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Conference on Preservation of Library Materials
Vienna, April 6-11, 1986

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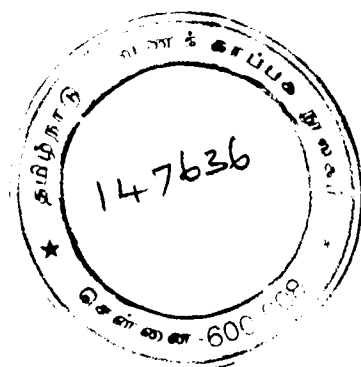
Conference on Preservation of Library Materials

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Foreword



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As announced in the last issue, RESTAURATOR is continuing its active role by making eight research papers on the development and application of conservation technology available. These papers were originally presented at the National Library of Austria, Vienna, April 6-9, 1986, during the Conference on the Preservation of Library Materials, sponsored by the Conference of Directors of National Libraries (CDNL) in cooperation with the International Federation of Library Associations (IFLA) and UNESCO. The goals of the Conference, identical with the goals of RESTAURATOR, were to increase public awareness of archives and library preservation work and problems, speed up the development of improved preservation technologies, and make the knowledge of these technologies more available throughout the world. The Conference Proceedings, which include over 40 papers, will be published by K. G. Saur, Inc. (Munich, London, New York, and Paris), as an official IFLA publication. The additional publication of eight of them in RESTAURATOR may be understood as being advance publicity for the Conference Proceedings. The papers that have been chosen for this issue are primarily technical in nature, because this is the special interest of the RESTAURATOR readers.

A ninth paper (p. 69) was solicited by RESTAURATOR to round out the excellent information assembled by William J. Welsh, Deputy Librarian of Congress, Washington, DC, who conceived and planned the Conference. This paper quantifies the physical condition of library collections, calculates the rate at which books embrittle, presents the technology underlying an alternative mass deacidification philosophy, sets this technology in the context of mass preservation, reviews the current status of mass deacidification in the United States, and proposes a different approach to funding the preservation of library collections.

The new world-wide IFLA program for archives and library "Preservation and Conservation" (PAC) was inaugurated at this Vienna Conference. Merrily A. Smith has been appointed Director of the PAC Center at the Library of Congress in Washington, DC. The regional centers (the first two established are Bibliothèque Nationale, Chateau du Sablé, France, Jean-Marie Arnoult, Director, and Deutsche Bücherei, Leipzig, German Democratic Republic, Wolfgang Wächter, Director) are taking responsibility for the IFLA PAC program in their regions and helping the Library of Congress in its back-up and planning roles. The Editors and Publisher of RESTAURATOR enthusiastically endorse the IFLA Preservation and Conservation program, and

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pledge RESTAURATOR's assistance by publishing its programs and achievements.

During the Conference in Vienna, RESTAURATOR received oral permission from the authors to publish their manuscripts which were distributed as preprints. Permission was also obtained from the sponsors of the Conference. RESTAURATOR subsequently confirmed these permissions by letter. Publication was originally scheduled in RESTAURATOR Vol. 7:3, in October 1986, six months after the Conference. Publication was postponed until the authors' papers were edited by the Library of Congress. Postponement followed postponement until March 1987, when RESTAURATOR was advised that an availability date could not be predicted. RESTAURATOR finally decided to proceed with publication.

RESTAURATOR gratefully acknowledges permission of the authors and the sponsors of the Vienna Conference to publish these papers, and looks forward to reviewing the full Proceedings when publication occurs.

Richard D. Smith
Associate Editor

Technology in Support of Preservation

by PETER G. SPARKS

It is a great pleasure for me to be here to talk with you today about a very important issue: the application of modern technology to the preservation of library and archival materials. The challenges of preserving library materials in the 20th century cannot be met by just skilled hands alone. Science and technology are needed if we are to save the cultural heritage of our civilization from premature decay and eventual loss.

Engineering, physics, chemistry and computer science – all have something to offer. We must either develop new technologies, or grasp the opportunities of existing technologies and apply them to the solution of special problems.

It is so easy to speak in passing about the need to take advantage of technological developments, and many of us do. However, this wish for technological solutions must also be accompanied by a willingness and commitment to invest both time and money in the effort. Top library management must understand that the needed research and development will be expensive, and the path to successful solutions will be marked with setbacks that require determination and commitment to overcome. No major technological development of civilization was accomplished overnight. Regardless of the era, every major advance required years of work to perfect. Then, as now, considerable funds and a willingness to learn from many failures was required before the project was a success. It was a long path from the Wright brothers at Kitty Hawk to the flight of the Concorde.

There are precedents for developing technological solutions for library preservation problems. Although progress moved slowly at first, there are examples of such developments in the past three decades. For the last 25 years, these developments have been primarily associated with the reproduction of documents and with individual document restoration.

In the last five years, other projects were started that deal with mass treatment of routine original library materials, and that are oriented toward developing solutions for some of the most acute preservation problems of our times.

I would like to review just a few of the developments in the preservation field that have made considerable contributions, as well as some of the newer projects that we will hear about today.

An important technological advance that was started in Spain and in Israel was the development of the leaf-casting machine for filling in areas of loss in

archival documents. This procedure has now been perfected through careful engineering and construction of specific equipment to accomplish this task at equal quality and in a more time-efficient way than the older hand methods. Here is an example of using engineering principles to develop a specific piece of equipment to meet a treatment need for individual documents. This approach has been very successful, and many laboratories around the world have adopted this technology and are using it routinely.

Other important examples come to mind in the work of Wolfgang Wächter at the Deutsche Bücherei in Leipzig, where he has developed important techniques for speeding up the treatment of paper documents. The work of Professor Otto Wächter here in Vienna is also notable. His work on the deacidification and strengthening of newspapers using a chemical process is a significant accomplishment. These are both good examples of the use of engineering and chemistry disciplines to solve a specific preservation problem and to apply that solution in such a way that a greater number of materials can be successfully stabilized or treated. There are other examples of this type of development in the preservation of the original object that have made similar contributions.

One technology that has made a substantial contribution for many decades to saving older materials and insuring their availability is microfilming. This preservation approach is different in that it creates a surrogate copy of the original and then this microfilm copy, in many cases, goes on as the primary preservation master. Not only have we dealt with creating a stable preservation copy by the application of this technology, but we have also taken a step to improve access to the information through multiple user copies of the master film. This is an important point that we must not forget in the preservation process, and if at all possible our technological advances in solving specific preservation problems should also address the issue of enhanced access.

In the past 20 years a chemical approach to neutralizing the acid in papers has developed through the work of William J. Barrow and others, and today, deacidification is a routine operation in conservation laboratories, where this chemical technology is applied to individual documents and leaves of rare books. In the last five to eight years there has been substantial progress in several countries to develop approaches to the deacidification treatment of routine library materials on a very large, or mass, scale. This work is notable and it is appropriate here to reflect on it. Regardless of where these developments are taking place – Canada, Austria, the United States or France – the aid of the paper chemist and the engineer has been enlisted to develop sophisticated technological innovations that will allow the preservation of literally thousands or hundreds of thousands of documents in a given year.

This is very important. Why? It is important because it demonstrates that

several institutions have not only committed themselves to solving one of the most acute preservation problems of our time, that of paper becoming weak and brittle from acid attack, but have also supported this commitment by investing in the effort an enormous amount of time and energy, and millions of dollars. The commitment and the effort grew out of a recognition of the problem of vast quantities of 19th and 20th century paper becoming brittle. Interested scientists and engineers, working alone and with concerned institutions, have developed concepts that could solve the brittle paper problem. The institutions involved have been willing to take the technological risk, that important step of putting money into research and development that had the possibility, but not the guarantee, of finding large-scale solutions to a large-scale problem. These same institutions have had to weather the failures, and celebrate the successes, before the process worked correctly. Mass deacidification will be a routine procedure in many institutions in five years.

Several pioneering R & D projects are also worth describing. Today you will hear about a product and a technology that is stirring the interest of the library field and has initiated pilot projects in several libraries. This is the use of optical media for the storage and the transmission of information. This is an example of a technology that was stimulated by industry, not by the library field. Although libraries were not driving the development of optical media technology, it quickly became apparent to a few far-sighted individuals that the application of this technology to information storage and delivery held great promise for libraries. Projects were then initiated to determine the feasibility of utilizing this optical media technology to improve access to information and possibly the preservation of information. Grasping this opportunity required vision, money, and – equally important – a library management that was willing to take the risk of undertaking research and development in an area that showed potential on the one hand, but that had not been practically demonstrated on the other. The results of research and development in optical storage of information could easily change the way libraries function by the year 1995. Strengthening weak paper to extend its useful life is an old idea that is receiving renewed attention. This idea has considerable merit and involves the use of known reactions in polymer chemistry. The engineering to scale up the lab process to a production system will be more challenging. Several research laboratories have started to consider this problem, and we will hear today about the British Library's effort.

In conclusion, let me say that I am convinced that many of the problems of conserving the cultural heritage in the world's libraries can be solved through the application of technological solutions. But it is not easy. Every national library, in its own way, must be willing to try out new technological solutions.

Every national library must be willing to take the initiative, to find the funds, to take the risks. By showing this leadership, by trying new ideas, by the investment of capital in pioneering research and development, the library field can move forward in finding innovative, cost-effective solutions to the preservation challenges in our libraries and archives.

Remember: Nothing ventured, nothing gained!

SUMMARIES

Technology in Support of Preservation

The role of science and technology in the development of new methods for preservation and restoration is emphasized and verified by examples: engineering and physics for mechanization of classic processes, polymer chemistry to develop new methods of paper strengthening, and reprography for data conversion.

La technologie comme aide à la préservation

Le rôle de la science et de la technologie dans le développement de nouvelles méthodes de préservation et de restauration est mis en relief et vérifié par les exemples suivants: ingénierie et physique pour la mécanisation des procédés classiques, chimie polymère pour développer de nouvelles méthodes de renforcement du papier, reprographie pour la conversion de données.

Technologie als Mittel der Konservierung

Die Bedeutung von Naturwissenschaft und Technologie für die Konservierung und Restaurierung wird betont und an Beispielen belegt: Maschinenbau und Physik für die Mechanisierung klassischer Prozesse, Polymerchemie für die Entwicklung neuartiger Methoden der Festigung von Papier, Reprographie für die Herstellung sekundärer Datenträger.

Dr. Peter G. Sparks
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Library of Congress
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USA

Deacidifying Library Collections: Myths and Realities

by RICHARD D. SMITH

BACKGROUND

Library collections in the United States are losing \$3.38 million every day to acid deterioration. A recent press article reports that the books in the Library of Congress, the world's largest depository of books, are "locked in the grasp of a chemical process that makes paper so brittle it crumbles like a dry leaf"¹ and that 270 million paper documents at the National Archives are crumbling due to the same process. Archivists and librarians around the world are watching the history of modern civilization deteriorate into dust as they inherit the "bitter legacy" of 19th century innovations in papermaking that make books slowly self-destruct. The shift in the mid-1850's from paper manufactured from rags and cotton to a more easily produced, widely available groundwood and chemical wood pulp paper has led to a problem where "more than 50% of all the books printed in the first half of the 20th century will be unuseable by the 21st century"².

Already, the paper in over 40% of the books in some libraries is so deteriorated that the use of these books is restricted, or denied completely^{3,4}. If such a widespread censorship were imposed due to political reasons, rather than inadvertent chemical attack, it would create major civil unrest in the United States. However, due to the slow and subtle nature of paper deterioration and the only recent availability of a proven cost-effective and efficient mass deacidification process, most librarians and archivists have been mute to what has been described at the Library of Congress as "the greatest crisis facing scholarship today"⁵.

THE CONDITION OF LIBRARY COLLECTIONS

Currently, research library collections in the United States contain approximately 300 million volumes. The lowest estimates of brittle books in individual collections average about 9%; the highest estimates average almost 50%. With an overall average of 30%, the use of 90 million books in U.S. research libraries is restricted because their leaves have become too weak and brittle for ordinary use as a result of acid attack.

To grasp the significance of the future condition of U.S. library collections, it is useful to compute the mean deterioration rate that defines the annual losses to a collection caused by acid deterioration. A scientific study of the condition of paper in 231 books randomly selected from the General Collection of Newberry Library in Chicago was conducted 20 years ago. The folding endurance of the paper in 20 of these 231 books was compared to the folding endurance of the paper in identical copies from the collections of the Lawrence University Library and the Research Libraries of the New York Public Library (NYPL). The results of this study on the condition of paper in different libraries were published by *Restaurator* Supplement No. 2 in 1972⁶.

The folding endurance findings were subsequently used to calculate the half-lives of paper in these libraries. The half-lives, i.e., the time for the books to lose 50% of their useability (folding endurance) were, and may still be, approximately:

Library	Half-life
Lawrence University	17.6 years
Newberry Library	16.8 years
New York Public Library	12.8 years

The shorter lifetime (more brittle condition) of NYPL books is caused not only by their greater use, making them appear like the heavily used books of reference collections, but also by the greater acidity of their paper, undoubtedly introduced by lower Manhattan's air pollution. Their pH values averaged one pH unit or, in terms of hydrogen ions, an incredible ten times more acidic than the pH values of the highly acidic Newberry Library books. The Newberry books were an average of one pH unit more acidic than the books from the Lawrence University Library. These results indicate, adjusting from logarithmic to linear scale, that books in the NYPL collections may contain up to 100 times more acid than books in the typical U.S. research library, which has pH values, use levels, and storage conditions similar to the Lawrence University Library.

These findings warrant thoughtful consideration by decision-makers when establishing priorities for mass preservation efforts. The standard statistical and laboratory testing procedures that were used in this comparison of three library collections are still accepted today. Moreover, equivalent results have been obtained when the same statistical techniques were applied to data produced in other independent studies. The folding endurance half-life of the paper in the 500 books that W. J. Barrow Research Laboratory examined in its landmark study has been computed as 17.2 years using the identical statistical

procedure⁷. This 17.2 year half-life is statistically identical to the half-life of 17.6 years for Lawrence University. Both collections were lightly used, and were from small, relatively unpolluted cities located near large bodies of water. In this context, the findings of the Barrow study, which are taken as the benchmark condition of U.S. research library collections, can be interpreted as being excessively optimistic for libraries located in cities such as Chicago and New York.

A third study lasting 22 years examined identical copies of the *Dictionary of American Biography* in libraries all over the United States and Canada. The study determined that, though differences existed, the paper in the copies in best condition deteriorated at an embrittlement rate of 57% in 15 years (half-life of 13.2 years), and 85% in 22 years⁸.

Based upon these three studies, an average half-life of 15 years is a reasonable assumption for the purpose of making estimates about the future condition of library collections. For convenience of computation, this report will use the average folding endurance deterioration rate of 4.660% per year, an amount almost identical to a half-life of 15 years.

THE DOLLARS AND SENSE OF MASS DEACIDIFICATION

Knowing that the annual mean deterioration rate of library books is 4.660%, the question to address is: What benefit can libraries expect from establishing mass deacidification facilities to convert their unstable acidic deteriorating collections into stable alkaline collections?

The Preservation Office of the Library of Congress reports that the diethyl zinc (DEZ) deacidification treatment increases the life of acidic paper three to five times⁹. An increase of two to four times, using less sophisticated methods, was reported in Smith's studies at the University of Chicago¹⁰. Assuming an average benefit of four times, and using the above formula, the book useability half-life increases from 15 to 60 years, and the rate of ageing after deacidification drops from 4.660% to 1.165% per year.

These acidic-unstable and alkaline-stable ageing rates put the choices more clearly when they are used as negative compound interest rates, i.e., depreciation, to compute the differences in annual losses in library book useability. The following calculations are made in U.S. dollars rather than folding endurance, because folding endurance has virtually no persuading power and guiding value for decision-makers who must judge the value of deacidification as part of their library's preservation program.

If for computational convenience we say that the Library of Congress holds 14,000,000 books, and each book has a replacement cost of US\$ 100, a simple

multiplication suggests the Library of Congress book collection has a cash value of US\$ 1,400,000,000. At a deterioration rate of 4.660% per year, U.S. taxpayers lost US\$ 65,240,000 last year ($\text{US\$ } 1,400,000,000 \times 4.660\%$), or US\$ 178,700 each day ($\text{US\$ } 65,240,000/365$ days) on books alone at the Library of Congress.

U.S. research libraries hold over 300,000,000 books, 22 times as many as the Library of Congress. By extrapolation, chemical deterioration last year cost major U.S. libraries US\$ 1,398,000,000 (US\$ 3,830,000 every day) in book availability. This US\$ 1.398 billion is over four times the annual book purchasing budget (US\$ 330 million in fiscal year 1984/85) of libraries belonging to the Association of Research Libraries. The US\$ 1.398 billion suggests, after subtracting for book purchasing costs, that the value of U.S. research library collections is decreasing at about three quarters of a billion dollars each year. Whether evaluated against a US\$ 750 million capital loss each year or against a US\$ 3.83 million loss every day in book collections only, the present preservation efforts of U.S. research libraries, although very impressive by historical perspectives, are barely scratching the surface of a gigantic problem. The current efforts by dedicated preservation librarians hardly qualify as an incoherent hiccup when measured against the collection management attention that book useability losses of US\$ 750 million per year demand from administrators of the research libraries.

Over 99% of all preservation work today involves reproduction of brittle books in new formats, providing new bindings or wrappers for deteriorated books, or establishing good book storage conditions. These measures, though useful, do not treat the primary causes of book deterioration. If books were people, these efforts are comparable to doctors putting their sick patients in hospitals, arranging for a comfortable room with a healthful environment, good food and nursing care, but providing no medical or surgical treatment to cure their illnesses.

