonium iodide (g)	4	0.5	0.5	4.70
cadmium iodide (g)	6	0.5	0.5	7.80
potassium iodide (g)	2			
ammonium bromide (g)			0.5	
cadmium bromide (g)	3	0.25		
sodium bromide (g)				1.60

Sensitization

- Current formula:

distilled water to make	1 l
nitric acid	3 drops
silver nitrate	20 to 80 g
potassium iodide	0.5 g

- Shoer's bath (high sensitivity): mixture of the two solutions:

solution 1:	distilled water	125 ml
	silver nitrate	25 g
solution 2:	distilled water	125 g
	lead acetate	25 g

Developers

1	distilled water to make	200 ml
	pyrogallic acid	0.5 g
	acetic acid	8 to 15 ml
2	ammonium iron sulphate (saturated aqueous solution)	100 ml
	water	700 ml
	acetic acid	20 ml
	alcohol (36°)	20 ml

Gelatin process

Audra's emulsion:

- Bromized gelatin:

water	100 ml
ammonium bromide	10 g
gelatin	2 g

– Ripening with the following solution:

water	25 ml
alcohol	25 ml
ammonium hydroxide	8 ml

– Silver nitrate solution:

water	50 ml
silver nitrate	15 g

Developers

– Ferrous oxalate:

This developer is obtained from a mixture (1/3) of the two following solutions:

(a)	distilled water to make	1000 ml
	ferrous sulphate	300 g
	tartaric acid	4 g
(b)	water to make	1000 ml
	neutral potassium oxalate	300 g

– Hydroquinone:

Two parts of solution (a) are mixed with one part of solution (b):

(a)	water to make	1000 ml
	sodium carbonate	250 g
(b)	water to make	1000 ml
	sodium sulphite	250 g
	hydroquinone	25 g

Hardening

5% potassium alum solution

Fixing

15 or 30% sodium thiosulphate solution

Alum fixing bath

water to make	1000 ml
sodium thiosulphate	150 to 300 g
potassium alum	50 to 80 g

APPENDIX C

Identification of the manufacturing processes

Biuret test*

10 to 20 mg of the sample are heated in a boiling water bath with 0.5 ml of conc. hydrochloric acid for 5 to 10 min. The solution is diluted to 2 ml with 10% w/v sodium hydroxide solution. The solution is filtered, if necessary, and to 1 ml of the filtrate 0.3 ml of 40% w/v sodium hydroxide solution are added followed by 1 drop of a dilute solution of copper sulphate. A violet colouration indicates the presence of a protein.

Ehrlich's reagent test**

Ehrlich's reagent: 4-dimethylaminobenzaldehyde (5% w/v in propan-1-ol) Using a scalpel, a sliver of emulsion (1×10 mm) is removed from the edge of the photograph and placed in a test tube. After adding one drop of sodium hydroxide solution (4M), the test tube is heated in a water bath for 5 min. and then cooled. One drop of copper sulphate solution (0.0 1 M) and one drop of hydrogen peroxide solution (20 vol.) are added. The latter must not be allowed to touch the sides of the tube. The test tube is shaken until foaming ceases and then heated in the water bath for a further 3 min. The test tube is cooled and three drops of sulphuric acid (2 M) added, followed by two drops of Ehrlich's reagent. Finally, the test tube is again heated in the water bath and development of a rose pink colouration indicates the presence of hydroxyproline. Development of the colour will take no longer than 10 min.

Identification of cellulose nitrate*

The nitrate in cellulose nitrate may be detected by dissolving 20 mg (approx.) of diphenylamine in 1 ml of concentrated sulphuric acid and pouring one drop of this solution onto a corner of the image (at the edge). The immediate development of an intense blue colour indicates the presence of nitrate.

Restoration of the peeling emulsions

Chemicals

– Chromic sulphuric acid

potassium dichromate	70 g
conc. sulphuric acid	70 g
distilled water to make	1 l

– Hardening solution

formalin (37–40%)	20 ml
anhydrous sodium carbonate	5 g
distilled water to make	1 l

* J. Haslam, H. A. Willis & D. C. M. Squirrell, *Identification and analysis of plastics*. Second edition, London, Iliffe Books, 1972, pp. 99–101.

** T. J. Collings & F. J. Young, *Improvements in some tests and techniques in photograph conservation*. Studies in Conservation, 21 (2), May 1976, pp. 79–84.

- Fluorhydric acid

sodium fluoride	50 g
conc. sulphuric acid	10 ml
distilled water to make	1 l

- Hardening and stripping solution

saturated potassium carbonate solution	2 ml
glycerine	1 ml
formalin	1 ml
distilled water	50 ml

- Gelatin based adhesives

The two solutions are coated successively on the new glass base:

Solution 1:

photographic gelatin	5 g
chrome alum	0.5 g
Kodak photo-flo (1/200 diluted)	5 ml
distilled water to make	500 ml

Solution 2:

photographic gelatin	4 g
distilled water	100 ml

For these solutions, the gelatin is dissolved with the help of a warm water-bath (45°C–50°C).

Summaries

Glass Plate Negatives. Preservation and Restoration

After a brief technological explanation of various processes for the production of negative pictures on glass plates, the authors have carried out an analytical bibliography on the conservation and restoration of these negatives, either based on collodion or gelatin. The various types of deterioration and their causes are well-known. The storage conditions have likewise been established. The number of restorations is, however, limited.

This bibliographical synthesis constitutes a source of information allowing experiments on restoration techniques for glass plate negatives, with the main purpose, to solve the problems of peeling emulsions and cracked or broken glass plates.

Les negatifs sur plaques de verre

Après un bref rappel technologique sur les différents procédés d'obtention d'images négatives sur un support en verre, les auteurs ont réalisé une bibliographie analytique sur la conservation et la restauration de ces clichés, qu'ils soient à base de collodion ou de gélatino-bromure. Les diverses formes d'altérations, ainsi que leur origine sont bien connues. Les conditions d'archivage sont également établies. Par contre, les traitements de restauration sont peu nombreux. Cette synthèse bibliographique forme une base d'informations permettant d'expérimenter des techniques de restauration des négatifs sur verre afin de résoudre en particulier les problèmes des émulsions décollées et des plaques de verre félées ou cassées.