If this assessment of present library practice causes concern, consider the restraint of the words in this article compared to the public outrage and calls for punishment that follow the theft of a few hundred books from a major research library. If this review of library preservation capability does not bring compulsion for action, ponder the difference between the public savings that decisive action by librarians could bring versus the losses in public property (38,300 books) that acid attack causes every single day of the year!

The difference between the acidic-unstable ageing rate of 4.660% and the alkaline-stable ageing rate of 1.165% (3.495%) estimates the benefit from deacidification. Any effective mass deacidification system, whether the Library of Congress DEZ system at US\$ 11,500,000 or the Wei T'o equivalent produc-

tion scale system at US\$ 1,000,000, represents an excellent bargain for the Library of Congress when contrasted with its annual collection useability loss that exceeds US\$ 65,240,000 in its book collections alone.

EXISTING DEACIDIFICATION PROGRAMS

The mass deacidification programs of four national libraries (the British Library, Bibliothèque Nationale in France, National Library and Public Archives of Canada, and the Library of Congress) illustrate the three mass treatment approaches to preservation of research library collections under development today.

The aqueous deacidification, strengthening, freeze-dry procedure (described by Wächter in this issue) is in a separate class because it has a different cost and production scale range than the following three approaches¹¹. Nonetheless, Wächter's technology has real merit and, at minimum, warrants application for special purposes.

The research program of the British Library (described by Clements in this issue) focuses on a mass strengthening treatment with mass deacidification as its secondary priority¹². Consideration is given to including an amine (a chemical similar to ammonia) in the strengthening agent to allow deacidification and strengthening to occur simultaneously. Unfortunately, in addition to having potentially hazardous health effects on users, amine deacidification agents are reported to discolor paper and react with nitrates and sulfates to produce acids, thus reacidifying the paper following deacidification^{13, 14}.

The Library of Congress mass deacidification program using DEZ appears to consider the deterioration caused by acid attack so overwhelming that the necessity for deacidification outweighs all other considerations. Peter Sparks, Director of the Library of Congress Preservation Office, has stated that the Library of Congress will look into mass gaseous strengthening after their DEZ facility is operational¹⁵. This author recognizes that gaseous strengthening is a possibility, but believes its economic and engineering problems will force the Library of Congress to consider the liquified gas strengthening approach mentioned above. The inherent problems of gaseous mass strengthening processes are: 1) books must be opened more than 180°, which is equivalent to lying flat on a table, so that the fore edges of the leaves are separated about one millimeter to allow the gaseous agent to penetrate; 2) the treatment cycle time is long because gaseous transfer of the low-vapor-pressure strengthening agents is a slow, costly process by comparison with impregnation of resin-strengthening agents in a liquified gas process¹⁶. As an alternative, using solvents to impregnate short-chain polymer resins would be less complicated, more effi-

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cient, and presumably would produce a strengthening effect similar to introducing vaporized monomers and polymerizing them into resins.

The National Library and Public Archives of Canada and Bibliothèque Nationale (discussed by Scott & Arnould in this issue) are applying a solvent-based mass deacidification approach that was developed as the first step in an all-around mass preservation program^{17, 18}. Its deacidification component uses an organic solvent (liquified gas solution) technology to dissolve, transport, and impregnate the stabilizing alkaline deacidification chemicals. Three additional properties of this solvent approach make it particularly suitable for mass preservation: 1) an acrylic or methacrylate resin can be impregnated into closed, bound books to bond paper fibers together and strengthen weakened paper; 2) magnesium alkoxides can be used to catalyze stabilizing reactions between alkylene oxide gases and unstable components of paper fibers. This reaction occurs rapidly and, together with magnesium's complexing, i.e., deactivation of trace metals, should greatly reduce oxidative attack¹⁹. 3) A safe fungistat such as bis (tri-n-butyl-tin) oxide could be introduced with the strengthening agent to prevent biological attack for at least 50 years, even in bad storage conditions.

MASS DEACIDIFICATION IN PRACTICE

The best known deacidification systems are the operating Wei T'o System at the National Library and Public Archives of Canada, and the proposed system of the Library of Congress. The Canadian mass deacidification system is based upon chemical processing industry methods and technology. This Wei T'o pilot plant facility was originally built to obtain production experience, and has been in production for almost seven years. It has worked routinely and well; far better than predicted. The full-scale system to treat hundreds of thousands of books per year that was originally planned to replace it has never been built, due to financial retrenchment by the Canadian Government and the fact the pilot plant is accomplishing more than was expected. The technology and know-how obtained from this pilot plant development is exclusively licensed to Wei T'o Associates, Inc., by its owner, Canadian Patents and Development Ltd., Ottawa, Canada.

The two staff members who operate the pilot plant system in the National Library/Public Archives Building can deacidify 40,000 to 50,000 books per year during their 7½ hour day, five-day week work schedule. (A larger staff, perhaps seven persons, would be required for each 12 hour flexi-shift in a full-scale facility treating 1,000,000 books per year).

The books, delivered on book trucks by members of the National Library

staff, are inspected for suitability for deacidification while being placed in baskets preparatory to vacuum-drying. Following drying, the baskets of bone-dry books are loaded, two baskets at a time, into the pressure chamber for the 50-minute deacidification cycle. Pressure is used to force the liquified gas deacidification solution into the books. Immediately after impregnation, the solution surrounding the impregnated books is returned to the storage tank for reuse. The wet books are vacuum-dried to remove the liquified gas solvent and deposit the deacidification agent throughout each book. At the end of the cycle, the baskets of books are placed inside cardboard boxes overnight for recovery to room conditions. They are returned to the library following visual inspection.

The cost of deacidifying one book, including labor, chemicals, and maintenance using this system was reported as US\$ 3.27 per book in April 1986 by the Public Archives of Canada²⁰. The reuse of recovered solvents, projected to begin in 1988, is expected to reduce the treatment cost per book by about US\$ 0.75, i.e., to about US\$ 2.50 each. This projected low unit cost in a pilot-scale mass deacidification system represents a tremendous achievement at the National Library and Public Archives of Canada, unthinkable only a few years ago.

The Library of Congress deacidification system uses gaseous DEZ as its deacidification agent (described by Sparks elsewhere in this issue)²¹. The DEZ process is recommended by the Library of Congress as offering librarians the best potential for a mass deacidification system.

However, since early 1986, various institutions such as the U.S. Congress, *Library Journal*, *Nature*, *New York Times*, and the U.S. National Aeronautics and Space Administration (NASA), have requested information and/or sought the author's guidance as a consequence of the mishaps on December 5, 1985 and February 14, 1986 at the DEZ Test Facility of the Library of Congress at the NASA Goddard Space Flight Center. This paper, originally presented on July 8, 1986, was revised at the requests of *College and Research Library News* and *Restaurator* to include a summary of the author's conclusions regarding the DEZ process based upon the information that has been published about the mishaps²²⁻⁴⁵. The most detailed publication is the NASA Goddard Space Flight Center's *Accident Investigation Board Report of Mishaps at the Deacidification Pilot Plant, Building 306 on December 5, 1985, and February 14, 1986*⁴⁶. It alone contains first-hand information on the mishaps.

The preceding 24 references (22-45), published in *Library of Congress Information Bulletin*, *Library Journal*, *Conservation Administration News*, *Abbey Newsletter*, *Nature*, and the *NASA Report*, etc., show unusually wide differences of opinion regarding the implications of these mishaps. Concerned librarians should

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examine all available publications, plus pertinent information that becomes available in the future, and reach their own conclusions regarding the causes of the mishaps and their impact on mass preservation in libraries. Additional background and information sources are given in *An Annotated Chronology of Articles, Comments, Pamphlets, Presentations, and Reports on The Library of Congress Diethyl Zinc (DEZ) Vapor Phase Deacidification Process: 1974 to Date*; an unpublished bibliography that was prepared by this author to obtain a balanced viewpoint of the DEZ development⁴⁷. A list of sources for information on DEZ is appended to the *Chronology*.

This author's impression from a study of the above publications is that the Library of Congress DEZ program has been politicized. The critically important technical questions that focus on what happened and why are being overlooked. What does seem clear from the primary evidence given in the *NASA Board of Inquiry Report*, i.e., from reading the statements and summaries of participants in the mishaps, is that this primary evidence demonstrates that personnel at all three organizations, the Library of Congress, NASA, and Northrup Services, Inc., appeared to be delinquent in fulfilling their responsibilities. Three basic signs of inadequacy are repeatedly evident: a pervasive low quality of technical and engineering work; a systemic deficiency in administrative control and leadership; and, in all three parties, a lack of understanding regarding the inherent hazards of working with DEZ. Karl Nyren, Senior Editor Emeritus at *Library Journal*, may have exaggerated in equating the mishaps at the Library of Congress NASA test facility with the Challenger space shuttle disaster⁴⁸. On the other hand, the *NASA Report* repeatedly indicates that the overall caliber of work on the DEZ test facility was not up to accepted professional standards⁴⁹.

An earlier 1983 document by Northrup Services: *Final Report: Full Scale Feasibility Test of a Vapor-Phase, Mass Deacidification Process for Preserving Books and Papers for The Library of Congress*⁵⁰ contains, together with the *NASA Report*, the best available information on the safety and hazards of deacidifying books with DEZ. This two-volume, 970-page report was primarily prepared for the 1982 Library of Congress DEZ 5,000 book test. It indicates that 1) Northrup Services personnel and consultants had understood and formally reported the hazards of working with DEZ to the Library of Congress in 1983, and 2) contrary to the flawless record the Library of Congress reported to Congress, a minor accident did occur in which an employee was burned by DEZ^{51, 52}.

The physical chemistry data that this *Northrup Services Report* presents indicates that if books had been in the empty test chamber when it contained liquid DEZ on December 5, 1985, the heat from a chemical reaction that occurs naturally between DEZ and paper during deacidification would have caused

the temperature to increase to 150°C (302°F). At 150°C, DEZ spontaneously commences to irreversibly decompose and produce large quantities of energy. The actual outcome is unclear because no one can prove, without duplicating the situation, that this reaction would have led to a major explosion. However, it is reasonable to believe that all of the DEZ present (331 kilograms or 730 pounds) rather than much less than a kilogram (which blew the door off the test chamber) would have ignited, produced a major fire, and injured personnel on December 5, 1985. The minimum effect would have been a DEZ-paper reaction causing the defacing, and probably charring, of the paper in the books. This scenario is unlikely because DEZ spontaneously decomposes at a lower temperature than is required to char paper.

Considerable confusion exists in preservation literature regarding the properties of DEZ. From one Library of Congress perspective, Williams & Kelly, inventors of the DEZ process, have repeatedly asserted that DEZ reacts with the hydroxyl (alcohol) groups of cellulose in paper fibers during the deacidification process^{53, 54}. Both manufacturers of DEZ report that DEZ reacts spontaneously with alcohols, i.e. their hydroxyl groups, just as DEZ reacts with the hydroxyl of water molecules^{55, 56}. Paper chemists have shown that the three alcoholic groups of each glucose unit in cellulose have the same chemical properties as the hydroxyls of lower alcohols, such as methanol, which the manufacturers mention. From an alternative Library of Congress perspective, Shahani & Wilson report that DEZ does not react with the alcoholic hydroxyl groups of cellulose in the current Library of Congress DEZ process, but only with the acids and residual water (0.5% by weight) remaining in the books undergoing deacidification⁵⁷.

Common sense suggests that all of these apparently contradictory statements must be explained. Perhaps the explanation is that the DEZ molecules simply do not come into contact with cellulosic hydroxyl groups during the currently proposed Library of Congress DEZ gaseous treatment. Limited reaction would be expected 1) if access is retarded by water molecules or 2) if treatment is terminated immediately after all water molecules have reacted with DEZ. The possibility that a different chain of events might occur in the event of another mishap warrants investigation. Librarians, insurance companies, and persons living in the vicinity of a DEZ deacidification facility should be fully informed regarding the potential of DEZ to spontaneously decompose or undergo hypergolic reactions on contact with paper. One indisputable evaluation technique would be for someone who believes DEZ to be safe to pour pure, liquid DEZ onto books under conditions that stimulate significant contact between DEZ and paper to simulate the different phases of the Library of Congress DEZ deacidification process.

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On the one hand, the Library of Congress has criticized the other parties, especially Northrup Services and NASA, explaining that the Library of Congress was unaware that NASA did not have the necessary chemical processing knowledge for safe operation of the facility (even asserting that NASA was fired)⁵⁸, and has oriented attention towards the DEZ Test Facility mishaps. On the other hand, the Librarian of Congress promised Congress the following when seeking authorization for the DEZ Deacidification Facility at Fort Detrick, MD: "The Library will be responsible for outfitting the diethyl zinc equipment within the structure, with the advice and assistance of Northrup Services, Incorporated"⁵⁹. Moreover, *Northrup's Full Scale Feasibility Test... Report* clearly shows that no one had prior experience in handling DEZ vapor beyond a research scale. That knowledge, including knowing what construction materials were compatible, simply did not exist.

In addition, the specifications and drawings distributed by the U.S. Army Corps of Engineers with its *Solicitation* for bids supposedly presented comprehensive engineering information for construction of the full-scale DEZ facility⁶⁰. This *Solicitation*, prepared with instruction from the Library of Congress itself and approved by the U.S. Army Corps of Engineers, confirms that the Library would be partially responsible if the information were incomplete. As two further examples, 1) the definition (p. 13A-8) for DEZ ("DEZ, a clear, colorless liquid at atmospheric and ambient conditions, igniting on contact with air, reacting violently on contact with water, but does not react with carbon dioxide, nitrogen, or helium") falls woefully short of providing the chemical engineering data essential to prepare reliable bids; and far more serious, 2) the *Solicitation* does not make existing information, e.g., the 970-page *Northrup Services Report*, available to prospective bidders.

This incompleteness in the *Solicitation* adds the U.S. Army Corps of Engineers to this group of those who did not fully understand the inherent hazards of working with DEZ (one of the conclusions of the *NASA Report*). Withdrawal of this *Solicitation* by the Library of Congress is unimpeachable evidence that the Library desperately needed unbiased, independent advice. To its credit, the Library admitted that it had erred. The Library severed its relationship with Northrup Services, Inc. and NASA, explaining that these organizations did not have the chemical engineering knowledge and experience necessary for the development of the DEZ System⁶¹. Though shortcomings did exist at both organizations, the Library's rationalization gives no recognition to: 1) the Library having taken the primary technical responsibility itself; 2) the 970-page safety report that Northrup Services had prepared; or 3) the fact that NASA had considerable prior experience with DEZ. DEZ had been evaluated by NASA as an ignition agent for the Apollo-Saturn Rocket. It was rejected in

favor of triethyl aluminum, perhaps because the decomposition reaction of the latter is self-limiting. The spontaneous decomposition of triethyl aluminum stops and reverses as the pressure increases. By comparison, the spontaneous decomposition of DEZ begins at 105°C, is unstoppable and continues with explosive speed and power until all of the DEZ is consumed. The vapor pressure of triethyl aluminum is too low for it to be effective as a gaseous deacidification agent.

These prior experiences indicate that before the DEZ test facility mishaps: 1) NASA was only peripherally involved as a facilitator for the Library of Congress DEZ project (the Library's contracts were with Northrup Services, Inc.); 2) all of the knowledge on DEZ at NASA had not been brought together; and 3) when the full review was made, NASA concluded it no longer wished to facilitate the Library of Congress DEZ mass deacidification project. The explanation by the Library that there was a lack of knowledge at NASA is naive if judged against the chemical engineering competence required to develop the new materials and technologies that are needed to handle the thousands of tons of hypergolic fuels (any combination of fuel and oxidizer that ignites spontaneously on contact) that NASA uses to power lunar rockets and spacecraft.

The *NASA Report*, public interest, and problems of fiscal management caused the Committee on Appropriations, U.S. House of Representatives, to become concerned about the Library's DEZ mass preservation program⁶². The Committee arranged that the Office of Technology Assessment (OTA) of the U.S. Congress undertake an independent review of the history, technical and economic feasibility, and safety of the Library's DEZ System, and compare the DEZ System both to alternative deacidification systems and to other existing and possible mass preservation technologies⁶³. This OTA study is unprecedented in that it marks the first time that Congress has requested an independent review of a high priority Library program. The OTA review of the Library's DEZ System commenced in June 1987; an interim report is scheduled for September 1987, and the final report for February 1988.

CHOOSING A MASS DEACIDIFICATION SYSTEM

Nonaqueous (gaseous or solvent) deacidification has come of age. From virtually no choices 25 years ago, librarians today can select between gaseous and liquid systems, among a variety of large and small-scale techniques, and among a variety of application methods and chemicals⁶⁴. This abundance of choice is even more startling if one remembers that less than 20 years ago, the Committee for Paper Problems, International Institute for Conservation – American Group, formally reported: "A nonaqueous means of deacidification that

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would not be harmful to paper, pigments, and the various media must be developed⁶⁵. At that time, only the laboratory-demonstrated mass deacidification process existed, but today, a production-proven mass deacidification process is available for use as the keystone in mass preservation facilities⁶⁶.

But is deacidification alone sufficient to extend a book's life? Many books may deteriorate more rapidly than present-day accelerated-ageing tests estimate. In addition to rapid ageing, bad storage conditions may develop; and together with floods, fires, and other unanticipated events, they may reduce the extension of book life that deacidification brings by 50%. This pragmatic view indicates that librarians cannot depend on deacidification alone, and as prudent professional managers, that they must build a safety factor into their long-range preservation programs.