Glasscheibennegative. Konservierung und Restaurierung

Eingeleitet von einem Überblick über die verschiedenen Herstellungeverfahren von Glasplatten mit photographischer Emulsion wird eine analytische Bibliographie geboten über die Konservierung und Restaurierung derartiger Negative, sowohl solcher mit Gelatine als auch solcher mit Kollodium. Die verschiedenen Schäden, die an ihnen auftreten können, sind bekannt, ebenso ihre Ursachen. Auch über die optimale Aufbewahrung gibt es kaum Meinungsverschiedenheiten. Die Möglichkeiten der Restaurierung sind jedoch begrenzt.

Die bibliographische Synthese ist gedacht als Informationsbasis für weiterführende Versuche zur Restaurierung von Glasplattennegativen. Deren Hauptziel muß das Bekämpfen von sich ablösender Emulsion und von gebrochenen Trägern sein.

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67. Thackray, M. & Roman, D.: *Intensification of faded photographs and underexposed negatives using radiosiotopes.* Atomic Energy, 24–30 (April 1972).

Françoise Flieder
Directeur de recherches au C.N.R.S.
Centre de Recherches sur la Conservation des Documents Graphiques
36 rue Geoffroy St-Hilaire
75005 Paris
France

Chantal Garnier
Technicienne au Ministère de la Culture
Centre de Recherches sur la Conservation des Documents Graphiques
36 rue Geoffroy St.-Hilaire
75005 Paris
France

Martine Gillet
Ingénieur au C.N.R.S.
Centre de Recherches sur la Conservation des Documents Graphiques
36 rue Geoffroy St.-Hilaire
75005 Paris
France

Paper Deacidification: A Bibliographic Survey
Part I

by DANIELLE MIHRAM

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Introduction

The bibliographic survey which follows could be considered to be the first annotated checklist of the holdings at Princeton University's Library on the subject of deacidification.

It is intended to serve as a practical reference tool. It is limited to writings in the English language, mainly original publications and including some published translations of works written in other languages. Within this limitation it is nearly exhaustive, including some articles in newspapers, leaflets of firms, etc. On the other hand, the technical literature from France, Germany, Italy is nearly totally omitted.

The corpus of the bibliographic survey has been divided into three main sections to facilitate the reader's access to information: namely, should deacidification be considered? When? Why? (*Deacidification: Yes or No?* p. 82); what are the main methods which are used? (*Methods* p. 86); and finally, in the third section (dealing with the topic of acidity and environmental factors causing acidity in paper p. 110), the reader will find a selection of citations which do not precisely deal with deacidification, but, rather, with procedures devised to measure the acidity of paper. Since such procedures are necessarily initial steps in the deacidification process such a section has been incorporated in the bibliography.

Restaurator 7: 81–98

With regard to the annotations which follow each citation, the reader will find that the comments are not evaluative but, rather, could be considered to be very short summaries of the works which were examined. In a very few cases (three), when available, the author's abstract has been reproduced in an abbreviated form (see W. K. Wilson et al. (p. 85), J. S. Arney et al. (p. 86) and G. B. Kelly, Jr. et al. (p. 91).

Evaluative comments did not seem appropriate here, since most of the papers or books are reports on experimental work, and, short of replicating each experiment, the reader cannot pass judgement adequately on each result given. The bibliography does contain, however, several evaluative reports (see, for example, C. Harris, G. B. Kelly Jr., and J. C. Williams.

We did not limit our search to any specific span of time, and the listing below spans almost a century of research (see R. Irvine and G. Sims Woodhead (1894), for example) though the major amount of research has been done during the past fifteen to twenty years. The "cut-off" date is approximately 1982, date of the termination of this project which satisfied initially the requirements of an independent study course which I took during my coursework for the MLS at Rutgers University. Hopefully, additions to this bibliography will appear in the future in enlarged editions of the list.

The literature search for the bibliography was, for the major part, a manual search into the pertinent reference sources. An online search was also done by the Princeton University Reference Retrieval Service (PURRS) so as to scan large data bases such as *Chemical Abstracts*. It is interesting to note, however, that about 80% of the citations obtained in PURRS (excluding the patents) had already been located in manual searching.

Several individuals have, in one way or another, contributed to the compilation of this work: Carol W. Hazen, who performed the online search in 1982; Dorothy Quick, who tirelessly roamed through the stacks and completed several inter-library loan requests; Robert Parliament and Susan G. Swartzburg, whose suggestions have led me to several fruitful sources: to each and all I express my warmest thanks.

I. DEACIDIFICATION: YES OR NO?

Arney, J. S., A. J. Jacobs & R. Norman: *The Influence of Deacidification on the Deterioration of Paper*. Journal of the American Institute for Conservation, 19(1): 34–41 (1979).

An examination of the influence on calcium carbonate deacidification of commercial rag and newsprint papers, at 90°C and 100% RH., shows that the decreased rate of deterioration cannot be explained solely in terms of a decrease in the acid-catalyzed hydrolysis process alone: atmosphere oxidation of paper is also retarded by deacidification.

Barrow, W. J.: *An Evaluation of Document Restoration Processes*. American Documentation, 4: 50–54 (1953).

A summary of the limitations as well as the desirable properties of some of the most widely used restoration procedures, deacidification, lamination, silking (or, alternatively, the use of tissue as a substitute for silk).

Darling, Pamela W.: *Our Fragile Inheritance: The Challenge of Preserving Library Materials*. American Library Association, 3: xxi-xlii (1978).

Preservation has become a most important aspect of librarianship, and the author surveys the problems which librarians face when the preservation of materials becomes necessary. A very short note on the subject of deacidification appears pp. xxxviii-xxxix. Though W. J. Barrow, the Library of Congress, and "a few independent researchers" are identified, no details of their work are given, and the author is not too enthusiastic about deacidification as a single solution to the problem of preservation which every librarian must face.

Darragh, David W.: *Deacidification of Brittle Manuscripts and Documents*. Restaurator, 2(3/4): 179–84 (1978).

A study undertaken in order to determine whether brittle papers (i.e. thoroughly degraded papers) should be deacidified or not. Rapidly deteriorating paper was deacidified and then subjected to accelerated aging in a dry oven at 100°C (a rough equivalent of 25 years of natural aging at 20°C). Samples were examined and their folding endurance was measured. Result: Deacidification is beneficial when papers will have sufficient strength to register 10 folds or more on the 45° fold setting on the M.I.T. Folding Endurance Tester. Paper with endurance of less than 10 folds would not tolerate deacidification treatments.

Grove, Lee E.: *Paper Deterioration - An Old Story*. College and Research Libraries, 25(5): 365–74 (1964).

Primarily a historical account of the deteriorating quality of paper made according to modern techniques, and the efforts to remedy such a situation. An extremely short note at the end of the paper mentions the research work of deacidification at the W. J. Barrow Research Laboratory.

Haas, Warren J.: *Preparation of Detailed Specifications for a National System for the Preservation of Library Materials*. Washington, D.C.: Association of Research Libraries, Feb. 1972.

Very short note (pp. 6–7) acknowledges the research of W. J. Barrow (and the Barrow Laboratory), and R. D. Smith. No details regarding deacidification procedures are given.

Harrison, Alice W.: *Conservation of Library Materials: Clip no. 11: Newspaper Clipping File.* APLA Bulletin (Bulletin of the Atlantic Provinces Library Association), 43(2): 6 (Sept. 1979).

Discusses various methods of preserving newspaper clippings: microfilming; deacidification and alkaline buffering; polyester film encapsulation. Bibliographic information, as well as complete addresses of suppliers are given. (Photocopying is recommended when the original clipping does not need to be preserved.).

Langwell, W. Herbert: *The Permanence of Paper Records.* Library Association Records, 55: 212–15 (1953).

Surveys the chief causes of paper embrittlement: e.g. during manufacturing: the use of the Hollander beating machine, as well as exposure to sulphur in the atmosphere. Contends that the protection obtained with the impregnation of paper with alkaline substances (chalk, lime-water) is short-lived. Laboratory research promises to develop substances which will counteract the acid-forming properties of the metallic impurities in paper.

Langwell, W. Herbert: *Permanence of Papers.* Technical Bulletin of the British Paper and Board Manufacturers' Association, 29(1): 21–28 (Feb. 1952); 29(2): 52–57 (Apr. 1952).

The first part of the paper studies the interaction of two factors affecting the permanence of paper: catalytic metals in the paper and sulphur dioxide in the atmosphere of industrial areas. The second part examines two methods used in the testing of the effectiveness of catalyst poisons (anti-catalysts): the first method giving results in 16 hrs., the second in 28 days. Among the possible methods suggested for the stabilization of papers is the addition of a buffer, or alkaline substance, to neutralize the acid in paper.

The Care of Books and Documents. London: Library Association, 1972 (Library Association Research Publication no. 10).

This pamphlet is intended to provide basic practical advice on the care and maintenance of library materials. It is mainly for the guidance of those libraries with small collections of valuable and/or irreplaceable materials. A short section on acidity (p. 14: 2.14) notes that no methods of deacidification for general library use have been developed, since the methods currently (1972) in use can only be employed in libraries with equipped laboratories, and serviced by qualified conservators. The pH meter and the Archivist's Pen are recommended as simple ways to test acidity.

Deacidification, Lamination, and the Use of Polyester Film Encapsulation. Special Libraries Association Geography and Map Division Bulletin, no. 99: 46–48 (1975).

Lamination without deacidification and alkaline buffering is nearly worthless as an archival preservation technique. Also, W. J. Barrow's guidelines for the testing and control of his deacidification solutions are not consistently observed by conservation workshops, and research for such controls is being carried out at the Library of Congress.

Peacock, Elizabeth E.: *The Effect of Internal Acidity on Textile Deterioration.* (Winterthur Art Conservation Program, Delaware.). Washington, D.C.: National Endowment for the Arts, Apr. 1980.

The effects of internal acidity on textile deterioration are described and compared with paper conservation. The results of experiments using deacidification agents (deionized water, magnesium bicarbonate, and magnesium methyl carbonate) on flax linen are given with regard to their effect on the textile's weight, color, stiffness, and tensile strength. N.B.: This article is included in this bibliography as a possible aid in the resolution of problems dealing with bookbindings or book covers containing textiles.

Waters, Peter: *Deacidification, Lamination, and the Use of Polyester Film Encapsulation at the Library of Congress.* Information Bulletin, Western Association of Map Libraries, 6 (3): 19–21 (June 1975).

A discussion of the advantages and disadvantages of each of those three methods of preserving manuscripts of archival value. The need for the proper testing and control of deacidification solutions is especially noted (p. 20).

Wilson, William K., Ruth A. Golding, R. H. McLaren & James L. Gear: *Effects of Magnesium Bicarbonate Solutions on Various Papers.* pp. 87–107 of Advances in Chemistry Series no. 193 (Preservation of Paper and Textiles of Historic and Artistic Value II; John C. Williams (ed.); Washington, D.C.: American Chemical Society, 1981).

As part of a long-range program on a study of the effects of various deacidification procedures on paper, the effects of magnesium bicarbonate on the physical and chemical properties of several old papers, some multicolored maps, and handsheets made from a bleached hardwood kraft, were studied. Results: reflectance usually increased with deacidification. Tear and tensile energy absorption improved. The sizing of the papers studied was destroyed by deacidification in magnesium bicarbonate. It was shown that deacidification did not remove aluminum from the carboxyl groups in laboratory handsheets. The stability toward accelerated aging at 90°C in closed cells of various handsheets led to inconclusive results (17 Tables of results are included).

Wilson, W. K. & R. L. Hebert: *Evaluation of the Stability of Record Papers.* TAPPI 52(8): 1523–29 (Aug. 1969).

A variety of pulps (ground wood, neutral sulphite, semi-chemical, bleached chemical wood, and rag) were artificially aged in the laboratory by means of heating for various periods of time at 90°C and at 50% R.H. The results of the changes in reflectance, pH, folding endurance, tear, burst, and tensile properties are tabulated in Table III through X. One of the results of this study shows that the papers containing calcium carbonate filler showed the lowest rate of degradation.

II METHODS

1. AQUEOUS DEACIDIFICATION

The 'Club Soda Formula' – The Use of Magnesium Bicarbonate Prepared with Magnesium Hydroxide and Club Soda to Protect Paper Against Aging. Abbey Newsletter, 15: 5 (July 1978).

The formula was originally developed by Richard D. Smith (President of Wei T'o® Associates around 1966). A list of materials needed, instructions for the preparation of the solution, as well as the treatment procedure are delineated. Information for ordering a test kit is also provided.

Is It Possible to Over-Deacidify? Abbey Newsletter, 15: 1 (July 1978).

A short summary of two reports by the Barrow Laboratory (The American Archivist 38(1): 65–66, Jan. 1975) and by William K. Wilson et al. (The American Archivist 41(1): 67–70, Jan. 1978) regarding the use of magnesium hydroxide as a better alternative than magnesium carbonate.