The need for this safety factor led to the development of the Wei T'o Mass Preservation System. The theory underlying this system assumes that, in addition to deacidification, both strengthening of weakened papers and protection against oxidative and biological attack are essential in the full-scale, mass preservation programs that research libraries need. In this approach, mass deacidification, though the most important component, is only one component of an optimized mass preservation program, and it must be compatible with the other components.

The Wei T'o System is selected as the example of the state of the mass deacidification art because it is the only mass deacidification system in use, and its evolution demonstrates several critical considerations when developing successful deacidification systems. These critical aspects include maintaining scrupulous scientific rigor and objectivity; choosing a lead person or group whose primary qualifications are breadth of technical knowledge and industrial chemical engineering experience in developing and installing new technology; thoroughly involving librarians, engineers, and operating personnel in the decision-making; using specially selected teams of experts for specific tasks; and delegating overall administrative control and/or review to an independent decision-maker, e.g., when qualified individuals are available, preferably to the preservation librarians who must make the deacidification system work in production.

The Wei T'o technology began as the author's Ph.D. research at the Graduate Library School of the University of Chicago. This first, or laboratory stage was supervised by an unparalleled group of engineers, scientists, and librarians that came from industry, the University of Chicago, and the Institute of Paper Chemistry⁶⁷. The second stage of development, installation of the pilot plant scale Wei T'o Nonaqueous Book Deacidification System in Canada, also brought together an extraordinary group. Major corporations such as DuPont

and the York Division of Borg-Warner Corp., together with other vendors and contractors, shared their technologies to overcome engineering and operational challenges that had never been encountered previously.

The first Wei T'o deacidification agent, magnesium methoxide, was improved by George B. Kelly, Jr., Chemist, Preservation Office, Library of Congress⁶⁸. Many Wei T'o improvements have followed and current research indicates others are imminent⁶⁹. The general acceptance of this technology by art, archive, and book conservation laboratories throughout North America and around the world is confirmed by independent evaluations of the effectiveness, versatility, and applicability to large and small-scale projects.

Far more pertinent, this acceptance indirectly reports the tens of thousands of independent decisions by archivists, librarians, curators, and expert conservators to choose a particular deacidification system approach. This use of the Wei T'o process commenced immediately upon its announcement, and has continued for 17 years⁷⁰. By comparison, except for research and development, not one book has been deacidified with the DEZ approach in the 13 years since its discovery⁷¹.

Test data comparing the Library of Congress DEZ and Wei T'o deacidification methods have not been published by either organization. However,

Table 1. Library of Congress: 21-day accelerated ageing test of gaseous diethyl zinc (conducted at 80°C, 80% humidity).

Folding endurance (number of folds at 500 g)				
<i>Days of accelerated ageing</i>	0	7	14	21
Untreated control	760	146	25	19
Deacidified with DEZ	622	191	99	62
Deacidified with DEZ after 7 days ageing	100	45	13	—
Deacidified with DEZ after 14 days ageing	—	—	—	—
Brightness (% Hunter brightness)				
<i>Days of accelerated ageing</i>	0	7	14	21
Untreated control	76	61	57	57
Deacidified with DEZ	75	62	57	54
Deacidified with DEZ after 7 days ageing	62	57	54	—
Deacidified with DEZ after 14 days ageing	—	—	—	—
pH (hot water extraction)				
<i>Days of accelerated ageing</i>	0	7	14	21
Untreated control	4.7	4.8	5.0	5.2
Deacidified with DEZ	5.5	5.3	5.9	6.0
Deacidified with DEZ after 7 days ageing	5.9	5.6	5.7	—
Deacidified with DEZ after 14 days ageing	—	—	—	—

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Table 2. Wei T'o: 21-day accelerated ageing test of Solution No. 2 (conducted at 80°C, 80% humidity).

Folding endurance (number of folds at 500 g)				
<i>Days of accelerated ageing</i>	<i>0</i>	<i>7</i>	<i>14</i>	<i>21</i>
Untreated control	760	146	25	19
Deacidified with Wei T'o #2	763	450	290	217
Deacidified with Wei T'o #2 after 7 days ageing	111	49	40	—
Deacidified with Wei T'o #2 after 14 days ageing	49	17	—	—
Brightness (% Hunter brightness)				
<i>Days of accelerated ageing</i>	<i>0</i>	<i>7</i>	<i>14</i>	<i>21</i>
Untreated control	76	61	57	57
Deacidified with Wei T'o #2	75	64	63	61
Deacidified with Wei T'o #2 after 7 days ageing	62	57	55	—
Deacidified with Wei T'o #2 after 14 days ageing	57	55	—	—
pH (hot water extraction)				
<i>Days of accelerated ageing</i>	<i>0</i>	<i>7</i>	<i>14</i>	<i>21</i>
Untreated control	4.7	4.8	5.0	5.2
Deacidified with Wei T'o #2	8.6	9.2	9.1	8.8
Deacidified with Wei T'o #2 after 7 days ageing	8.6	8.9	9.1	—
Deacidified with Wei T'o #2 after 14 days ageing	9.3	9.3	—	—

the National Diet Library of Japan sponsored such research at the University of Tokyo Agro-Industry⁷². Tables 1 and 2 present the data from their 21-day accelerated ageing evaluations of the Wei T'o Solution No. 2 and the Library's DEZ deacidification treatments. The basic differences between Wei T'o Solution No. 2 and the Wei T'o Liquified Gas Solution used for mass deacidification are 1) Solution No. 2 is prepared for use in air at ordinary pressures and 2) Liquified Gas Solution contains more deacidification agent.

The Wei T'o Solution No. 2 shows much better folding endurance retention than DEZ. It remains stronger after 21 days of ageing (217 folds) than the DEZ-treated paper does after 7 days of ageing (191 folds). The Wei T'o No. 2 also shows better performance in stabilizing aged paper, i.e., retrospective library collections, than the DEZ-treated paper does. For example, the effect of DEZ-treating papers that had been aged for 14 days may have been detrimental, while treatment with Solution No. 2 appeared to double the strength of the paper, from 25 folds to 49 folds.

The effects of ageing on whiteness (color reversion) were measured as Hunter brightness. Papers treated with Wei T'o Solution No. 2 remained whiter after ageing than those treated with DEZ.

The pH measurements were evaluated by a hot extraction method. (Hot

extraction is the preferred test for ageing studies because it gives a more accurate prediction of acidity than cold extraction does. Cold extraction is the preferred method for evaluating current pH). The results indicate that Wei T'o No. 2 deposited sufficient buffer to maintain the pH for 21 days of ageing while the DEZ-treated papers exhibited an unexpected tendency to remain in an acidic condition. Although not definitive, these tests were conducted independently of both the Library of Congress and Wei T'o. These results warrant thoughtful examination by archives and research libraries.

The Wei T'o Nonaqueous Book Deacidification System has been described by the Library of Congress in testimony to the U.S. Congress as unsuitable for its use⁷³. The Library of Congress claimed that the Wei T'o process requires a preselection of books because some books may be defaced by the treatment, and that the production capacity is insufficient to meet the needs of the Library of Congress.

During the seven years of operating experience since early 1981, the need to identify and protect a few books with sensitive inks has not been found either excessive or expensive at the National Library and Public Archives of Canada⁷⁴. Peter Waters, Conservation Officer at the Library of Congress Preservation Office, advised that he 1) found no signs of ink feathering and 2) held a "thoroughly positive view on the merits" of the Wei T'o process following his 1983 visit to the pilot plant in Canada⁷⁵. Perhaps more important in the long run, new chemicals and technology that Wei T'o is introducing should provide an additional basis on which to lay this preselection fallacy to rest⁷⁶.

A different type of "defacing" can be anticipated as a consequence of increased velocity of DEZ gases when the Library of Congress test deacidification facility is scaled up to full production size. It can be assumed that DEZ molecules travel at far greater speeds in a full-scale facility than in a small test facility. In a simplified way, the problem that greater speed introduces can be visualized if one imagines the DEZ molecules as sand particles impacting against and producing, through erosion, the elegant stone formations of the national parks of the southwestern U.S. A more conservative comparison is the awesome effect of the far less (than DEZ) reactive gases used as fuels in the industrial furnaces, kilns, and smelters. Ceramic engineers are all too familiar with the capability of these gases to stain non-reactive, refractory bricks at 1600°C (2912°F). When adjusted for temperature, the pressure (density) of these gases is approximately 200 Torr, a number only ten times greater than the pressure of 20 Torr proposed for pressure during deacidification with DEZ. When one combines this staining possibility projection (not unreasonable as a down-scaling factor of ten versus the up-scaling factor of 25 times proposed for the Library of Congress production scale facility) with a recognition that books

in the production-scale chamber form a tortuous labyrinth, it seems obvious that the amount of defacing will be much greater in larger than in smaller facilities. The primary reason for the additional staining is that more DEZ molecules will impact against and react with the surfaces of books where their directions change. Considerable confirmation that a staining problem does exist was demonstrated by the 5,000 book test in 1982.

Another question on which additional information is needed is whether the DEZ process will actually deposit the DEZ deacidification agent uniformly. If it will, a concern arises because the margins of books contain more acidity and need a heavier dose and consequent reserve as a result of their greater exposure to oxygen and polluted air. Fortunately, since DEZ enters as a gas, a greater deposit can be expected in the margins because the deposition of DEZ is presumably increased by increased frequency of molecular impacts with potential deposition sites. The amount of gaseous agent deposited will also be affected by the number and size of the pores or holes in the paper of closed books. The total volume of these holes is far smaller, and the quantity of material to be deacidified is far greater, in dense, highly calendered papers than in light, porous papers. The uniformity of deposition in this type of situation is a function of the chemical activity of the reactants, the amount of the reactant (DEZ) available to react, and the length of time during which the reaction occurs.

Consequently, all other factors being equal, librarians might wish to know whether significant differences in deacidification treatment could exist among books that vary in the weight of paper to be deacidified and the surface area available for penetration by factors of five to ten. There are many possibilities for overcoming these types of staining and deposition problems using solvent systems, where the concentration of deacidification agent, point of deacidification agent deposition, temperature, pressure, wetting and drying rate, and solvent itself can be varied widely through control of operating conditions. By contrast, the chemical and physical properties of a low-vapor-pressure, reactive material such as DEZ establish a range of practical operating conditions that offer, by contrast, very limited flexibility. For these reasons, this author agrees with assertions by the Library of Congress that one mass deacidification system will encounter defacing problems in production-scale operations; but respectfully points out that a difference of opinion exists as to which of the two systems it will be that harms books.

With reference to the potential capacity of the Wei T'o System, the Library of Congress has always reported factually to Congress the originally specified output of the Wei T'o "pilot plant" system of 30 books per cycle, five cycles per 7.5 hour shift, one shift per day, five workdays per week. The Library com-

Table 3. Comparison of production histories of Library of Congress DEZ and Wei T'o systems.

	LC DEZ	Wei T'o
Years in development	13 years	17 years
Cost of development (up to 1987)	US\$ 5-6 million	< US\$ 500,000
Years operational	0 years	7 years
Treatment cost/book (production)	US\$ 2.50-\$4.00	US\$ 2.00
Pages treated (production)	0	> 10 million
Value of preserved materials	US\$ 0	> US\$ 200 million*

*Includes North America, Europe, Australia, New Zealand, and Africa.

pared this production against the production of the proposed Library DEZ Facility at Fort Detrick, MD. An existing operating Wei'o T'o pilot plant is being compared with a proposed, non-operating, full-scale facility! This comparison misleads the public and Congress because it compares the original conservative 1975 estimate for present-day reality against the projected estimates and goals of a Library of Congress development project.

The Library of Congress projections are based on an operation running 24 hours per day, seven days per week. To make a fair comparison, the Wei T'o pilot plant should be scaled up to a comparable size. A simple conversion, involving merely doubling the size of the treatment chamber and increasing the size of certain peripheral components, would yield 645,000 books per year at 89% of capacity. This conversion would result in a one-treatment-chamber unit and is on a scale where future operational results are literally guaranteed from past operating experience. When evaluated from this more logical perspective and on the output of one deacidification chamber, the production-scale Wei T'o System actually has the *larger* capacity. In fact, the Wei T'o System more than meets the selection criteria of the Library of Congress. The 89% capacity output of two Wei T'o chambers exceeds the projected capacity of the two chambers in the DEZ system by over 30%⁷⁷.

By contrast, the original plan for scaling-up at the Library's Fort Detrick facility was projected based on a scaling-up factor of 50 to 75 times rather than two times with Wei T'o; data from 13 unpublished tests of up to 100 books each rather than seven years of Wei T'o production experience⁷⁸; and changing from a laboratory "use once and discard" chemical test philosophy to a more complicated "recapture and recycle" production scale operation. By comparison, almost no changes are required in the Wei T'o system. The revised scale-up plans and projections for the new design in preparation by Texas Alkyls are reported to be a 25-fold expansion of the test data⁷⁹.

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A cost comparison of the respective full-scale systems is difficult to make because only limited information exists. The author's expectation is that the installed cost of a Wei T'o System of comparable production capacity of 1,000,000 books per year would be less than 15% of the projected installed cost of the Library of Congress DEZ Facility at Fort Detrick. The unit deacidification costs per book for the Wei T'o System have been estimated based on operational experience. At this time, equivalent cost information does not exist for the DEZ System. It is expected that the Library's capital costs and unanticipated book handling (preselection?) labor costs will make their unit DEZ deacidification cost significantly more expensive than the Library originally reported. In summary, Table 3 shows the comparison between the two approaches.

CONCLUSION

Libraries should not take the emergence of mass deacidification and the development of Wei T'o technology reported here as suggesting that all of their mass preservation problems have been solved. Significant understanding of library preservation problems now exists within the conservation, industrial, and scientific worlds, and this information is being made available to the general public^{80, 81}. Libraries are no longer standing alone, and their preservation problems are beginning to achieve the visibility that they deserve. Librarians have an economic justification as well as a proven technology to use in planning the strategies for preserving their library collections.

FOR ADDITIONAL INFORMATION

Additional information to help libraries choose between different mass deacidification systems is provided by George M. Cunha's study: "Mass Deacidification for Libraries", published by *Library Technology Reports*, American Library Association⁸². The report Cunha prepared is important because it represents a courageous first attempt to present a critical evaluation. The current perspective at the Library of Congress is available in Shahani & Wilson to supplement the information presented in this article⁸³. A bibliography of over 50 references published from 1977 to 1987 on the Wei T'o System is available for updating the evaluation by Shahani & Wilson⁸⁴.

National TV news releases on library preservation and mass deacidification directly recognize the importance of libraries to society. The American Film Foundation will release, in the autumn of 1987, *Slow Fires: On the Preservation of the Human Record*, a 60-minute TV video report on mass preservation problems

and technology, sponsored by the Council on Library Resources, Library of Congress, Andrew M. Mellon Foundation, and National Endowment for the Humanities⁸⁵. A 1987 *GSU Views* interview of this author by President Leo Goodman-Malamuth II, Governors State University, presents a 30-minute video introductory discussion of mass deacidification⁸⁶. Daniel J. Boorstin, Librarian of Congress, explained the problems confronting librarians and the Library's DEZ Process on the National Broadcasting Company's "Today Show", July 7, 1986⁸⁷. "The Decay of Culture" from the *Science Notes* program (1986, 4 minutes) of the Public Broadcasting System's San Francisco station KQED-TV briefly explains the Wei T'o System and provides general background about the University of California at Berkeley on book deterioration and preservation⁸⁸. The "How About Saving Old Books" news release (1985, 1.5 minutes), sponsored by the National Science Foundation and General Motors Research Laboratories, recognizes the Wei T'o System as an advancement in science and technology⁸⁹. The American Chemical Society's "Fountain of Youth For Library Books", news release (1984, 2 minutes) uses the Wei T'o System as an example of good chemistry and chemical engineering⁹⁰. These video tapes are available for educational use by libraries; the first three from their producers, the last two from Wei T'o Associates, Inc.

In addition to the specially selected reports on mass preservation in this issue of *Restaurator*, all of the remaining 40 papers presented during the conference in Vienna April 6-9, 1986, on "Preservation of Library Materials" are soon to be published⁹¹. The state-of-the-art-and-science of paper conservation is in press as the *Proceedings of New Directions in Paper Conservation* (10th Anniversary Conference of the Institute of Paper Conservation), April 14-18, 1986, Oxford University⁹². The techniques for preserving the most impermanent papers, i.e., groundwood papers and newsprint, will be reported in the "Proceedings of the First International Symposium on Newspaper Preservation and Access", held August 12-15, 1987⁹³. An update on the status of all of the major mass preservation technologies will become available during the Sixth Congress of the International Association of Archival, Library and Graphic Restorers at the State Library for Prussian Cultural Artifacts, in West Berlin, October 6-9, 1987⁹⁴.

The Office of Technology Assessment of the U.S. Congress is scheduled to submit its final report in February 1988 on the evaluation of the plans of the Library of Congress to deacidify books using DEZ and other mass deacidification and preservation technologies⁹⁵. The Canadian Conservation Institute (CCI) will sponsor a several-day conference on paper conservation in Ottawa, Canada, during October 1988⁹⁶. The Technical Association of the Pulp and Paper Industry (TAPPI), the premier professional association of the pulp and

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paper sciences, will sponsor a comprehensive conference on the science and technology of paper preservation in October 1988⁹⁷. The difference between the CCI and TAPPI conferences is that the CCI conference is oriented towards paper conservation and restoration technologies, and the TAPPI conference will focus on applying paper science and technology to library collection administration and management.

This burst of review, compilation, and dissemination of information really confirms the growing capability of librarians to determine the useful life of books. The formal evaluation by the Office of Technology Assessment of the Library of Congress DEZ Mass Deacidification System, regardless of the investigative outcome, primarily means that a first-rate deacidification process will be identified, properly funded, and put into production at the Library of Congress. The sponsorship by TAPPI of a symposium on paper preservation signals both a new availability of paper knowledge to conservators and an increasing ability of librarians to influence the quality of paper in the future.

SUMMARIES

Deacidifying Library Collections: Myths and Realities

The magnitude of the preservation problem caused by acidic paper in U.S. research libraries is expressed as an annual loss of national wealth. A general review of the different mass deacidification approaches for deacidifying library materials is presented. The Library of Congress DEZ and Wei T'o deacidification processes, the two approaches that appear practical, are compared on the basis of their respective technologies and projected treatment and capital costs. A detailed history of the 1985/86 DEZ mishaps and their political consequences is provided. A listing of major current publications, meetings, and programs is reviewed to demonstrate preservation work in the process of undergoing a major expansion.

Désacidification des collections de bibliothèques: mythes et réalités

Les bibliothèques américaines de recherche expriment sous forme de perte annuelle de la richesse nationale l'amplitude du problème de préservation causé par l'acidité du papier. Elles présentent une étude générale des différentes approches de désacidification de masse appropriée au matériel bibliothécaire. Les procédés de désacidification DEZ et Wei T'o, de la bibliothèque du Congrès, sont les deux approches qui semblent s'imposer et sont comparées sur la base de leurs technologies respectives, de leurs traitements projetés et de leur coût de capital. Une histoire détaillée des contretemps du programme DEZ 1985/86 et de ses conséquences politiques est fournie. Une liste des principales publications courantes, des rencontres et des programmes est passée en revue afin de démontrer le travail de préservation relié à un processus de forte expansion.

Neutralisierung von bibliothekarischem Sammelgut: Erwartungen und Wirklichkeit

Das Ausmaß des konservatorischen Problems als Folge des säurehaltigen Papiers in amerikanischen wissenschaftlichen Bibliotheken wird ausgedrückt als jährlicher Verlust an Volksvermögen. Es wird ein allgemeiner Überblick gegeben über die verschiedenen Methoden der Massenneutralisierung. Die DEZ-Methode der Library of Congress und das Wei T'o Verfahren, die beiden welche praktikabel zu sein scheinen, werden miteinander verglichen hinsichtlich ihrer Technologie, des Verfahrensablaufs und der Kosten. Die Unfälle von 1985/86 in der DEZ-Anlage und ihre politischen Folgen werden geschildert. Abschließend wird ein Überblick über laufende Veröffentlichungen, Tagungen, Vorhaben u.s.w. gegeben, um zu zeigen, in welchem Maße das Problem der Konservierung ins öffentliche Bewußtsein und in die Praxis der Bibliotheken eindringt.

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Mass Deacidification at the National Library of Canada

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MASS DEACIDIFICATION

Nearly every book printed during the past one hundred years, and more, either is brittle or will become brittle as a result of acid decay¹. This includes most of the books printed since the Confederation of Canada in 1867, that is, most of our printed heritage as a nation. And, because of atmospheric pollution, a great deal of earlier Canadiana, printed on papers we like to think strong and durable, is also threatened. The responsibility of the National Library of Canada (NLC) is to preserve in original format as much Canadiana² as possible. To achieve this, sound preventive conservation is imperative. The NLC has an operational conservation program based on the preventive conservation technique – mass deacidification – which has become an essential element in the conservation of Canadiana.

Mass deacidification is regarded primarily as a preventive conservation measure because the stabilization and buffering of book papers while they are new and strong will increase the life of the paper by several times, and should minimize future restoration needs. Mass deacidification cannot restore strength to weakened papers; fold strength is the same before and after treatment. This is not meant to suggest that retrospective holdings should be excluded from a mass deacidification program, but rather to emphasize the necessity of giving new materials priority over old.

The Wei T'o Nonaqueous Book Deacidification System, or simply the Wei T'o System, invented by Richard D. Smith, was developed and built by the Public Archives of Canada, at a total cost of about \$500,000 CAN over a seven-year period. Work on the pilot test plant began in 1974. It was completed in 1978. Installation was followed by extensive and rigorous testing and in December 1981, the system became operational (Fig. 1). The system works as follows:

Books chosen for mass deacidification are placed in wire baskets and dried for 36 hours in a vacuum dryer. This removes the normal dampness of paper. Two baskets, containing between twenty and thirty books, are then loaded into the process tank. Deacidification solution is then pumped in, and pressure is then

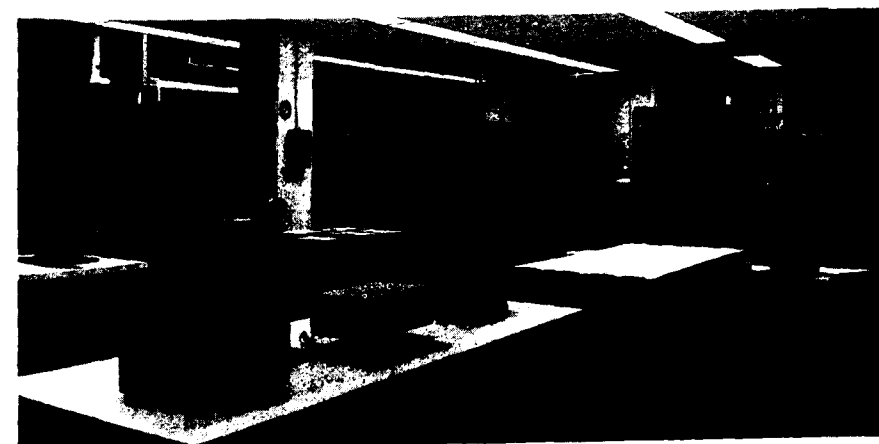


Fig. 1. General view of the deacidification equipment.

increased to ensure complete penetration. Vacuum drying then removes the solvent (which is recovered for reuse). Warm air is introduced at the end of the cycle, pressure is returned to atmospheric level, and the books are removed (Fig. 2).

The deacidification cycle lasts approximately one hour. The baskets are placed in plain corrugated boxes, where the books return to room temperature and regain normal moisture from the air. They are inspected and returned (or sent) to their respective divisions. A newly deacidified book does not undergo any change in appearance³.

Each book is identified as treated by a small numerical stamp on the verso of its title-page.

THE WEI T'O SYSTEM

The NLC has found the Wei T'o System to be effective, economical and efficient. The pH levels achieved range from 8.5 to 9.5 (7 being neutral). Deacidification is relatively inexpensive at \$3.50 US or \$4.50 CAN per book. Current routines are simple because the safety of the system makes possible an in-house program which reduces the amount of movement for materials. Nothing is held in the mass Deacidification Unit for more than one week. During that period, the books are delivered, examined and prepared for treatment, dried, deacidified, reacclimatized, inspected, identified as treated and sent to the stacks.

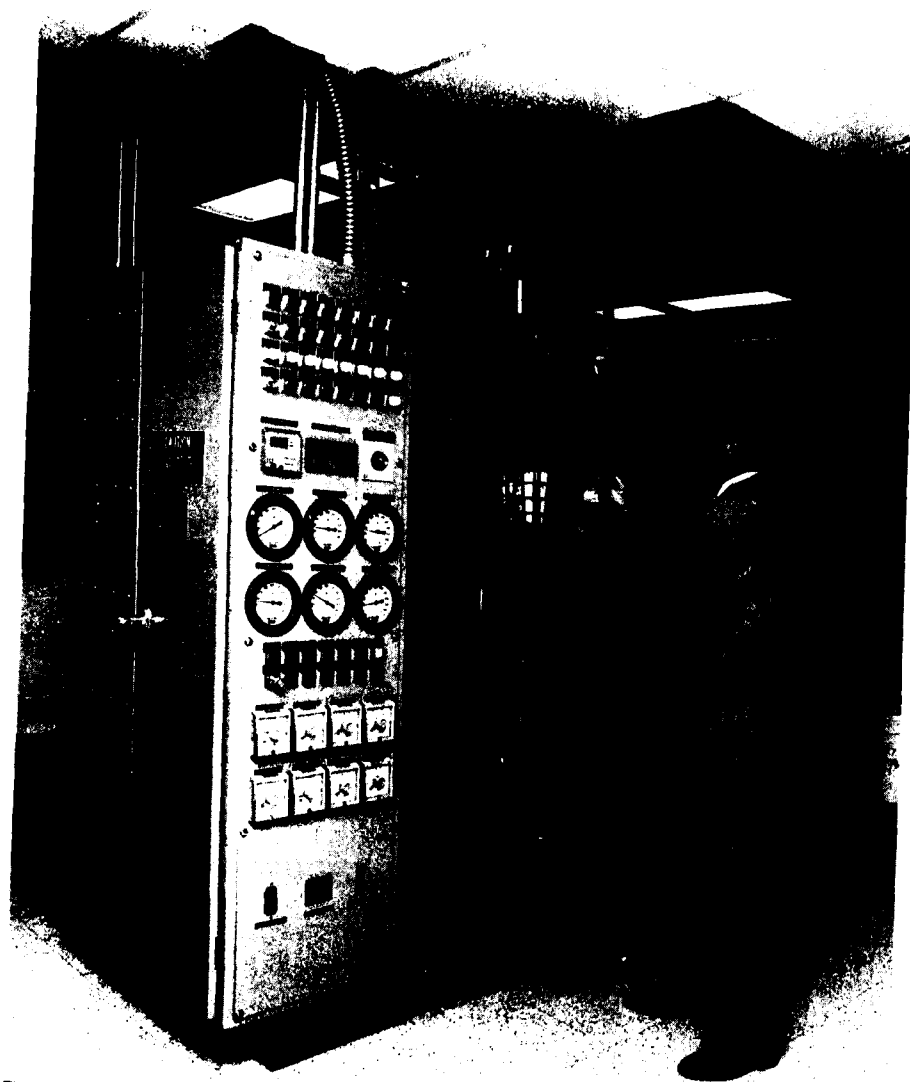


Fig. 2. Process tank being loaded with pre-dried books.

Limitations

The present system does have a few limitations, which means that some pre-selection is necessary. The process tank currently in use is that of the original pilot project, built on a modest scale for the sake of economy. It will

only accommodate books up to 25.5 cm × 21 cm in size. This is the present system's greatest disadvantage. The deacidification agent does not appear to harm leathers, and leatherbound books from the general retrospective collection are routinely sent for treatment. However, new leatherbound books and leatherbound books from the Rare Book Collection are not, as the mass deacidification procedure requires that the books be thoroughly dried, which could have a permanent adverse effect. Until laboratory tests are completed, this policy will continue. Some coloured illustrations must be masked with blotters to prevent the off-setting of colours, a technique also used to keep library stamps from causing damage. Testing has shown that some plastics used on paperbound books react to the Wei T'o System. Mylar covers are therefore removed before deacidification. On the positive side, testing has proven that the strength of PVA bound paperbacks is enhanced by treatment in the Wei T'o System. With the limitations mentioned, we have found that one fifth to one quarter of the materials received cannot be treated. As noted, this is mainly because of size. With a larger process tank, there would be little that could not be treated in the Wei T'o System. At the same time, testing continues.

Capacity

Practical experience has demonstrated that the present system could deacidify about 3000 books each week, or about 150,000 a year, the average book being 2.5 cm thick. However, we have not yet been able to operate the system to its full capacity, i.e. 24 hours a day, seven days a week.

Currently, it runs for one shift a day, five days a week, and can deacidify about 40,000 books a year. The only impediment to full use of the system is the limited number of technicians we can employ for this program because of budget restraints. The possibility of extending the existing shift within the parameters of the flexible work day is under investigation; this would enable us to double the number of cycles now possible daily, and would enable us to treat more than 80,000 books each year using the existing small process tank, without going to a second shift. The existing capacity of the system will serve the NLC's needs for the treatment of new Canadiana. Last year we received on legal deposit some 13,900 monographs, i.e. 27,800 items, and about 74,500 new Canadian official publications were also added to the collection. For computational purposes, five official publications equal 2.5 cm or one monograph, on an average.

Mass Deacidification at the National Library of Canada

PROGRAM

The NLC has given Canadiana priority in its mass deacidification program, with new Canadiana taking precedence over retrospective materials. To the end of the 1984/85 fiscal year, however, the program was limited to the deacidification of retrospective holdings from the Canadian Official Publications Collection. Some 35,000 items were treated. (More than 7,000 monographs from the Library of the Public Archives of Canada were also treated.) The focus on government publications was due to problems with the spine label formerly used. Official publications are not labelled in the NLC collections. An aluminium-backed, pressure-sensitive label compatible with the system is now in use. Since the beginning of the current fiscal year in April, the program to treat legal deposit materials and new Canadian official publications began in earnest, but retrospective materials are still sent to ensure that the system is never idle. Such materials are retrieved *en bloc*, size being the only factor considered. As the capacity of the system expands, the NLC plans a systematic on-going program for the treatment of the retrospective collection, eventually including non-Canadian materials. Since the entire collection comprises some five million items, we expect this program to continue for many years.

The NLC's experience has shown that even a small liquified mass deacidification system can make significant inroads into the problem of brittle books. Cooperative/commercial applications appear to be attractive both to academic and research libraries and to the private sector in Canada.

SUMMARIES

Mass Deacidification at the National Library of Canada

A report is given on the first four years of experience with the Wei T'o Nonaqueous Book Deacidification System of the National Library of Canada, that was begun in 1974, completed in 1978 and finally tested in 1981. Working 24 hours a day in its full capacity – what not yet has been operated in practice – the system can deacidify 150,000 volumes. A disadvantage of the system is that some pre-selection is necessary: leatherbound books cannot be treated indiscriminately; some coloured illustrations must be masked; some plastics used for bindings can suffer harm.

Désacidification en masse à la Bibliothèque nationale du Canada

A signaler un rapport sur les quatre premières années d'expérimentation du système Wei T'o non aqueux de désacidification des livres de la Bibliothèque Nationale du Canada, commencé en 1974, achevé en 1978 et finalement testé en 1981. Pouvant fonctionner à pleine capacité 24 heures sur 24, ce qui jusqu'ici n'a pas encore été le cas en pratique, le système peut désacidifier 150 000 volumes. Un désavantage du système est qu'une présélection est nécessaire dans une certaine mesure: les

livres reliés en cuir ne peuvent pas être traités indifféremment; certaines illustrations en couleur doivent être masquées; certains plastiques utilisés pour les reliures peuvent être endommagés.

Massenneutralisierung in der Nationalbibliothek von Kanada

Es wird über die ersten vier Jahre der praktischen Arbeit mit dem Wei T'o Neutralisierungssystem der Kanadischen Nationalbibliothek berichtet, das 1974 begonnen, 1978 vollendet und 1981 aus der Testphase in die Praxis überführt wurde. Bei voller Ausnutzung der Kapazität rund um die Uhr, was bisher noch nicht möglich war, könnte die Anlage 150 000 Bände pro Jahr behandeln. Ein Nachteil des Systems ist, daß die Bücher nicht ohne Vorinspektion behandelt werden können: bei Ledereinbänden ist eine Auswahl nötig; manche farbigen Abbildungen müssen maskiert werden; einige Kunststoffe in Einbänden können Schaden nehmen.

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Mass Deacidification in France

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The new generations of librarians now have to face difficulties nobody would have imagined a few decades ago at a time when acquiring and distributing documents were their only preoccupation. The poor quality of papers and the consequences this implies in the everyday life of libraries, have brought about a change in conscience, and the economic crisis has contributed its share in sharpening the spirit of conservation. Solutions have been proposed during the past few years to cope with industrial abuses and the various neglects of our time. We are therefore obliged – and it's not the least paradoxical – to cure diseases which are nothing but mistakes and not, in many cases, effects of chance. The acidity of paper is a terrible disease since books, even if they don't all die, are all infected and no country today can boast of being protected against this calamity. Ancient productions indeed, but also contemporary productions, there is no escaping it, and as time goes on, known remedies come up against a major obstacle: the quantity of documents to be treated, and the necessity to treat them as soon as possible.

So the point is not only to know the techniques of treatment but also the methods of work and organisation in order to control this mass of documents. The aim of this report will be to examine the means we now have at our disposal in France, as well as to propose thinking over the methods of exploiting those techniques.

For some years, researches have been carried on to succeed in working up a technique of treatment that takes into account not only the quality of documents but especially their quantity. The solution to neutralize papers is not, in fact, a recent discovery. Since the 1940s, Barrow, Kelly and others, have tested various methods and tried numerous products to restore to papers a pH and an alkaline reserve necessary to their conservation. Unfortunately none of them is really satisfactory nor offers the required characteristics for quick treatments on a great number of documents.

The necessity to progress quickly has led searchers to direct their works to solutions only demanding little handling. If the first criterion of choice for a method is above all its chemical efficacy, the second is the whole of its means of exploitation. Therefore, it's advisable to draw one's attention to this particular point of workmanship before, during and after the treatment itself. This parameter has been the preoccupation of the laboratories which have thought about the building of stations of deacidification.