Arad, A.: *Automated Mass Spraying of Documents.* Archives et Bibliothèques de Belgique, 46: 288–96 (1975).

A description of an application of the Barrow Spray deacidification process used by Arad at the Israel State Archives (figures and photographs are included). (N.B.: "The complete discussion of the method, its chemistry and detailed results deserves a separate paper but at this stage I may state that the results are satisfactory" (p. 290)).

Arney, J. S., A. J. Jacobs & P. Newman: *The Influence of Calcium Carbonate Deacidification of the Deterioration of Paper.* AIC (American Institute for Conservation) Preprints, Toronto 1979 Washington, D.C.: AIC, 1979.

Examines the effects of calcium carbonate deacidification on the rates of deterioration of commercial rag and newsprint paper at 90°C and 100% R.H. Evidence is presented to show that the decreased rate of deterioration resulting from deacidification cannot be accounted for, in terms of a decrease in the acid-catalyzed hydrolysis process. Atmospheric oxidation, shown to play an important role in the deterioration of the paper samples, is also retarded by deacidification. Figures (2), and a table illustrate the results.

Barrow, W. J.: *Deacidification of Documents.* pp. 6–8 of The Barrow Method of Restoring Deteriorated Documents. Richmond, VA: W. J. Barrow, 1979.

Documents soaked in a solution of calcium hydroxide (to neutralize the acidity) and then in a solution of calcium bicarbonate (to carbonate the residual hydroxide of the first solution) reached a pH of 8.4–8.8 after treatment. Various types of inks and their reaction to such a process are briefly discussed.

Barrow, W. J.: *The Barrow Two-Bath Deacidification Method.* American Archivist 39(2): 161–164 (Apr. 1976).

Discusses at length the proper means of preparing and handling deacidifying solutions used in the Barrow two-bath deacidification method (calcium hydroxide and then calcium bicarbonate). The resultant pH of the paper thus treated ranges between 7.5 and 9.0.

Barrow, W. J.: *Deacidification and Lamination of Deteriorated Documents, 1938–63.* American Archivist, 282: 285–290 (Apr. 1965).

Deals primarily with the lamination of deteriorated documents. A brief notation is made (p. 286) regarding the components of the solution recommended for deacidification prior to lamination: calcium hydroxide and calcium bicarbonate. The soaking of documents in such solutions produces consistently a near neutral or mildly alkaline condition in the treated documents.

Barrow, W. J.: *A Two-Year Research Program.* Vol. 1. of Permanence/Durability of the Book (7 vols). Richmond, VA: W. J. Barrow Research Laboratory, 1963.

Describes the progress of a series of tests undertaken by the Barrow Research Laboratory in their study of the permanence/durability of the book: folding endurance test; tear resistance test; test for acidity; accelerated aging. One chapter deals with spray deacidification (pp. 22–26) by means of a magnesium bicarbonate solution.

Barrow, W. J.: *Spray Deacidification.* Vol. 3 of Permanence and Durability of the Book (7 vols). Richmond, VA.: W. J. Barrow Research Laboratory, 1964.

A detailed description of the magnesium bicarbonate spray deacidification procedure developed by Barrow (23 tables of results and 2 figures are included).

Barrow, W. J. & Reavis C. Sproull. *Permanence in Book Papers.* Science 129(3356): 1075–84 (24 Apr. 1959).

Describes the deacidifying procedure used to stabilize the acidic deterioration of book paper manufactured during the period 1900–1949: twenty-six reams of different papers commonly used in books were soaked overnight in a saturated solution of calcium and magnesium bicarbonate, then air-dried. Comparison was made of the physical and chemical characteristics of specimens of each of these papers, with and without the stabilizing treatment, and both before and after accelerated aging (7 figures and 4 tables of the results are included).

Barrow, W. J.: *Deacidification*. Chapter 5 (pp. 45–53) of Manuscripts and Documents: Their Deterioration and Restoration. Charlottesville, VA: Univ. of Virginia Press, 1955.

The use of calcium hydroxide and calcium bicarbonate appears to be the most effective and suitable method so far (1955) devised for the elimination of acidity in deteriorated papers dating from 1400 to 1859 A.D. The effect of such a process on the printing inks of the documents are discussed. The chapter concludes with a cautionary note: no attempt should be made to carry out such procedures without proper instructions.

Barrow, W. J.: *Restoration Methods*. American Archivist, 6(3): 151–54 (1943).

Acidity, the chief cause of brittleness found in many documents, is briefly explained. Two principal methods of restoration to be used, once deacidification has occurred, are described: silking and lamination with cellulose acetate foil. Conclusion: lamination is by far the most successful method.

Boustead, W. M.: *The Surface pH Measurement and Deacidification of Prints and Drawings in Tropical Climates*. Studies in Conservation, 9(2): 50–7 (1964).

A description of the deacidification of prints and drawings which was carried out at the Conservation Department of the Art Gallery of N.S.W. (Australia). The method which was used approximately follows that of Barrow: immersion in a solution of calcium hydroxide, followed by an immersion in calcium bicarbonate. pH measurements and strength tests, taken before and after deacidification, demonstrated that the treated sections have a greater resistance to testing than the untreated sections. The author concludes that, though not permanent in its effects deacidification is useful when lamination, and ideal environmental conditions are not possible.

Church, Randolph W. (ed.): *Deterioration of Book Stock. Causes and Remedies. Two Studies on the Permanence of Book Paper Conducted by W. J. Barrow*. Richmond, VA: Virginia State Library, 1959

The findings of these two studies appeared first in: Publisher' Weekly (Sept. 1957 and Jan. 5, 1959) and Science (Apr. 24, 1959). 500 non-fiction books printed and published in the U.S. were tested for fold, tear, and pH characteristics and the results tabulated. 95% were found to have a life expectancy of 50 years or less. The second study is a description of the treatment used for the stabilization of book papers (an overnight soaking in a saturated solution of calcium and magnesium bicarbonates). Tables of results are provided, and the conclusion shows that the method is simple and inexpensive, with a daily output per person of 2,400 pp.

Clapp, Anne F.: *Spray Deacidification of Secondary Papers*. pp. 69–71 of Curatorial Care of Works of Art on Paper. Oberlin, Ohio: Intermuseum Conservation Association, 1978 (3rd rev. ed.).

A step-by-step description of the spray method of deacidification using magnesium bicarbonate. The technique does not establish a long-lasting buffer (because during the act of spraying some of the bicarbonate changes to carbonate and settles on the surface of the paper, thus reducing the amount of penetration of the solution), and is not adequate for use on paper of value.