The history of the French station started in 1977 at a time when the Biblio-

thèque Nationale after the end of a sample survey in its collections decided to plan the repairing of its stock and to programme preventive action to avoid incommunicability and the disappearing of a great part of its collections. The "Plan de sauvegarde" has worked in several directions as early as 1979: treatment of newspapers, treatment of printed books and measures of conservation in all departments.

Printed documents in general, whether they are in sheets or volumes, have more particularly attracted attention because of the state of the paper. In conjunction with their repairing and their microfilming, it was decided that a special research would be started for their deacidification considered rightly as one of the main causes of their degradation.

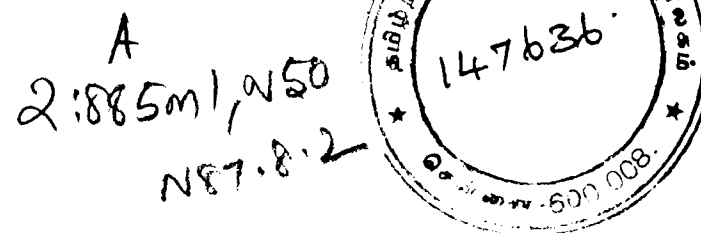
The Centre de recherche sur la conservation des documents graphiques, laboratory of the Centre national de la recherche scientifique, had to test different methods in a very short time in order to make it possible to achieve the treatment of documents before any repairing. The essential problem was to find a quick process neutralizing papers on a great scale, two conditions that those who have dealt with the matter know very well.

In 1982, a solution was proposed with the help of a French private society specialized in the field of gases and their applications: the Société Mallet, from Paris. Nevertheless it was necessary to wait until 1984 for financing to be obtained and to decide its building. It was finished in 1985 for the part dealing with the main treatment. But there remains to be finished the part dealing with re-treating non-consumed products which has met with difficulties of an architectural kind totally independent of the scientific aspect. Everything will be completely operational at the end of June, 1987.

Installed on the premises of the Centre de conservation de la Bibliothèque Nationale at the Château de Sablé (250 kilometers to south-west of Paris), this station of deacidification is not an innovation in its main characteristics.

The product kept for processing is the carbonate of methylmagnesium well-known for its neutralizing properties and which provides papers with a good alkaline reserve, a condition without which any deacidification would offer no interest.

The process is divided into three stages. The first one is the drying of papers by a passage through two successive drying cupboards in order to bring moisture rate to 0%. The second step is the main treatment: the neutralizing agent is introduced under pressure into a cell where books have been put. After about 30 minutes of contact, the liquid is retrieved by creating a vacuum recovered into a distillation station in order to be able to reuse part of non-consumed products after they have been treated again. During a period of tests, it has been decided to carry out three treatments a day, five days a week, that is



to say – according to the number of pages of the volumes – from about 600 to 900 volumes a day, roughly 4,000 a week. These figures are probably well within foreseeable reality. But the period of adjustment has not been finished yet and we show advisable reserve. Our aim is to treat the greatest possible number of volumes, so changes will certainly be effected during the next few years in order to increase the capacity of the plant.

This, in its general outline, is the present French way for neutralizing acidified papers. It is in fact only a first step, the necessary way. Not only will improvements have to be found but also other techniques which will implement faster physico-chemical treatments. The ideal technique will be the one able to reinforce paper as well as neutralize it in the same operation.

But a mass treatment of collections could not be bound by the simple technical solution of a problem through a process which, if it holds certain importance, is nevertheless only one aspect of the conservation of collections. And it would be a strategic mistake to believe deacidification is the ultimate remedy: how many years will be necessary to treat the problem, as it is increasing from day to day? How much time will there remain to treat collections preventively? The problem by its nature and its capacity goes beyond only the good will of librarians.

In the "Plan de sauvegarde" of the Bibliothèque Nationale, deacidification has been conceived as both an aim and a means. As early as 1860, France has used wood pulp in great quantities for book printing. Consequently the number of XIXth century documents in poor condition is considerable. Neutralization is therefore imperative to keep the integrity of volumes but also, more simply, to keep their contents. For some of these books, repairing is no longer possible: after microfilming, they are deacidified and put away into envelopes of permanent paper. For others, i.e. those which can still be saved, repair is attempted. After sample surveys and locating on the shelves and at the moment when they are communicated to readers, they are declared "incommunicables" and sent directly to Sablé to be deacidified and reinforced. Since 1980, this process has been systematic and each volume, after photographing, is treated in an aqueous solution, which implies numerous hands – it is not always the case – and considerable time for disassembling, drying, then reinforcing and assembling again. Old bindings (from the beginnings of the XXth century for most of them) are not kept but only if they offer particular characteristics. Indeed it is more interesting to find again the original state of the book – usually its stitching – rather than repairing a bad binding. Work has started with series of popular novels and children's literature of the XIXth century. As to preventive action, it was carried out on French and foreign official publications, as well as on documents recently entered. Consequently, the organisation of the treat-

ment takes place on three different levels. The starting of mechanized deacidification will imply the extending of preventive treatment since it would be ridiculous to wait until documents had reached the first degree of their degradation to treat them. That is why new acquisitions will be deacidified before going through binding with the hope of avoiding the mechanical weakening we fear so much. We do not know if we must go on speaking of binding in the original sense of the word, or better of protecting, which would be more in keeping with reality and to what book-keeping aims at.

Indeed, traditional binding is no longer sufficient guarantee against handling. In spite of a great effort in the choice and quality of materials, the weakening of paper is puzzling as to the use of common sewing techniques. More precisely, XIXth and XXth century books which have been treated should not be backed any more. This habit, so-called "well-finished binding" which was invented by the XIXth century, does not correspond to the elementary criteria of conservation. Backing which aims at strengthening the backs of books after pasting and rounding them with the pane of a hammer, evilly results in crushing the paper and making it even more brittle. Therefore, the books are now only sewn on tape and pasted in order to provide good cohesion of the back without prejudicing the strength of the paper nor the possibility to consult them. It is worth remembering that thanks to this mediaeval technique, a good many manuscripts and printed books have been transmitted to us in a correct state.

Mass deacidification of the collections of a library cannot therefore be dissociated from a group of measures aimed at preserving documents whatever their age may be. It cannot either be dissociated from certain aspects of the making of books and their privileged base, paper.

To any judicious mind, who would like to go on as *Candide* or *le Neveu de Rameau*, the logic adopted by our contemporaries in the field of conservation will seem paradoxical. That the necessity of great efforts should be devoted to the treatment of XIXth century books, nobody will deny. Nobody knew, at that time, the consequences of an amazing discovery: the possibility of making paper with something other than rag. But for almost half a century, everybody has been fully aware, or nearly, of the courses of degradation of papers. At the beginning of this century, a general administrator of the Bibliothèque Nationale, Léopold Delisle, noted in one of his yearly reports, that papers of previous decades, books and newspapers did not keep very well and that remedies had to be found rapidly; Léopold Delisle then advocated a policy of binding extended to all documents. Today, we know which remedies are to be applied. The *Neveu de Rameau* would have perfectly agreed with contemporary librarians but he would not have failed to mock them and be puzzled at seeing them doing

Mass Deacidification in France

their utmost to try and preserve newly printed books, books which suffer from the same diseases as those of the XIXth century. In spite of our present science and technique, we persevere in printing on bad paper as if nothing had been done for half a century, as if two distinct universes with the same purpose ignored each other.

Candide would have then explained to the Neveu de Rameau how, in our kingdom, some people endlessly rebuild what others destroy with the most perfect unconsciouness, and thus all is well in the best of the worlds. And the story went on for a long time, a very long time, such a long time that one day it was concluded that paper, being a very bad base, had to be suppressed and so poor librarians would be restored to serenity.

But there may be another development to this story. There may be another way to conclude this syllogism whose terms are apparently absurd thanks to simple measures: using non-acid paper in book-printing, indicating the pH on reams or rolls of paper; pointing out on each edition the quality of the paper used, deacidifying the paper on its coming out of presses, which would not interfere with the making itself and would leave librarians the only task (but how heavy it is already) to treat old papers.

There may be still other solutions which have not been explored yet.

These few measures stated are not spectacular innovations, but simple means whose logic would have made it up between Candide and our contemporaries. Unfortunately, that time has not come yet, and for a long time to come we will still have to reckon with the inconsequence of our times. Because other evils have not yet finished marking down the paper and crushing it a little more, and one of the latest is certainly not the least, namely the degrading of the quality of wood itself which undergoes, in its lifetime, the attacks of air pollution. If acid rains do not reach all the forests in the world and if they have not yet revealed all the evil consequences they carry as to the survival of trees, it is certain they won't improve the quality of our papers to come if each country, as well as the international community of paper users who are still numerous, do not rapidly awake to the consciousness of these phenomena.

SUMMARIES

Mass Deacidification in France

Based on general ideas on paper decay as a result of changed production technologies, a report is given on the efforts to overcome this problem, as far as the Bibliothèque Nationale in Paris is concerned, by a Plan of Rescue. Its central idea is to establish a center for different treatments in Sablé, mainly for deacidification with carbonate of methylmagnesium.

Désacidification de masse en France

A partir des idées générales sur le déclin du papier perçu comme résultat d'un changement des technologies de production, un rapport est proposé efforts entrepris pour surmonter ce problème quant à la participation de la Bibliothèque Nationale de Paris à un plan de sauvetage. L'idée centrale du rapport est d'établir à Sablé un centre pour différents traitements, principalement la désacidification avec du carbonate de méthylmagnésium.

Massenneutralisierung in Frankreich

Nach allgemeinen Überlegungen über Papierzerfall als Folge geänderter Produktionsmethoden wird über die Bemühungen berichtet, die in Frankreich unternommen wurden, um dieses Problem zu überwinden, soweit die Bibliothèque Nationale in Paris davon betroffen ist. Die zentrale Idee ist die Einrichtung eines Zentrums für verschiedene Behandlungen in Sablé, dessen wichtigste Einheit eine Anlage zur Massenneutralisierung mit Methylmagnesium Karbonat ist.

Jean-Marie Arnoult

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Château de Sablé sur Sarthe
France

Mass Deacidification at the Library of Congress

by PETER G. SPARKS

PETER G. SPARKS

It is a pleasure for me to be here today to talk with you about how the Library of Congress is making a concerted effort to focus the technology of mass deacidification on solving the preservation challenge in its collections. It is our hope that by converting acid paper to alkaline paper that we will prevent a major brittle paper disaster from occurring in our collections within the next 20 years. The application of deacidification technology on a very large scale over this period will preserve millions of volumes for hundreds of years in their original format, keeping the paper in these books from becoming brittle and requiring costly and time-consuming microfilming.

My presentation will start with some historical background, go into basic chemistry of paper degradation, review single-page and mass treatment and discuss our mass deacidification activities at the Library of Congress.

The principles of papermaking have not changed since its invention in China nearly 2000 years ago. The basic ingredient of paper is cellulose fiber, which for centuries was obtained from old rags of linen, cotton clothing, and other plant sources. Cellulosic fibers can be separated and processed in water, and dried, to form a tightly woven paper mesh. In the middle of the 19th century the demand for paper had surpassed the supply of rags, and hence the gradual conversion to wood pulp papers began. The crushing of the fibers with the mortar and pestle to make pulp became highly automated with the advent of continuous paper-making equipment and, in the case of better grade book papers, it became a chemical process. The great speed at which modern paper can be made was achieved at the expense of paper permanence. It is the modern chemistry of pulp and paper production that has introduced the acids that cause paper deterioration. Acid-producing materials enter the paper in chlorine bleaching and, more seriously, with the introduction of sizing, essential to modern printing papers. Earlier paper was sized by dipping in gelatin or natural glue-like mixtures. Modern papers use rosin that is precipitated with a chemical known as alum, and which is the principal cause of acidic paper.

The brittle paper challenge can be summarized as follows: causes are shown on the one hand and known solutions on the other. The causes are well understood, with the primary culprit identified as alum-rosin sizing. The solutions yield papers whose lifetimes can be measured in centuries rather than decades. Environmental controls are important because the two solutions depend on good conditions for maximum lifetime benefit.

Now, let's discuss some simple chemistry about why paper becomes brittle from acid attack and how the deacidification agent stops this process.

The embrittlement process can be best understood by looking at paper and its chemical characteristics at the molecular level. If we start with a sheet of paper and look at the fibers at higher and higher magnifications, and continue this process into the world of molecular dimensions, we would get to a point where we could see the cellulose chains that are made up of connected rings having specific chemical groups attached to them. This chain structure can be idealized to a ball stick model so the cellulose can be viewed as a collection of beads, held together by links in a long chain. It is this long chain characteristic of cellulose that contributes directly to the paper fibers' strength. With this in mind, let us leave our mental image of the cellulose molecule and talk about alum-rosin sizing.

Alum is a common name for a compound used in the paper industry known as aluminum sulfate, or sometimes referred to as potassium aluminum sulfate. Under the influence of high humidity and warm temperatures, alum breaks up into different products by a reaction called hydrolysis. The acid generated from the hydrolysis of alum attacks the cellulose molecule which leads to the breaking of the chain structure. This chain-cutting process yields a paper that is weak and embrittled.

The application of a deacidification agent to the paper inhibits this chain-breaking process. These agents are usually chemical compounds called bicarbonates, carbonates or oxides, which can react directly with the free acid in the paper. Thus, a simple chemical reaction between the deacidification agent and the free acid in the paper prevents the acid from attacking and breaking the cellulose chain.

Now, I would like to discuss some general ideas about deacidification, deal briefly with single-page treatment and then move on to mass treatment. All successful deacidification processes, whether they are single-sheet or mass techniques, have fundamental similarities. In all processes the agent is first brought into intimate contact with the paper material.

Secondly, the deacidification agent chemically neutralizes all the existing free acid in the paper.

Thirdly, an alkaline reserve is left in the paper, and, finally, all liquids or reaction by-products are removed from the paper before it is returned to circulation.

There are a number of deacidification processes that have been used and experimented with in the last 20 years.

Single-page deacidification is usually applied to rare and important items and is done by, or under the guidance of, a trained conservator. The technique cannot be applied efficiently to thousands of items at once, although with similar materials one can develop limited production techniques.

The attempt to find an approach for treating great numbers of items at the same time has led to considerable research and development during the last ten years. The objective of this research has been to develop a chemically sound process that is cost-effective and which can treat hundreds of thousands of items in a given year.

The Library of Congress, in an exhaustive research program spanning a five year period, has chosen a gas phase process using a material called diethyl zinc, or "DEZ" for short. This process has been demonstrated at the lab bench and pilot plant scale.

We have been working with NASA's Goddard Space Flight Center for the past four years to buy the engineering required to scale up, using a chamber that will hold 5000 books, and to demonstrate the process at this level. The first 5000-book-test was accomplished on October 15, 1982. Additional trials and experimentation have been done on a smaller scale to reach an optimum treatment process design, and engineering tests continue to define optimum plant design. Because of the reactive properties of DEZ, it cannot be exposed directly to excess water or oxygen. Thus, the treatment must be carried out in a closed chamber so that the books and the DEZ gas can be brought together in an environment free of excess water and oxygen. Diethyl zinc as a material possesses properties that set its deacidification mechanism apart from others.

First, gaseous DEZ moves easily between the pages of the book, diffusing into the paper fibers and coming into intimate molecular contact with the cellulose chains to react with and neutralize all weak and strong acids.

Secondly, and at the same time, it reacts with water in the fibers to form the alkaline reserve compound zinc oxide. This molecular reaction of the DEZ with water forms a uniform distribution of small particles of the alkaline reserve compound throughout all the paper fibers, and yields completely reproducible lifetime enhancement for every book treated.

Thirdly, the zinc oxide reserve imparts fungistatic activity to the paper, preventing future biological growth.

The diethyl zinc process is carried out in three simple steps: *First*, the residual water in the book is carefully lowered so that the correct amount of water is present to react with the DEZ to form the alkaline reserve. This is completed in about 18 hours. *Second*, DEZ is introduced into the chamber as a gas at low pressure and left to permeate the paper, react with the water and neutralize excess acid for a period of about 12 hours. In the *third* and last step a significant amount of water is re-absorbed into the paper and the ZnO reserve can be modified by reaction with CO₂. The books sit in a rehumidification room for about 1-2 days to regain more water before returning to the Library.

The Library of Congress has developed plans for implementing the diethyl

zinc process on a large scale. Our best case plan at its present level of development is an operational treatment plant in 1988. That will deacidify 500,000 to 1,000,000 books per year. (A model and sketches of the facility were shown on slides.)

Engineering activities currently center around construction and operation of a small-scale test facility which allows scaled-up testing and design of the large chemical delivery system for the main facility. This operation has taken place at NASA's Goddard Space Flight Center for the last year. (This facility was shown on a following slide.) The initial design of the chemical system test in this facility had numerous design problems and a portion of this facility was damaged and out of operation. This information is being fed back into a redesign effort of the DEZ delivery system, and testing of this design is projected for 1987.

The Library has done considerable work and continues to work on the logistics of moving books out of the collections and taking them to and from the deacidification facility. An estimate of our production figures at start-up are shown (on the next slide), and as you can see, in a few years time we hope to be up to treating a million volumes a year.

Needless to say, the logistics of moving this many books out of the Library to the facility and bringing them back to the Library and putting them on the shelves is a major undertaking.