An Idea for Deacidification of Newspapers. Hollinger Update: unnumbered (pp. 2–3) (Nov. 1981).

A step-by-step description of a low cost deacidification technique (including the "recipe") for newspaper clippings.

The Deacidification and Alkalinization of Documents with Magnesium Bicarbonate. Washington, D.C.: Library of Congress Publications on Conservation of Library Materials. Conservation Workshop Notes on Evolving Procedures, series 500, no. 1 (Working draft), July 1978.

Introductory remarks warn the user of possible deleterious effects of such treatments on some materials. The notes instruct the reader how to determine the strength of the solution, and how to apply the solution to paper (several methods are discussed: unpressurized; use of the Seltzer bottle; immersion; use of the spray gun).

Poole, F. G.: *William James Barrow*. pp. 230–43 of Library Conservation. Preservation in Perspective (John P. Baker & Marguerite C. Soroka, eds.). Stroudsburg, PA: Dowden, Hutchinson & Ross, 1978. Reprinted from: Encyclopedia of Library and Information Science (Kent, A. et al. (eds.), New York: Marcel Dekker, 1969–) vol. 2, pp. 257–70 (1972).

A summary of the full range of Barrow's work. Six of Barrow's most representative publications constitute the bibliography at the end of the summary.

Santucci, L.: *The Application of Chemical and Physical Methods to Conservation of Archival Materials*. Bollettino Dell' Istituto Di Patologia Del Libro fasc. 1/2: 85–111 (1961).

Deals with all aspects of paper conservation. Half a paragraph is devoted to deacidification (p. 97): Barrow's use of calcium and magnesium carbonates. No evaluative or analytical comments are given.

Tang, L. C.: *Washing and Deacidifying Paper in the Same Operation*. pp. 63–86 of Advances in Chemistry Series no. 193 (Preservation of Paper and Textiles of Historic and Artistic Value II; John C. Williams (ed.); Washington, D.C.: American Chemical Society, 1981).

With a chemical feeder one can wash and deacidify, or deacidify directly, paper with deionised water containing added calcium ions. Results of the experiments, in which varying rates of alkali were fed to deionized water, are given (Tables are included). The resultant alkaline reserves produced in two types of paper are indicated.

Club-Soda Time Capsule. Time Magazine, Sept. 2, 1974, p. 10.

A very short, non-technical, and rather tongue-in-cheek announcement of R. D. Smith's Club-Soda recipe for deacidification, using milk of magnesia.

Williams, J. C., C. S. Fowler, M. S. Lyon & T. L. Merrill: *Metallic Catalysts in the Oxidative Degradation of Paper*. pp. 37–61 of Advances in Chemistry Series no. 164 (Preservation of Paper and Textiles of Historic and Artistic Value; John C. Williams (ed.); Washington, D.C.: American Chemical Society, 1977).

Paper which contains transition metal catalysts, compounds of copper, cobalt, or iron can become acid by oxidative degradation and may not be stabilized with alkaline earth carbonates. Paper was treated with copper acetate at various pH levels and given accelerated aging. The degradation was determined by the change in folding endurance: the humid oven caused more drop in folding endurance than did the dry oven. Dry-oven aging has little predictive value for oxidative degradation. Figures (7) and Tables (7) illustrate the discussion.

Wilson, William K., Mary C. McKiel, James L. Gear & Robert H. McClaren: *Preparation of Solutions of Magnesium Bicarbonate for Deacidification of Documents*. Washington, D.C.: National Archives of the U.S., Preservation Services Laboratory, Preservation Services Division, 1979.

A report compiled to assist the document restorer in the preparation of magnesium carbonate solutions. Included in the report is information about the variables associated with the preparation of magnesium bicarbonate solutions, and descriptions of various procedures for the preparation of magnesium bicarbonate solutions.

2. Non-Aqueous Deacidification

Non Aqueous Aerosol Spray Deacidification. American Archivist. 36(4): 575–77 (1973). In "Technical Notes", Clark W. Nelson, ed.

Richard D. Smith's "Wei T'o® Non aqueous Aerosol Spray Deacidification Solution" is described in detail and its advantages and limitations are discussed.

Nonaqueous Deacidification. American Archivist, 34: 75–76 (1971). In "Technical Notes", Clark W. Nelson, ed.

Richard D. Smith's abstract of his doctoral dissertation ("The nonaqueous Deacidification of Papers and Books" is reproduced. Introductory remarks by Nelson, describe the structure of the dissertation and provide ordering information.

Technical Mailbag. American Archivist, 31(1): 814–16 (Jan. 1968).

Summary of G. M. Cunha's report on Langwell's vapor phase deacidification technique. See American Archivist, 30: 614–15 (Oct. 1967).

Baynes-Cope, A. D.: *The Non-aqueous Deacidification of Documents*. Restaurator, 1(1): 2–9 (1969).

Investigates the use of methanol solutions of barium hydroxide (applied by brushing, dipping, or spraying) for the deacidification of documents which cannot be deacidified in aqueous solutions (e.g. vellum or papers containing water soluble inks). The results of acidity and folding endurance tests taken before and after treatment show that the method is effective and safe.

Jonson, Laurence F.: *Preservation of Art for the Art Dealer & Framer: Paper Deacidification. Parts 1 and 2*. Art Dealer and Framer 14, Aug. 1976: 52–56; Oct. 1976: 9–12. (For Parts 3 and 4 see: Smith, Richard D., 1976, below).

Part 1.: Cites, in part, the "Abstract of the Disclosure" which appears in Smith's patent (U.S. no. 3, 676, 182, see below p. 92). This first part is a demonstration of the deacidification process using Wei T'o® spray. Annotated photographs serve as illustrative aids. Part 2.: Procedures for spray deacidification and various spray guns are discussed. Illustrations serve as demonstrations.

Kelly, Jr., George B., Lucia C. Tang & Marta Krasnow: *Methylmagnesium Carbonate – An Improved Non-Aqueous Deacidification Agent*. pp. 62–71 of Advances in Chemistry Series no. 164 (Preservation of Paper and Textiles of Historic and Artistic Value: John C. Williams (ed.); Washington, D.C.: American Chemical Society 1977).