How books in our retrospective collection and new books will be chosen for the deacidification process is currently going on at the Library, and we have developed some rationale for making decisions for which books would be sent first, etc. Not all decisions have been made as yet, but several issues are clear at the present time. First, we will be deacidifying all new books prior to putting them into the collections, because this is where the greatest benefit of deacidification is possible. Selection from the retrospective collections is more complicated, and we have developed an approach that selects large blocks of materials to facilitate the logistics handling but also takes into account the importance of these collections to the Library's overall mission. We are currently trying to integrate those ideas with the DEZ benefit information, so that we can optimize saving those books that are most important to the Library's collection, but also at the same time get the most benefit from the treatment.

In summary, let me leave you with some encouraging words about deacidification as a promising approach to keeping the "book" available in libraries and preventing costly microfilming of brittle materials. The brittle paper challenge in front of us has been clearly defined. We know why paper becomes brittle and have identified several solutions to prevent this from happening. Manufacture of alkaline paper and the mass deacidification of library materials

Mass Deacidification at the Library of Congress

to make them alkaline appear to be the promising solutions to extend the permanence of stronger papers.

This combination of technologies can provide the team work to solve this important worldwide challenge by the end of this century.

SUMMARIES

Mass Deacidification at the Library of Congress

A review of the decay of cellulose and its chemical causes is presented. The outlook for the chemical process (DEZ) that the Library of Congress has selected to fight this decay is given. The engineering problems that have delayed installation of the Library's facility (planned to deacidify one million books per year) are noted.

Désacidification de masse à la bibliothèque du Congrès

Une étude est disponible sur le déclin de la cellulose et ses raisons chimiques ainsi qu'un point de vue sur le procédé (DEZ) choisi par la bibliothèque du Congrès pour lutter contre ce déclin. Ce procédé implique de nombreux problèmes quant à la conception de l'ingénierie, lesquels sont la cause d'un retard dans les prévisions d'équipement destiné à traiter un million de livres par an d'ici 1988.

Massenneutralisierung an der Library of Congress

Es wird ein Überblick über den Abbau von Cellulose und seine chemischen Ursachen gegeben sowie ein Ausblick auf den Prozeß, den die Library of Congress als Mittel im Kampf gegen seine Folgen ausgewählt hat, nämlich DEZ. Der Prozeß birgt zahlreiche technische Probleme, die dazu geführt haben, daß die Anlage, die für die Behandlung von einer Million Bücher pro Jahr geplant ist, nunmehr auf das Jahr 1988 aufgeschoben wurde.

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Paper Strengthening

Mass Conservation of Unbound and Bound Newspapers

by OTTO WÄCHTER

Today, with all the talk of rapid deterioration of book, magazine and newspaper materials in library holdings from the present and previous century, a horrified librarian may perhaps question if the damages are really so serious or if one isn't perhaps dealing with a case of "preservation policy." And one may ask if there doesn't seem to be a bit of exaggeration in the announcement by the Committee on Preservation and Access in July 1985 in Washington that in many American Libraries already every fourth book is threatened by mechanical and chemical destruction. Because one's first impression on walking through the stacks is that the books and periodicals are largely intact, and, in fact, the bulk of damaged books that are brought in on a daily basis to our conservation shops and offices are chiefly Xerox-corpses – those volumes which have suffered spine breakage from being pressed on the copying surface during copying, especially copying by the reader.

NEWSPRINT

It is merely the durability of old newspapers which seems questionable even to the most optimistic librarian. Especially the condition of those newspapers which are not bound but simply bundled together is sometime lamentable. When such packets of newspapers are opened, the leaves often break apart at the folds, even when these newspapers only date back to the year 1900 or 1920. The browned breakage points also make it clear to the eye that the paper fibers in these areas have already completely disintegrated. But the doubter continues to be disturbed by the notion that book collections can already be endangered to the same extent. He remembers, for example, that the much used reference works *Keyser* and *Deutsches Bucherverzeichnis* from the beginning of this century are still in usable condition in our libraries, whereas the same volumes in the New York Public Library are said to be completely ruined. Does this mean that location in an industrial or population center may account for the difference? Or must the paper quality of books be impaired simply because the pH value lies under 7? Three- or five-hundred year old papers are today often still in top condition, even when their pH values are only 5 or less. Is it possible that there is such a basic difference between hand and machine made paper?

AN OLD STORY

One also remembers, however, those analytical tests of newspaper volumes which were carried out in England and also that legendary 1900 volume of the *Daily Express*. The browned and brittle borders of its bound newsprint register a sulfuric acid content of 1.2%, but the acid content of the protected central portion of the text block is only 0.14%¹. Here the paper is not browned and is still elastic. This is evidence of how air pollutants work their way concentrically from the outside to the inside of a text block. It is of further interest that this volume stood for twenty years in reading rooms both heated and lighted by gas. Many library holdings, particularly in the last century, were subjected to similar concentrations of SO₂ in the air, a higher concentration perhaps than that prevalent in contemporary industrial centers.

The adverse effects of pollutants on library materials have been confirmed. As early as the middle of the last century, Farrady was able to define the "red rot" of leather bindings as environmentally caused acid damage – this trained bookbinder and chemist had an eye for ruined materials. In the case of paper there is the additional problem of internal acid damage from alum sizing and from the lignin in wood pulp additives. The attacks proceed simultaneously from within and without, and if we don't want to acknowledge the damage because we haven't yet seen it, we still have to accept it as certain. The comparison with the present state of European forests thrusts itself upon us. Even though a large part of the forests still appear to be green, infra-red aerial photography reveals that the greater part of our forest stock is already sick.

The newspaper holdings of libraries are in particularly acute condition. In the case of newsprint, however, we must acknowledge that by its very nature it never pretended to be anything more than ephemeral. Newsprint, that flower-of-an-hour among the many other more durable types of paper, was always a throw-away product, long before the advent of the throw-away society. In the research library, however, essentially short-lived newspapers must be preserved as records of their time, always and, if possible, eternally. The technical problem of preservation therefore arises on its own.

Wood pulp papers with high wood content, even under the best environmental conditions with very limited use and in an unfolded condition, seem to have a "life expectation" of no more than about 200 years. Therefore, the half-life stage for many wood pulp papers from the early production period has now been reached. They should soon undergo preservation treatment; when they reach the stage at which they are falling apart, preservation measures will be both troublesome and expensive.

WOOD PULP CHEMISTRY

That in dealing with pulped wood one is grasping a hot iron was also clear in the paper delivered by Jan Lyall during the ILC Congress in Washington in 1982. "The preservation of wood pulp paper is one of the most difficult concerns. Before the mechanism of the decomposition process is explained it will be difficult to treat valuable objects with good conscience," he states in his "Conclusions."² One of the chief obstacles in the investigation of obviously damaging lignin is that careful isolation – that is, separation from the wood structure without chemical or mechanical effects – is not yet possible. "Delignification," the reduction for conservation purposes of wood pulp from papers containing wood presents a fascinating challenge. Perhaps one should first look to the processes involved in the production of wood pulp paper for clues in developing a treatment. The wood pulp in paper forms both fibers and filler (fiber portion and filler portion). The fiber portion contains long fibers, short fibers and longer fragments of cell walls. They constitute the fiber network of the paper in which the fine particles (filler) are embedded. The strength of the paper is a function of the fiber portion. The number of fibers in the sheet of paper determines resistance to tearing, elasticity, energy absorption, and opacity. The high light diffusion coefficient of wood pulp (600–700) makes for high opacity (transparency) and thus permits the production of thinner papers. Among the composite materials of wood are cellulose, hemicellulose and lignin, in large quantities and, in smaller quantities, resins, volatile oils, tannins, natural dyes, hydrocarbons, pectins, mucilages, gums, starches, protein and organic acids. The undesirable characteristics are probably traceable to lignin or certain portions of the lignin. Industry tries to break down the lignin during paper production. Lignin content amounts to 25–30% for coniferous trees and a lesser 15–17% for deciduous trees. The paper industry is able to break down these great quantities of lignin through the use of spherical boilers, concentrated bases and boiling procedures under several atmospheres of pressure. This process is suitable for the production of industrial paper pulp, but if it were applied to printed materials, the printing ink would be lost. That is why such forced cures can not be employed in conservation.

Independently of this, however, the Conservation Laboratory of the Austrian National Library has developed a process by which individual examples of art on paper can be subjected to wood removal, delignification, deacidification, and buffering. The process is expensive and is suitable above all for art on paper. During this conference you were able to see the equipment. If one considers that works by artists of the Vienna art nouveau school already fetch prices of from 200,000 to 3,000,000 Austrian Schillings and that many of them

are executed on wrapping paper of very high wood pulp content and are therefore short-lived, then an expensive method seems justifiable. A "life expectancy" of about 200 years can thereby be at least doubled. For a large scale procedure such as is necessary for newsprint preservation, however, this method would be too cumbersome. Thus for newspaper conservation other considerations were brought to bear.

THE PROCESS

We should now turn to a description of the actual impregnation process. The block or bundle of newspaper leaves 3–4 cm high is put into a metal tub that is perforated on the lower edge (to allow the excess solution to run off after impregnation) and has two handles. The height of the tub is 6.5 cm – the drawers in the freeze dryer have a clearance of 7 cm. The metal tub is placed in a plastic tub which is slightly larger and 10 cm high. The newspaper block with the tubs are put into the vacuum machine (Fig. 1). As complete a vacuum as possible is created so that the air is substantially withdrawn from the fiber interstices. With the use of exterior controls, the text block is then flooded with the



Fig. 1. The vacuum chamber open before putting in the books.

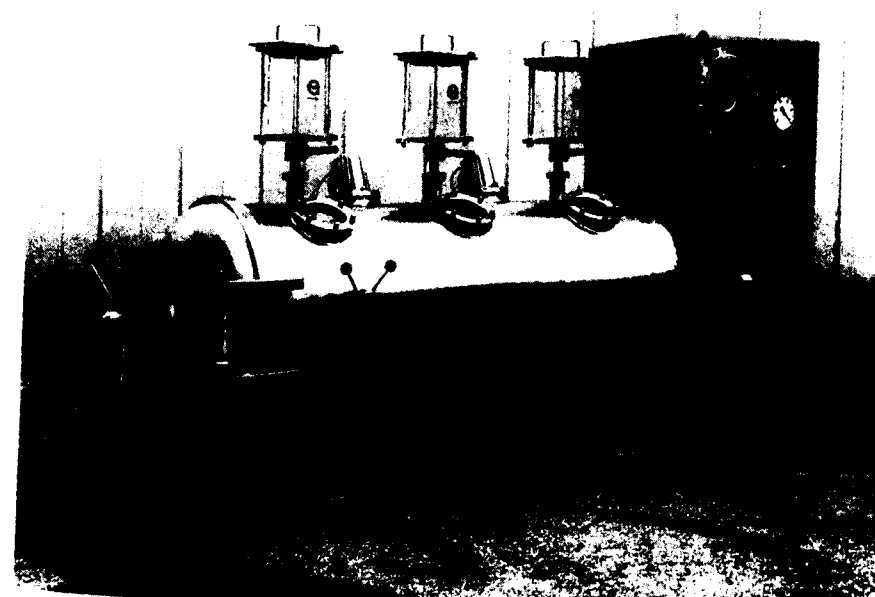


Fig. 2. The vacuum chamber during operation.

strengthening solution (Fig. 2). After about two hours the text block is completely saturated and air is once more let in, simultaneously forcing the solution deep into the fiber interstices. (If it occurs that the impregnation process actually allows for a more thorough saturation of the border areas than of the central portion, that is not disadvantageous, since the outer portion of the text blocks have been subjected to more environmental damage and require more intensive restoration.)

The following should also be taken into consideration during the impregnation process. To impregnate a text block 3–4 cm high, one requires about 18 liters of liquid for a mid-size format newspaper; 2–3 liters are pressed out by hand after the impregnation; this is the solution which can no longer be absorbed by the leaves. During impregnation, the text block swells to about twice its height. After the manual liquid removal, it drops back about a quarter (4 cm to 8 cm to 6 cm). One aid in the impregnation process must still be mentioned. When the regenerating solution is poured into the tub, the text block always floats to the top. During this phase it must be kept down by the use of clamps, which for their part must be sufficiently flexible not to inhibit the swelling of the text block. For this purpose we use 3 cm-wide strips of sheet aluminum. They

are soft and can easily be bent around the text block and the tub. When the text block swells, they yield but still hold it down in the tub. After impregnation and the subsequent pressing out of the solution, the inner tub is placed over a sink to drain.

During subsequent steps the text block remains in the metal tub. It next comes into the quick freeze chamber, where it is to be turned into an ice block as quickly as possible. At first temperatures of from -30° to -40°C are necessary in order to avoid the formation of large ice crystals. Five hours are required to deep freeze the text block. After they are frozen through, the ice blocks go into the freeze dry chamber. Here, too, the work is carried out in a vacuum. Through a prescribed sequence of freezing and heating, the "frozen product" is now treated in such a way that it is held just under the freezing point (it cannot be allowed to thaw) but that the water evaporates so that drying can proceed. (The pressure is regulated to correspond to half the pressure of the water vapor at the sublimation temperature. In this case, since water is the chief component of the solution, a value between 1 and 4 mb was called for. It is advisable to arrive at the final temperature of the shelves in stages. At the beginning $+35^{\circ}\text{C}$ is sufficient; this is finally raised to $+70^{\circ}\text{C}$. It is necessary to find the heat of sublimation which effects rapid drying without allowing the frozen product to thaw out.) At the beginning of our experimental work we had at our disposal apparatus which could be regulated only slightly; the frozen product remained for the longest period at -30°C and freeze drying therefore took about one month. With the freeze drying equipment which you have seen we can dry out the ice block in about two days. It was this reduction of the drying period which made this procedure possible and economical.

Upon completion of impregnation and drying, decisions must be made on the future binding of the newspapers.

1) In the best case, where the block is only 3 cm (or even 4 cm) thick and the binding has not fallen apart, it is often sufficient to put the text block back into its old boards after it has been compressed.

2) If the volume had to be split and this did not cause the binding to fall apart, it is possible, as with adhesive bindings, to put the sections back together and to hang them in the old boards.

3) If the old binding has loosened or fallen apart during impregnation and freezing, the volume must be cut afresh at the spine and then supplied with an adhesive binding.

4) Unbound bundles of newspapers or wire-stitched volumes cut at the spine before impregnation must be adhesive-bound. A new set of boards must be made.

The impregnation procedure described above was developed primarily for

newspapers and newspaper volumes. Certainly it will some day be possible to apply this method to books and periodical volumes, but the conditions must be somewhat modified. Newsprint, because of its naturally relatively high absorptive capacity can be best treated using this system.

A NEW PRESERVATION PROCESS

A new system was found with the assistance of two physical processes: impregnation of the text block in a vacuum (each sheet is penetrated by a strengthening, neutralizing and buffering solution) and subsequent freeze drying (in order to prevent the sheets from sticking together during the drying process). The chemical considerations were that the introduced strengthening agent should simultaneously effect an impregnation of the fiber composition from within and provide a surface protection from without. The simultaneously introduced neutralization agent buffers the acids arising from within the sheet on the one hand and, on the other hand, retards the effects of harmful gases from the atmosphere – each time a double effect. It has been demonstrated that the introduction of vegetable and even heavily diluted animal sizes has retarded yellowing of newsprint for a matter of decades. Yellowing is obviously triggered by the oxidation of lignin in wood pulp (particularly its phenolic groups). Sizing of newsprint produces a surface film that obviously delays oxidation. As a strengthening agent we finally chose a combination of celluloses and polyvinylacetates, and, as a neutralizing agent, calcium salts. The fact that newsprint initially yellows during buffering with magnesium and calcium salts should not be a cause for alarm; the unbuffered leaves would yellow and brown to a much greater extent over the course of time.

In the Conservation Laboratory of the Austrian National Library the leaves of an entire year's run of a newspaper were first, on a trial basis, manually coated with a mixture of MC (methyl cellulose), Planatol and magnesium carbonate. Five grams of magnesium carbonate are dissolved in one liter of distilled water in a soda water bottle, and then 20 g of methyl cellulose are dissolved in it. Five parts of this solution are mixed with one part of a type of Planatol that contains no softeners (Wood Size PV/H9). This is applied quickly and evenly to the individual newspaper leaves using a flat brush roughly 15 centimeters wide. If Planatol BB is used instead of the type mentioned above, a certain amount of surface sticking of the leaves may occur during compression of the text block. On the other hand, one can readily do without the softener, because in the long run it is the uncertainty factor in this adhesive (if Planatol BB is used as an adhesive, the softener is probably needed for reasons of elasticity). This process is very economical but is not up to dealing with the

some 7,000 newspaper leaves which arrive at the Austrian National Library every day. In accordance with considerations similar to those discussed above, the National Library in Belgrade coats newspaper leaves with a mixture of gelatin and calcium carbonate.

In order to streamline the impregnation procedure, the Conservation Laboratory had already in 1973 experimented with the impregnation not only of individual sheets but also of bound monthly newspaper volumes in a single immersion procedure, thus handling about 1,000 sheets at a time. The impregnation agent used at that time was alcohol soluble polyvinylacetate (Regnal 7). The impregnation and drying functioned well, but there were a large number of drawbacks and failures. For the ongoing restoration of our entire newspaper holdings Regnal would be too expensive for the impregnation process; moreover, it is very difficult to obtain in Western Europe (it is produced in Eastern Europe and the U.S.A.). Large quantities of the volatile solvent isopropanol (or carbon tetrachloride) are harmful to health; work in appropriately protected installations makes handling more difficult. The drying period for a volume ran about three weeks and involved a lot of odor; a drying room was required. Some inks from more recent newspapers tended to run.