Methylmagnesium carbonate, prepared by carbonation of a solution of magnesium methoxide, is compared with the magnesium methoxide as a deacidification agent for paper. Although the two materials are equally effective in deacidification and in prolonging the life of the paper, the methyl magnesium carbonate is 2 to 10 times as stable to water, depending upon the solvent used. This stability avoids premature precipitation, minimizes surface deposits, and increases the interval between cleanings of equipment, making the solution much more convenient to use. The use is covered by U.S. Patent no. 3,939,091, Feb. 17, 1976, assigned to the Library of Congress. A royalty-free, non-exclusive license will be available.

Deacidification – Methyl Magnesium Carbonate Non-Aqueous Treatment. Washington, D.C.: Library of Congress Publications on Conservation of Library Materials: Conservation Workshop Notes on Evolving Procedures, Series 500, no. 2 (Working draft), July 1977.

Introductory remarks note the advantages of using methyl magnesium carbonate when compared to magnesium methoxide. Treatment with methyl magnesium carbonate is not recommended for all kinds of papers but has been found useful in the treatment of manuscript materials of the last 200 years. Instructions for the preparation, testing, storage, and application techniques of the solution, are given.

Update ... Deacidification Technology. Library Scene, 11: 9 (July/Aug. 1982).

Announces the award of U.S. Patent No. 4,318,963 ("An Improved Treatment of Cellulosic Materials") to Richard D. Smith (together with the Library of Congress and Wei T'o® Associates). The invention makes possible the preparation of many different kinds of non-aqueous deacidification

solutions using magnesium alkoxides. The advantages of the invention are also given (the solutions are safer, have greater penetrating powers, and are more economical).

Preiss, David: *Preserving Pulp Paper.* American Artist, 39: 24 (1975).

Describes the properties and effects of Wei T'o® liquid or spray solution patented by R. D. Smith.

Santucci, L., G. Ventura & Mariagrazia Zappala-Plossi: *An Evaluation of Some Non-Aqueous Deacidification Methods for Paper Documents.* Archives et Bibliothèques de Belgique Special Issue, 12: 131–54 (1974).

A report on the authors' experimentations with barium hydroxide and magnesium methoxide which were contemporary with those of A. D. Baynes-Cope and R. D. Smith. Eleven Tables of experimental results are given.

Smith, Richard, D.: *Paper Deacidification. Parts 3 and 4.* Art Dealer and Framer Nov. 1976: 40–46 and Dec. 1976: 7–12. (For Parts 1 and 2 see: Jonson, 1976, above.).

Part 3: Discusses concepts underlying non-aqueous deacidification. Offers guidelines for deacidification, and discusses details of deacidification treatments using Wei T'o®. Precautionary remarks regarding deacidification procedures are given. Part 4: Three methods of deacidification are discussed and described: brushing, dipping, and spraying.

Smith, Richard D.: *Nonaqueous Deacidification.* in "Technical Notes", American Archivist, 34: 75–76 (Jan. 1971). Also published in TAPPI 54: 587–88 (May 1981).

A lengthy abstract prepared by Smith of his dissertation, The Nonaqueous Deacidification of Papers and Books. Information regarding the purchasing of a copy of the dissertation is also provided.

Smith, Richard D.: *Hints for Better Spraying.* Park Forest, ILL.: Wei T'o® Associates, 1971.

A seven-page illustrated leaflet with instructions for best control of spraying paper of various dimensions.

Smith, Richard D.: *The Nonaqueous Deacidification of Paper and Books.* Chicago: Univ. of Chicago Graduate Library School, 1971 (Ph. D. dissertation). Abstract for this dissertation does not appear in Dissertation Abstracts International.

In contrast with existing methods of deacidification (deemed unsuitable or prohibitively expensive) a new process is developed and discussed: paper or books are impregnated with a non-aqueous deacidification solution containing an organic solvent and a benign alkaline deacidification agent. The deacidification solution is composed of an alkali metal or alkaline earth metal alkoxide dissolved in

a chlorofluorohydrocarbon solvent containing MeOH as a solubilizing agent for the alkoxide. Magnesium methoxide is the preferred deacidification agent (stable, low cost, no detrimental side reactions) and laboratory aging studies made with single sheets of paper show that non-aqueous deacidification can produce results equivalent or superior to present day (1970) aqueous treatments while the life expectancy of moderately acidic book papers is increased by two or three times (includes Figures and Charts).

Smith, Richard D.: *Guidelines for Preservation.* Special Libraries, 59: 346–52 (1968).

The preparation and implementation of preservation policies suited to the needs of various libraries are suggested; causes of paper deterioration (including acid deterioration) are enumerated and discussed. A recipe for non-aqueous deacidification ("Chicago Process") is tabulated (p. 351).

The Use of Magnesium Bicarbonate Prepared with Magnesium Carbonate and Club Soda to Protect Against Aging. Undated flyer of Wei T'o® Associates, Inc.

A step-by-step description of the procedure for deacidification by means of the Wei T'o® non-aqueous solution.

Wei T'o® Solutions-General Information. Wei T'o® Technical Note TN-101 (1 Mar. 1977).

Note describing the uses of Wei T'o® solutions no. 1 and 2.

Properties of Wei T'o® Deacidification Solutions and Sprays. Wei T'o® Associates, June 1981.

A one-page leaflet containing technical information, which is tabulated (Guide for Selection; Chemical Properties; Vapor Properties), about the properties of Wei T'o® deacidification solutions and sprays. Since 1982 ("cut-off" date of this bibliography) updated leaflets compiled by Wei T'o® Associates have been issued. In particular: *Using Wei T'o® Deacidification Sprays and Solutions: Questions and Answers* (18 June 1984) – A very detailed six-page document; *Wei T'o® Nonaqueous Book Deacidification System* (1 July 1985) – A one-page description of the process, with a concluding short bibliography of Smith's publications on mass deacidification; and *Wei T'o® "Soft Spray" Deacidification System* (15 May 1985) – A two-page document describing in detail the process as well as the equipment (cost and maintenance considerations are included).

3. Vapor Phase Deacidification

Dangerous and Unpredictable: Strange Effects of VPD Sheets. Abbey Newsletter, 9: 3 (July 1977).

Laboratory testing of Langwell's vapor phase deacidification process (VPD), as well as experimental treatment of 200 volumes, show that the method is dangerous: the VPD sheets are poisonous, even when precautions are taken, and should not be used.

DuPuis, R. N., J. E. Kusterer & R. C. Sproull: *Evaluation of Langwell's Vapor Phase Deacidification Process*. Preservation Supplement of Library of Congress Information Bulletin 29: A41–43 (June 4, 1970).