IMPREGNATION

Because of the above-mentioned problems and disadvantages associated with Regnal, we then experimented with using the familiar methyl cellulose in the impregnation process. At first there were new difficulties. Viscous cellulose solutions do not penetrate the newspaper block well. Newsprint acts like a filter paper, that is, it lets the water through and holds back the cellulose. The impregnation process was improved by several means.

The first was the use of the low viscosity (more easily penetrating) cellulose types MC 14 or MC 40; they are scarcely weaker in their strengthening effects for wood pulp printing paper than the high viscosity MC 400. The Division for Pulp and Paper of the Austrian Wood Research Institute was able to demonstrate this effect. In the opinion of paper chemists this can be explained by the fact that these celluloses, which are weaker in their binding power but more flexible, can better penetrate the paper structure and better envelop the fibers. Therefore, after the brittle paper is dried out, they can provide almost as good a support as can the high viscosity celluloses with more binding but less penetrating power. In the case of newsprint, low viscosity celluloses are weaker in their sizing effects, but they nevertheless cause about a 150% increase in the strength of the fiber structure both in height and width.

For "normal brittle" newsprint (the ones which at the "Deacidification Talks" of the Library of Congress in June 1985 were assigned the fold endurance count 1-50 and categorized as weak to moderate), celluloses of various viscosity are sufficient. For the category "brittle," with the fold endurance count of 1, they are too weak. In this case softener-free polyvinylacetate was tested to supplement the cellulose (Planatol PV/H9, Walpol SA 500 and Walpol VA 413); these watery artificial resin dispersions combine optimally with the celluloses. Even the supplemental magnesium and calcium buffers create no difficulties with regard to penetration or the subsequent freeze drying.

Further experiments were conducted to improve the penetrating powers of these solutions. We attempted to make the text blocks more receptive through the insertion of wire bands after each section and by spreading open the text block with the help of perforated aluminum sheets. This was successful with small format text blocks (up to the size of a telephone book) but beyond that there were problems. It turned out, however, that it was not necessary to spread open the text blocks if the newspaper volume was not thicker than 4 cm. Up to this size the strengthening solution can penetrate any format in a vacuum. Loose newspaper leaves are now treated in 4 cm thick bundles. Thicker newspaper volumes are broken into 3-4 cm thick blocks after the old boards have been removed (normal volumes are therefore usually divided in half) in such a way that the remainder of the old binding (only wire stitching should be cut away by machine) stays on the text block for the rest of the process. It provided support and prevents movement of the sheets in the text block.

FREEZE DRYING

Dehydration. The separation of a substance that is to be dried from its water content already begins while ice is forming during the freezing process. During the drying process, however, a greater number of water molecules leave the dried substance.

During the freezing process, low temperatures should be attained as quickly as possible, thereby reducing the tendency toward crystal formation. When a liquid hardens into a solid body, crystallization can occur, i.e. the molecules are incorporated into a crystal lattice thus bringing order to their previously amorphous state. If the temperature, however, is very low, the kinetic energy available during hardening is insufficient to bring them to their places in the crystal lattice. The molecule structure hardens in its amorphous state and maintains this after drying, exactly retaining its original characteristics. This is true especially for biological solutions.

The formation of small crystals can, however, hardly be avoided. Luyet and

Gehnio have demonstrated that the temperature drop must come to at least some 100°C per second in order to assure that freezing takes place in an exclusively amorphous state. But small crystals do no great damage. At slower freezing rates, on the other hand, larger crystals form, since the size of the crystals is inversely proportional to the denseness of the crystal population and the speed of freezing. The creation of small crystals produces some benefits; on drying they leave behind so-called vacuoles, small hollow spaces through which the remaining water molecules can somewhat more readily pass to the surface of the item being frozen. For rapid deep freezing, the freezing temperature should come to -40°C in order to guarantee that the text block freezes through. Depending on the eutectic point of the solution being used, the temperature can then be raised up to just under the freezing point, where the vapor pressure of ice is at its highest and therefore the drying rate is fastest. The eutectic point during freezing is -30°C for water soluble MC; with a polyvinylacetate additive it is -24°C.

The layer thickness of the text blocks creates a problem, especially because of the insulating effect of the paper. The large water content also plays a role. During impregnation the weight is multiplied. The condensor and pumps used in the equipment must be very powerful. As the vapor pressure drops, the drying process is retarded. Above all, in the final stage of drying a particular problem arises since increased heat of sublimation must be supplied to already dried insulating layers of paper. For especially extensive newspaper volumes, one could accelerate the procedure by using the laboratory technique of freezing with dry ice.

FINAL REMARKS

In all the years since 1973 during which we have grappled with the development of a system for the restoration of our old newspaper holdings, it has been clear to us that as a small nation we would never have available to us large-scale technologies such as the DEZ process and that we also would never have a conservation team of from 50 to 100 persons, as do other national libraries, for the restoration of our old newspaper holdings and of our 19th and 20th century book holdings (the hiring of a single additional conservator already creates problems for us). From the beginning we have searched for a system that is affordable and that can operate with very little manpower (one to two specialists). Certain operating costs must of course also be allowed for.

If with our "mass process" we are unable to treat such large numbers of books as, for example, the DEZ process, the Vienna process has the advantage

not only of neutralizing and buffering paper without the use of gases but also of simultaneously improving the consistency of brittle paper.

ACKNOWLEDGEMENTS

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SUMMARIES

Paper Strengthening: Mass Conservation of Unbound and Bound Newspapers

Introduced by a history of the efforts undertaken by libraries that are confronted with the poor durability of newsprint and by a survey on newsprint chemistry a new system for deacidifying and strengthening is described. The system is based on combined impregnating the volumes with an aqueous solution (or emulsion resp.) of methyl cellulose, a little bit of PVAC and magnesium carbonate in a vacuum chamber and freeze drying them. Most important for good success is choosing an apt type of MC and carrying out freeze drying in an apt manner.

Renforcement du papier: Conservation de masse de journaux reliés et non reliés

Un nouveau système de désacidification et de renforcement vient d'être décrit, avec en introduction une histoire des efforts entrepris par les bibliothèques, confrontées à la faible durée de vie du papier journal et à une étude sur la chimie de celui-ci. Le système est basé sur la combinaison d'une imprégnation des volumes par une solution aqueuse (ou émulsion) de méthylcellulose, un peu de PVAC et de carbonate de magnésium, ceci en chambre sous vide, et d'un séchage par congélation. Le plus important pour une bonne réussite est de choisir un type approprié de méthylcellulose et d'entreprendre le séchage par congélation de façon adéquate.

Papierverstärkung: Massenkonservierung von ungebundenen und gebundenen Zeitungspapieren

Nach einem Überblick über die Geschichte des Problems der mangelhaften Dauerhaftigkeit des Zeitungspapiers in den Bibliotheken und über die Chemie von Holzschliffpapier wird ein neues Sy-

Paper Strengthening

tem zur Neutralisierung und Festigung dieses Materials beschrieben. Es basiert auf der Imprägnierung mit einer wäßrigen Lösung von Methylcellulose mit einem Zusatz von PVAC und Magnesiumcarbonat in einer Vakuumkammer und auf anschließendem Gefriertrocknen. Der Erfolg hängt maßgeblich von der Wahl des richtigen MC-Typs und von der Durchführung des Gefriertrocknens ab.

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Emerging Technologies – Paper Strengthening

by D. W. G. CLEMENTS

D. W. G. CLEMENTS

INTRODUCTION

The difficulties faced by libraries in trying to cope with the huge quantities of documents in need of preservation are all too familiar. To cope with this preservation crisis a number of options exist but hand based conservation, while of the greatest importance for the preservation of our heritage, can only be applied to the minority of those items in our collections that are in need of treatment. This is why various technologies are being pursued to try to find an approach that will allow larger quantities to be preserved in any given period at as low a cost as possible.

The greatest underlying problem relates to paper containing ground wood but inevitably degradation occurs in all paper, especially that used in the production of books over the last one hundred years. The main cause of this deterioration is acid catalysed hydrolysis of cellulose, the principal causes being alum-rosin sizing, atmospheric pollution and degradation of lignin. The primary approach for the bulk treatment of the books themselves has been based on the use of deacidification together with the deposition of a residual buffer to provide protection against further acid attack and two main methods are currently in use, a liquid-phase method using magnesium methoxide in methanol and freon, and a vapour-phase method with diethyl zinc. Such methods undoubtedly work, allowing whole books to be treated and operate by slowing down the rate of deterioration so extending the life of the paper. They do not, however, alter significantly the mechanical properties of the papers treated and a bulk process that not only neutralises the acids present but also enhances the strength of the paper would greatly extend the life of the paper and help in coping with the preservation crisis.

PROCESS REQUIREMENTS

In looking for a satisfactory treatment process, it can be postulated that it should take account of the following features:

- (a) it should impart resistance to further deterioration
- (b) it should improve the mechanical properties of paper, particularly its fold endurance and tear resistance whilst retaining its flexibility so allowing papers to continue to be used

- (c) the process should produce negligible changes in sheet dimensions, especially thickness
- (d) the process should ideally be applicable to most if not all types of fibres and paper or at least result in minimal damage
- (e) no significant damage to the printing or binding should occur
- (f) the process should be suitable for routine application to large batches of books with the minimum of pre-treatment, e.g. no dis-binding
- (g) reagents should be able to be used safely in the process and present no hazards to subsequent users of treated materials
- (h) unit costs of the process must be reasonably low

RESEARCH FINDINGS

The British Library has commissioned research into an alternative approach to treating paper that retards degradation and restores some strength to the paper to enable continued handling in the future by the deposition of a polymer within the substrate so helping to strengthen and protect the individual fibres within the paper. The laboratory work carried out so far indicates that the process involves the following steps:

- (a) the books etc., to be treated have to be placed in a suitable container
- (b) the container is purged with nitrogen to remove air and free oxygen
- (c) a monomer mixture is introduced into the container, the quantities being based on the weight of the books therein
- (d) the system has to be left for several hours in order to allow the monomer mixture to diffuse and be uniformly distributed throughout the paper
- (e) the container and books are then exposed to a low intensity gamma-ray source until they receive the appropriate dosage of radiation. This results in monomers being converted to polymers and at the same time are chemically attached to the paper or substrate to form a paper-polymer mixture
- (f) any residual monomers must be removed safely from the container by purging with air to avoid any danger to the operators
- (g) the books would then be removed from the container and left in a well ventilated area for a few days to ensure any traces of monomers have gone before they are returned for sorting and re-shelving

Though such a treatment process is easy to describe it was difficult to develop and is currently in the process of moving from a pure laboratory project to testing out the system on several (5–10) books at a time in stainless steel jars and to the developments needed to convert to a practical production process.

Emerging Technologies – Paper Strengthening

Initially much of the work was involved in the choice of monomers as the resultant polymers need to be polar in nature and flexible at room temperature if they are to confer improvements in strength. The choice of monomers also had an important effect on the polymer yield and it was found not only that woody papers were more difficult to treat than pure cellulose but that aged papers of all types were more difficult to treat as well. The ease of reaction graduated from:

modern cotton > modern mechanical > aged cotton > aged mechanical

However, good results were obtained using a combination of acrylate and methacrylate esters without the need to add solvents to increase penetration. In particular ethyl acrylate and methyl methacrylate (volume ratio 5:1) were used with the impregnated paper being subjected to gamma radiation utilising low dose rates (about 0.3 m rad per hour) and total doses of less than 1 m rad at ambient temperature and normal atmospheric pressure levels. Substantially homogeneous deposition of the polymer seems to occur both within each single page and over entire books. Good results have been obtained with a mixture of papers both in terms of increased resistance to subsequent degradation and in particular by increased fold endurance with weight increases of about 15–20% in book papers to keep within normal shelving weight limits. The treated papers showed no significant changes in dimensions.

The polymers are to be found deposited throughout the core of the fibres as well as on and between the fibre surface but the voids in the fibre matrix of the paper are not completely filled. Interfibre bonding is increased through the presence of polymer filaments as is interfibre fibrillation. At the levels of polymer deposition being used blocking or sticking together of pages does not generally appear to be a problem. This was assessed by preliminary tests using temperatures of 20° and 85° C at a pressure of 180 g/cm² (exceeding the ASTM standard of 31 g/cm²).

Strength enhancement (assessed using standard procedures) has occurred with increases of about 5 to 10 times or more of the original fold endurance being obtained when about 15–20% by weight of polymer is incorporated though when the original fold endurance is low (10 or less) more variable results are to be found.

It has also been found possible to include a basic co-monomer (an amine substituted alkyl methacrylate such as dimethylaminoethyl methacrylate) to neutralise any acids in the paper and provide resistance against future acid attack thus making a one-step neutralisation/strengthening process. The basic co-monomer is readily polymerizable and only small amounts are required to

effect neutralisation. Samples treated with standard polymer mixture containing small amounts of polymerizable amine produced marked strength improvements and the paper remained neutral over a period of time. Recent work has found that the addition of multi-unsaturated co-monomers to the monomer mixture can lead to even greater improvements in fold endurance, from 3–5 times more than the standard polymer mixture, which results in improved life expectancy.

While further work is required on the effects of these treatments on the paper and bindings and subsequent conservation processes that might be applied, it would appear that the paper appearance is not altered, that bindings are not damaged, plastic covers can occasionally be softened but separating individual volumes with sheets of paper should overcome this problem, and while inks need to be further tested, preliminary results for inks used in the text look promising though problems still need to be resolved in regard to inks used in certain book covers. All these will of course require further verification.

THE NEXT STAGE

The next stage will be concerned with the technical confirmation or otherwise of the application of the graft co-polymerisation technique to the large scale treatment of books and will need to address a number of topics including the following:

- (a) selection of optimum monomer mixtures
- (b) means of monomer distribution into groups of books so as to ensure homogeneous distribution
- (c) design of a treatment container and testing of large and small batches of books
- (d) methods of packing books into a container
- (e) identification of process limitations
- (f) detection and removal of residual monomers from treated books
- (g) further tests on the effect of the process on books, paper and inks and subsequent conservation treatments that might be applied. Assessment of long term effects of polymerisation.

SUMMARIES

Emerging Technologies – Paper Strengthening

A report is given on a research project commissioned by the British Library to strengthen brittle paper without dis-binding the books. The method is to impregnate them with monomer acrylics and to radiate for polymerisation. By including an amine substituted alkyl methacrylate into the treatment a one-step deacidification-strengthening process can be achieved. The research project will go on checking the possibility of graft co-polymerisation.

Nouvelles technologies: le renforcement du papier

A signaler un rapport sur un projet de recherche commissionné par la Bibliothèque Britannique concernant le renforcement de papiers fragiles sans défaire les reliures des livres. La méthode consiste à les imprégner d'acryliques monomères et de les irradier en vue de polymérisation. En incluant au traitement un méthacrylate d'alcyle substitué d'amine, l'on peut obtenir en une opération un processus double de désacidification-renforcement. Le projet de recherche se poursuivra par une vérification des possibilités de greffe de copolymérisation.

Neue Technologien: Festigen von Papier

Es wird über ein Forschungsprojekt der British Library berichtet, das eine Methode zum Ziel hatte, nach der brüchiges Papier gefestigt werden kann, ohne daß die Bücher, in denen es sich befindet, zerlegt werden müssen. Die Bücher werden mit monomeren Acrylaten getränkt und zur Polymerisation bestrahlt. Durch Zugabe eines aminsubstituierten Alkylmethacryls kann in einem Arbeitsgang neutralisiert und gefestigt werden. Die weitere Forschung wird sich mit den Möglichkeiten der Pfropfpolymerisation befassen.

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Mechanizing Restoration Work

The Deutsche Bücherei in Leipzig and its Role as a Regional Center for IFLA

by WOLFGANG WÄCHTER

At the end of 1964 the first steps were taken to establish a restoration workshop at the Deutsche Bücherei (DB) in Leipzig. From modest beginnings this has grown over the last 20 years into an efficient facility covering 200 m² of floorspace and employing a staff of eight. The policy governing its development has always been to translate research findings into the practice of preservation and restoration and to improve the cost-benefit ratio for these operations. We have found in our own experience that this can be done only by dealing with the problem of large-scale restoration, and this inevitably involves the mechanization of restoration work.

For example, our workshop was made a consulting center for training restorers in the GDR in 1978, and the first mechanized equipment for the wet treatment of material started operating in 1979. The period from 1980 to 1984 saw the development of optimal restoration techniques for wood pulp-containing-paper. At the same time, a technical book treating the subject was published and well received by international experts as could be seen from the favorable reviews. In 1985 the Deutsche Bücherei assumed the function of a regional center for preservation on behalf of IFLA, a commitment which is an honor as well as a challenge to become even more efficient in the improvement of preservation and restoration techniques in future.

In the pursuit of our new function we set about providing the necessary facilities by completing the related planning and building work for a new restoration department in 1985. As a result, we now have excellent areas for individual and teamwork, meeting and common rooms, social facilities, a darkroom and photolab, a room for wood and metalworking, etc. In addition, most of the furniture and equipment has been replaced, creating an esthetic and functional environment and an extremely good atmosphere at work.

As well as this capital investment for the safeguarding of library materials we made organizational changes and created an Office for the Care of Stocks. The Office oversees the activities of the restoration workshop, the in-house book-binding and the bindings department. This new structure will improve the availability of our stocks and help to keep them in better condition.

Having described our facilities and organization, let me now say something about the content of our work as a regional center.