A short summary of the results reported by DuPuis et al. in their paper appearing in Restaurator, Vol. 1(3): 149–64 (1970): see next entry below.

DuPuis, R. N., J. E. Kusterer & R. C. Sproull: *Evaluation of Langwell's Vapor Phase Deacidification Process*. Restaurator, 1(3): 149–64 (1970).

A series of experiments were carried out to test the effects of W. H. Langwell's CHC (cyclohexylamine carbonate) process. Results showed that, though the CHC treatment does raise the pH level of treated paper, and does improve the fold endurance and tear resistance of treated paper, it appears to destroy the effects of rosin sizing and decreases the brightness and fluorescence of various papers. The process is dangerous: serious health hazards are caused by the hydrolysation of CHC to cyclohexylamine (an odorous and toxic chemical) on exposure to moist air. (Five tables of results are included).

Kelly, Jr., George B. & John C. Williams: *Inhibition of Light Sensitivity of Papers Treated with Diethyl Zinc*. pp. 109–17 of Advances in Chemistry Series no. 193 (Preservation of Paper and Textiles of Historic and Artistic Value II; John C. Williams (ed.); Washington, D.C.: American Chemical Society, 1981).

The presence of zinc oxide in paper, combined with high humidity, increases the degrading effect of ultraviolet light on paper. Since the original diethyl zinc paper deacidification process left zinc oxide as an alkaline reserve, ways to inhibit accelerated degradation were sought. Samples of the treated papers were exposed briefly to a low concentration of hydrogen iodide (about 2% by volume). It was determined that the presence of 0.05% iodide in the paper is sufficient to inhibit completely the accelerated degradation with little effect on brightness. When the diethyl zinc process was modified to leave zinc carbonate rather than zinc oxide as the alkaline reserve, it was found that the books thus treated did not show increased light sensitivity, and had photodegradation rates similar to, or slightly less than, those of untreated books.

Langwell, W. Herbert: *The Vapour Phase Deacidification of Books and Documents*. Journal of the Society of Archivists, 3(3): 137–38 (1966).

A short description of the CHC (cyclohexylamine carbonate) method of vapor phase deacidification: an interleaving in books, of CHC sheets.

Langwell, W. Herbert: *Vapour-phase Deacidification: A Recent Development*. Journal of the Society of Archivists, 4(7): 597–98 (Apr. 1973).

A small note describing the vapor phase deacidification (VPD) process.

Langwell, W. Herbert: *Vapor Phase Deacidification*. In "Technical Notes", American Archivist, 29: 566–68 (1966).

Detailed instructions, compiled by W. H. Langwell for the American Archivist of the Langwell vapor phase method of deacidification. The editor of "Technical Notes" also invites his readers to run experiments, testing the method, and hopes that the results will be reported to him.

McCarthy, Paul: *Vapor Phase Deacidification: A New Preservation Method*. American Archivists, 32(4): 333–42 (Oct. 1969).

Discusses the vapor phase deacidification (VPD) process, and the testing of the method by G. M. Cunha (see G. M. Cunha, American Archivist 30: 615, Oct. 1967 and 31: 85, Jan. 1968). Conclusion: VPD sheets or sachets will effectively decrease acidity in paper initially but their long term effectiveness is seriously questionable.

4. Mass Deacidification

Update: Mass Deacidification Methods. Abbey Newsletter, 4(1): 15 (Jan. 1980).

The "Boston method" for mass deacidification (noted anonymously in the Abbey Newsletter of Oct. 1978) "was a dud". A short update of the diethyl zinc and the morpholine processes is also given.

Deacidification of Bound Volumes. Abbey Newsletter, 2(2): 1 (Oct. 1978).

A research group in Boston (whose identity remains secret) is said to have invented a new method of mass deacidification of books that is faster and cheaper than existing methods. A listing of the existing methods (a) morpholine vapor (Barrow); (b) magnesium methoxide or methyl magnesium carbonate in alcohol and chlorofluorocarbon (Freon: Wei T'o® solution (Smith)); and (c) diethyl zinc (Library of Congress), followed by a short note on mass deacidification constitutes the body of this announcement. (See "Update..." in Abbey Newsletter, above).

The AIC Convention. Abbey Newsletter, 15: 1–2 (July 1978).

A short account of the paper, "Mass Deacidification with Diethyl Zinc Vapor", presented by George B. Kelly. The short abstract, published in the preprint, is reproduced.

Kathpalia, Yash Pal: *The Problem of Acidity in the Conservation of Documents*. UNESCO Bulletin Libr., 29(5): 268–70 (Sept./Oct. 1975).

Acidity is identified as one of the main causes of deterioration of paper. A process of mass deacidification with ammonia is proposed for documents, located in India and South East Asia, which are highly acidic, and which disintegrate when deacidified by means of aqueous and non-aqueous deacidification processes. Existing fumigation facilities could be used for this process. No experimental data is provided by the author. The process is offered as a suggestion worthy of scientific study.

Kelly, Jr., George B.: *Mass Deacidification.* pp. 59–70 of Preservation of Library Materials (Joyce R. Russell ed.). New York: Special Libraries Association, 1980.

This paper is part of the Proceedings of a seminar held at Rutgers University (July 20–21, 1979), and sponsored by the Library Binding Institute and the Princeton/Trenton Chapter of the Special Library Association). A survey of existing deacidification methods leads to the conclusion that mass deacidification can be effective when diethyl zinc is used in gaseous (vapor) form. A description of the diethyl zinc process is given (photographic illustrations are provided). The paper is followed by a series of answers to questions raised by the audience.

Kelly, Jr., George B.: *Mass Deacidification with Diethyl Zinc.* Library Scene, 9(3): 6–7 (Sept. 1980).

The chemical properties of diethyl zinc are described, and a detailed description of the process of non-aqueous mass deacidification of paper (as well as common binding materials) is given. Diethyl zinc is found to be effective, non-injurious to books, and relatively economical once a vacuum chamber has been acquired.

Test of Mass Paper Deacidification Done at LC in July. LJ/SLJ Hotline, 11(21): 2 (1982).

A one-paragraph announcement of the first large scale mass paper deacidification test using diethyl zinc.

LC Completes Deacidification Experiment. Wilson Library Bulletin, 57(4): 283 (Dec. 1982).

A very short announcement of the Library of Congress's mass deacidification experiment (using diethyl zinc) at NASA's Goddard Space Flight Center (Greenbelt, Maryland). An announcement of test results for this same experiment appears in: Mass deacidification test results due soon from LC experiment. Library Journal, 107: 1586 (Sept. 1, 1982).

Library of Congress Announces Completion of Test Aimed at Adding Hundreds of Years to Life of Books. News from the Library of Congress: leaflet number PR82–107, (10–22–82).

Announcement of the successful completion of the Library of Congress's first large-scale mass deacidification experiment in which 5,000 books were treated with diethyl zinc (DEZ), at one time, in a large NASA vacuum chamber (located at Goddard Space Flight Center, Greenbelt, Maryland) originally designed to test satellites destined for outer space. Complete results of the experiments expected in 1983.

Library will Conduct New Tests to Prolong Life of Books. Library of Congress Information Bulletin, 41(22): 149–50 (1982).

Announcement of the Library of Congress pilot mass vapor-phase deacidification test (using DEZ (diethyl zinc)) during which materials from the Library of Congress and six other Institutions(National Archives, New York Public Library, New England Document Conservation Center, and the Libraries of Columbia, Stanford, and Yale universities) are to be tested.

Mass Deacidification at the NL (of Canada). National Library News, 14(3–4): 1–3 (1982).

Outlines and describes the apparatus and method used for the mass deacidification initiated by R. D. Smith at the Canadian Public Archives. This paper constitutes a companion piece to Smith's "Progress in Mass Deacidification at the Public Archives" (See below, Smith, 1979).

Vapor-Phase Process for Mass Deacidification of Paper and Books Developed. Paper Conservation News, 1(4): 1–4 (Nov. 1973).

Announcement and discussion of the vapor phase mass deacidification process patented by James E. Kusterer, Jr., and Reavis C. Sproull: books and papers are exposed to the vapor of morpholine in an airtight, moderately heated, chamber. The article reviews other methods of deacidification.

New Deacidification Process to be Used to Stop Book Deterioration. Publishers' Weekly, 216(2): 70 (Oct. 1, 1979).

Announcement of the morpholine mass deacidification process, developed by the Pacific Northwest Conservation Laboratory (Port Orchard, Wash.), through Research Corporation (N.Y.). The technique is said to be capable of treating large numbers of books and documents at costs under $1 per volume.

Smith, Richard D.: *Progress in Mass Deacidification at the Public Archives.* Canadian Library Journal, 36: 325–32 (Dec. 1979).

Background information on the progress of Smith's pilot mass deacidification program developed at the Public Archives of Canada since 1974. The paper includes a brief, but thorough, review of the various modern major deacidification methods, beginning with the work of O. Schierholtz. (See, also by Smith: Mass Deacidification at the Public Archives of Canada, p. 131 of Abstracts and Preprints, International Conference on the Conservation of Library and Archive Materials and the Graphic Arts. London: Institute of Paper Conservation and Society of Archivists, 1980).

Smith, Richard D.: *Design of a Liquefied Gas Mass Deacidification System for Paper and Books.* pp. 149–58 of Advances in Chemistry Series no. 164 (Preservation of Paper and Textiles of Historic and Artistic Value; John C. Williams (ed.); Washington, D.C.: American Chemical Society, 1977).

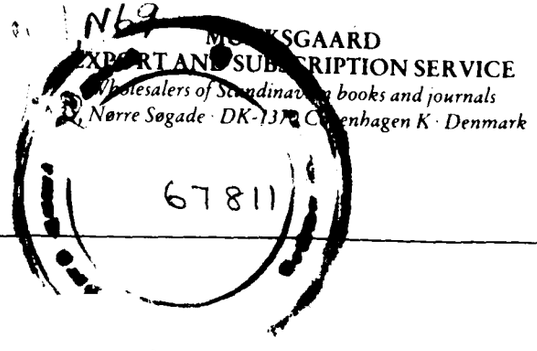
A detailed description of Smith's mass deacidification project at the Public Archives of Canada.

Walker, Bernard F.: *Morpholine Deacidification of Whole Books*. pp. 72–87 of Advances in Chemistry Series no. 164 (Preservation of Paper and Textiles of Historic and Artistic Value; John C. Williams (ed.); Washington, D.C.: American Chemical Society, 1977).

The description of a process based on impregnation with a mixture of morpholine vapor and water vapor. The equipment is fully automated. Estimates show a total deacidification cost of about $0.32/lb. A demonstration of the process is available (1976) at the Virginia State Library where 250 books are processed per day. (Tables of results and illustrations are given).

Williams, John C. & G. B. Kelly, Jr.: *Research of Mass Treatments in Conservation*. pp. 244–52 of Library Conservation. Preservation in Perspective (Baker, J. P. and M. C. Soraka (eds.), Stroudsburg, PA: Dowden, Hutchinson & Ross) 1978. Reprinted from the Bulletin of the American Institute for Conservation of Historic and Artistic Works, 14(2): 69–77 (Apr. 1974).

Basing their work, in part, on Barrow's findings, the authors describe their simple, low-cost method of mass deacidification, by means of the diethyl zinc vapor-phase method, developed by them at the Preservation Research and Testing Office at the Library of Congress (Patent granted, July, 1976: U.S. Patent no. 3,969,549).



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Manuscripts should be original typescripts or superior photocopies (not carbon copies), in double spacing and on one side only of the paper. They must be carefully revised, as alterations in print are expensive. The paper used must be non-absorbent. Author's name should be accompanied by title, position, and working place or institution.

All graphs, drawings, or photographs are to be referred to as figures (abbr: Fig.) and should be numbered in sequence with Arabic numerals. Each figure should be identified with a figure number on the back. Any lines, numbers, or lettering that are to appear in the illustrations should be large enough for the necessary reduction. Line drawings should be drawn with black India ink on white paper and should be about twice the size of the finished blocks. Graphs can be plotted on plain white or blue squared paper; grid lines that are to show should be inked in black. In general, photographs should be about 1½ times the size of the final block and must be submitted as mounted glossy enlargements showing good detail and adequate, but not excessive, contrast. Authors should indicate in the manuscripts the approximate position of text figures.

Italics only are used for emphasis, especially for distinguishing titles of books and papers. Italics are marked in the manuscript by underscoring.

References within the text should be indicated by numbers corresponding to those in the list of references. The list should be placed at the end of the paper and should contain no reading matter. For example:

1. Barrow, William J.: *Restoration methods*. American Archivist 6 (1943): 151–54.
2. Hunter, D.: *Paper Making*. New York 1947.

Authors alone are responsible for the opinions expressed in their papers.

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