In September 1985 two seminars on paper splitting were held in Leipzig

under the auspices of the international working group of restorers of archive and library materials and prints. These two events were quite indicative of the demand that there is for specialist meetings. In recognition of this widespread interest we plan to hold similar seminars each September, again as part of our work as a regional center of IFLA. We are presently drawing up a list of subjects that might be eligible and would appreciate your contributions in the form of concepts, requests and expertise.

Outside this framework, as you might call it, there is now ample opportunity for individual projects. We are now in a position to provide, on a permanent basis, 10 workplaces for students or trainees from any part of the world. As a national advisory and consulting center we would also be glad to give assistance with specific technical problems.

Another area where we will continue our efforts is the mechanization of restoration work. Now that we have had first results from the wet treatment technique, which embodies most current research findings, we find ourselves under pressure to search for efficient stabilization procedures. The reason is the condition that many of our wood-pulp-containing materials are in, and we are quite impressed with the large scale and technical perfection of the project for deacidification undertaken by the Library of Congress. While this is a necessary and important step toward solving the problem as a whole, it is at the same time limited to the aspect of preservation.

Our own projects are concerned with rational approaches to stabilizing heavily damaged stocks. All libraries have large quantities of these, and preserving the original is often the most important consideration. For some libraries, microfilm or microfiche may be a feasible solution, but this will not resolve all aspects of the problem.

For a considerable time now we have tried to supersede manual paper splitting with a mechanized technique and are at present finalizing the design work for a machine. The documentation becomes available this July (1986). At the same time, we have successfully completed the model experiments for all the functions of the unit and tested the auxiliary materials involved. It is expected that construction of the unit will start in the second half of 1986 so that practical testing can begin in 1987.

We foresee the following benefits from mechanized paper splitting:

1. A tenfold increase in the quantity handled as compared with the manual method.
2. Better quality through the elimination of subjective errors.
3. A major cost saving from matching the capacity of wet treatment to that of mechanized stabilization.

By way of summary and generalization one could say that if we are now handling hundreds of sheets per day the number is to rise to thousands per day in future, with better quality and lower costs.

Even now, while we are still working to complete the second major mechanization project at the Deutsche Bücherei, we have plans for more ambitious undertakings. In following these, however, we are fast approaching the confines imposed on us by the limited capacity of an individual establishment or country.

A realistic concept of what is currently possible in the large-scale restoration and preservation of paper in terms of economy, esthetics, quality and quantity might take the following form:

At the present time, all requirements can be met by integrating mechanized wet treatment with the mechanized reconstruction of lost substance and the mechanized stabilization of whole pages.

The wet treatment plant in Leipzig, the casting machine from Copenhagen and the splitting machine now in the making also in Leipzig form the beginnings of a system for the industrialized restoration of paper.

For users such as libraries and archives this linkup has the advantage of being extremely flexible. While the complete arrangement could deal with the most serious cases of paper damage, the individual units would take care of less damaged materials. Within the limitations of what we know today, this system is the best available to fulfill the chemical, physical and esthetic demands that can be made on efficient paper restoration.

We have concrete evidence to support this statement which may appear a little absolute to some. In the last few months, the restoration workshop of the Deutsche Bücherei has handled manuscripts showing extreme damage. In the case of these documents, international cooperation was practiced in that the sheets went through mechanized wet treatment in the Federal Republic of Germany, lost substance was reconstructed using Per Lauersen's casting machine in Copenhagen, and the whole sheet was then stabilized by splitting in Leipzig. The results speak for themselves and indicate that this is a realistic approach to the preservation of library stocks and desirable for all users. Considerable effort is, however, needed to turn these first beginnings into an accepted standard.

Under an active and vigorous policy of preservation which should also make good use of the related effects, we have a real chance of drastically improving the condition of the stocks that are now in our libraries and archives.

SUMMARIES

Mechanizing Restoration Work

A report on the history and the activity of the Restoration Workshop of the Deutsche Bücherei in Leipzig is given. It ends in an outlook how the "industrialized restoration of paper" can be reached by combining mechanized wet treatment as just in practice in certain workshops in West Germany, leaf casting at the conveyor belt as developed in Copenhagen and mechanized paper splitting according to the Leipzig technique.

La mécanisation du travail de restauration

Un rapport est disponible sur l'histoire et l'activité de l'atelier de restauration de la deutsche Bücherei de Leipzig. Il se termine par un point de vue sur la possibilité d'atteindre une "restauration industrialisée du papier" en combinant traitement humide mécanisé, comme cela se fait en pratique dans certains ateliers d'Allemagne de l'Ouest, distribution de feuilles sur bande transporteuse comme cela est développé à Copenhague et division du papier selon la technique de Leipzig.

Mechanisierung restauratorischer Arbeit

Es wird ein Bericht über die Arbeit und die Geschichte der Restaurierwerkstatt der Deutschen Bücherei in Leipzig gegeben. Er mündet in einen Ausblick, wie die "Industrialisierung der Papierrestaurierung" erreicht werden kann, nämlich durch die Kombination von mechanisierten Naßbehandlungen, wie sie in einigen westdeutschen Werkstätten praktiziert wird, mit dem Anfasern am Fließband, das in Kopenhagen entwickelt wurde und dem Papierspalten nach Leipziger Technik.

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The Conservation Treatment of Paper

by OVE K. NORDSTRAND

One of the hard-to-swallow-realities of the library and archive world is the fact that all paper items in our collections are in the process of deterioration. Relentlessly.

The process ordinarily proceeds at an extremely slow rate. But negative influence from the environment accelerates it. Therefore it is our prime professional duty to create as sound and positive an environment to our collections as technically and economically possible. Better prevent than cure.

However, the process of deterioration not only may be accelerated. Truly, it may be decelerated, too, by skilful application of suitable conservation treatments, and particularly if they are coupled with suitable changes in the environment of the collections. Therefore, ethically considered, the preservation of paper in our collections becomes the common objective of librarian and conservator; of the manager and the technician. The chief aim of the paper conservator then is, by skilful application of the technical means at his or her disposal, to prolong the useful lifetime of any paper item which is brought into the laboratory for treatment.

In principle a range of procedures are at the disposal of the conservator. However, the actual treatment to be utilized in the individual case will depend, and definitely must depend, on the specific demands of the individual item, and on some fundamentally significant principles which in any case must be respected. Thus the integrity of the individual item must be strictly respected. All procedures utilized must be reversible, and all procedures and materials used in the conservation treatment must be well documented in the Conservation Record. Last, but not least, the principle of "the-less-done-the-better" should be respected. These principles should be considered central parts of the ethics of paper conservation.

The conservation treatment of paper should proceed as a planned, but flexible, process. The decisions of what to do, and sometimes what *not* to do, usually are made between the librarian responsible for the item and the conservator responsible for the treatment. But prior to any decision the item is carefully investigated by the conservator, using a range of technical procedures, to establish a detailed picture of its structure and condition of preservation. All observations made during this initial investigation, as well as those made subsequently during the conservation process must be carefully noted and, if necessary, illustrated in the Conservation Record.

The actual conservation treatment falls into a number of phases. In case the

item has been attacked by microorganisms the first phase is disinfection. This is carried out by gassing the item in an atmosphere of either ethylene oxide, or methyl bromide at reduced pressure. Else the starting phase will be a cleaning process to remove dust and grime which has accumulated on the surface of the paper. The cleaning proceeds in stages. First a mechanical cleaning with hand-held and rotating brushes, and if necessary, scalpels and needles. Next follows, if necessary, a solvent cleaning. With a suitable organic solvent fatty spots and the like are removed. At last the paper is washed in tap water. If a detergent is added to the water the washing should end with a rinse in running tap water for at least 20 minutes' duration. Research results from the Library of Congress some years ago proved that distilled water should never be used for the washing of paper.

During the initial investigation the acidity of the paper is measured. This usually is done with the aid of an electronic instrument, a so-called pH-meter. The acidity is expressed in the pH-value, which is a figure on a logarithmic scale ranging from 1 to 14. The value 1 is the most acid, the value 7 is neutral, and the value 14 is the most alkaline. If the pH-value actually measured on a paper item is below 6, a neutralization will usually be undertaken. Neutralization of paper may be done by various procedures, all of which will move the pH-value of the paper to the alkaline side of the neutral point on the scale. Doubtless the procedure most widely used is the Barrow-procedure. Here the paper is first exposed for 20 minutes to a bath of 0.15% calcium hydroxide, which neutralizes acid in the paper. Next the paper is exposed for another 20 minutes to a bath of 0.20% calcium bicarbonate. This leaves a buffer of calcium bicarbonate in the paper. The buffer protects it to some extent against further attacks of acid. Another procedure which is widely used, at least in the USA, is the Wei T'o procedure. Here the paper is neutralized with magnesium methoxide in a mixture of methanol and freon. In the near future a mass-neutralization procedure will be taken into use by the Library of Congress, based on the use of diethyl zinc in the vapour phase in a dry vacuum. In this process the acid in the paper is neutralized and a buffer of zinc oxide remains in the paper.

Stabilization of the paper, which is the next step in the process, may be carried out by various means, ranging from the classical gelatine planing to the modern treatment with cellulose derivatives. Of the latter, the sodium carboxymethyl-cellulose and the hydroxy-propylcellulose have proven particularly useful. Both materials have the common advantage that a mixture of water and ethyl alcohol may be used as the swelling agent. Thus cockling of the paper, when wetted, may be reduced. Soluble nylon, which was formerly hailed in western Europe and USA, and polyester impregnation which was similarly

once hailed in eastern Europe, have both been proven by practical experiences to be less than suitable for paper conservation purposes.

It is the task of the paper conservator to restore to full useability any paper item brought to the laboratory for treatment. Therefore the conservation treatment usually also will include some elements of restoration. Thus rifts and tears in the edges must be closed and reinforced with narrow, torn strips of Japanese tissue. The tissue strips may be pasted on or used in the heat-seal manner. Holes and lacunae may be filled either by pasting patches of Japanese paper torn to the size of the hole, from both sides, or by leaf-casting, with paper pulp either in the manual or the machine-mode. In cases where the paper has become heavily weakened or directly embrittled, it may prove necessary to use some kind of physical reinforcement. This may take the form of a backing with a sheet of Japanese paper of suitable strength, if the paper has writing on one side only. Or it may take the form of an in-pasting between sheets of Japanese tissue, and a hard pressing, if the paper has writing on both sides. Still another procedure widely used, particularly in the USA, is encapsulation between sheets of polyester film, which are sealed along all four sides.

However, it should be underlined that this procedure generally is less than suitable for pencil-and coal-drawings, as well as for pastels, due to the generation of static electricity on the film-surface.

Lamination of paper between sheets of thin cellulose acetate- or polyethylene-film with a reinforcement of Japanese tissue, pressed together to a sandwich between heated plates or rollers, must be considered a last resort only. It can be used to add some years to the physical existence of documents which cannot be successfully treated in any other way, and which could otherwise be expected to perish over a short period of time.

The collections of any large, old library may hold a fair selection of items representing the wide variety of purposes paper was utilized for as carrier for written, printed and drawn presentations, and the varying stages of disrepair into which these items may have fallen in the course of time. In principle the selection of items sent to the paper conservation laboratories for treatment should reflect this state of affairs, but seldom does. There is a tendency, by itself understandable, that the librarians who are in charge of the collections set a higher priority to their most valuable items, valuable in terms of monetary value, and a lower priority to other items. This clashes with the ethical rule of conservators not to discriminate between items with respectively higher or lesser monetary value. As it is, the problem arises from the deplorable fact that almost everywhere the available resources are too limited. But viable ways to solve the problem must be found, and doubtless can be found, if librarians and conservators could get into unbiased discussions about it.

Some remarks should be made to indicate how wide the range of problems is which are put before paper conservators for solution. Since the problems regarding rare printed books will be the subject of another session at this conference we will here limit ourselves to look at some of those related to manuscripts, maps and works of art on paper.

PAPER MANUSCRIPTS

The category of *paper manuscripts* is by itself very large and very widely varying. From the scraps of third century paper manuscripts excavated from dilapidated watch towers on the outskirts of the Middle Kingdom of China, over a great many intermediates, up to the more or less casual notes of, for instance, present-day politicians which have proven either historically significant or in other ways worthy of preservation. Hardly any of these manuscripts were ever intended to have lasting value. But once recognized, and particularly once inside a public collection, they must be preserved, and their preservation consequently is the head-ache of the paper conservators of the respective institutions.

In the conservation treatment of paper manuscripts each case must be conducted individually with due consideration of the particular nature and properties of the materials of each item. And the full spectrum of treatments so far described and a few to add, will usually have to be used. Paradoxically the conservation problems of manuscripts of newer date frequently appear more complex and problematic than those of older ones, and may call for considerable inventiveness on the part of the conservator. Paper manuscripts quite often are rather acid, with the amount of acid present stemming from the ink. Frequently the acid of the ink has corroded the paper to such an extent that the paper appears extensively perforated. In such cases conservation, and particularly neutralization, as well as the subsequent restoration are very time consuming processes calling for considerable dexterity on the part of the conservator.

MAPS

Practically speaking the category of *maps* should be divided into two sub-categories: 1) flat maps and 2) globes. The conservation problems of flat maps in all essentials are the same as those of works of art on paper. But the conservation of globes involves a number of special problems, some of which have to do with the globe-body while some have to do with the gores on which the globe image was drawn or printed. The latter are of concern to us.

Globes as a rule have been varnished, and the dust and grime adhering to the surface of the globe will therefore be removed simultaneously with the removal

of the varnish. For the removal of the varnish a traditional alcoholic varnish stripper is used.

All practical experiences have demonstrated that conservation treatments of the paper gores carrying the globe image, wherever possible, should be carried out with the gores *in situ* on the globe body. Were the gores dismounted from the globe body and exposed to conservation treatments in the ordinary way the situation might become uncontrollable. This is due to the fact that the paper will swell on wetting and shrink on drying and the paper gores therefore would not fit exactly together when they are re-mounted on the globe-body. If the gores are treated *in situ* these problems will not occur.

Damaged areas of the paper may be filled by pasting in patches of Japanese paper torn to the size of the damaged area. The surface of the globe body consists of a smooth layer of *gesso*. When the paper is exposed to conservation treatments while *in situ* it may locally loosen from the *gesso* and form a blister. This problem may be solved by injection of a cellulose-paste, preferably hydroxypropyl-cellulose in water/alcohol. Then the paper is worked gently down and covered with a piece of release paper and a thick swab of cotton wool, which is weighted down during the drying. The paper also locally may have loosened at the seams. Here starch paste is brushed in under the loosened paper which is next worked down with the bone folder and weighted during drying. The paper which was pasted in to fill damaged areas is toned down with watercolouring, and finally the globe is re-varnished, usually with a traditional mastix varnish.

WORKS OF ART ON PAPER

The category of *works of art on paper* doubtlessly is the most demanding to the paper conservator. A broad range of widely different techniques were used in the creation of these items. At times even a combination of different, and virtually differing, techniques were used for the same item, which greatly complicates matters. But above all, every step the conservator takes in the treatment of these items must be taken with due consideration to the esthetic values of the item. Works of art on paper are artistic creations and as such often of considerable monetary value. Therefore the conservation and restoration treatments must not influence the esthetic appearance of an item in any way which may detract from its monetary value. For this reason some conservation procedures must be more or less modified when works of art on paper are to be treated. Neutralization of acid thus only rarely may be done by bathing. Instead, a floating procedure must be used in which the sheet is placed with its back floating on the surface of the neutralization bath. During the floating it may be necessary to support the sheet with an open-meshed nylon or polyester

web. When this procedure is used, repeated treatment is necessary, and between the treatments the sheet should be fully dried.

Pen drawings made with iron-gall ink may present the particular problem of ink corrosion, which already has been touched upon. Ink of the iron-gall type consists of an infusion of sulphate of iron with gallo-tannic acid and, if unbalanced, an amount of sulphuric acid is formed which from the ink of the pen strokes penetrates into the paper and corrodes the fibres. Items attacked in this way cannot be treated with any wet procedure, or at least only with difficulty and great care. Here procedures like that based on magnesium methoxide in methanol will be mandatory, and after neutralization a physical strengthening will be necessary. This is done by dry-laminating the sheet with moderate heat and pressure a sheet of Japanese tissue impregnated with polyvinyl-alcohol to the back of the drawing.

Old engraved maps with hand-colouring may hold the problem that part of, or the entire, colouring is sensitive to water. In such cases, if wet treatments are necessary, the sensitive areas must be protected, which may be done with thick cellulose-paste. In this connection it should be observed that copper-plate engravings must not be pressed too hard, since the impressions of the plate edges into the paper should be preserved.

As a matter of fact, works of art on paper is the only category of items treated by the paper conservator where retouchings are permissible. However, they should always be done in such a way that they are clearly recognizable on scrutiny, but unobtrusive at ordinary observation. And they should always be done with water-colours which may easily be removed again, if necessary.

The final stage in the conservator's treatment of a work of art on paper is the mounting of the item in a passe-partout. The passe-partout is meant to give the item future protection against negative influences, mechanical and chemical, from the environment. Therefore it should be made from good, stout, acid-free board, which is as free from metal impurities as technically possible. And its components should be prepared in such a way that they fit exactly together. The item should be fastened to the mat with hinges of Japanese paper. The frame should touch the item as little as possible, and be of a thickness of board sufficient to keep the front protection out of contact with the item.

The time limit set for this session has allowed for only a rather perfunctory presentation of some aspects out of the multitude of challenging problems which face paper conservators during our daily work. In spite of this it is my hope that the presentation has conveyed to you at least an outline of the nature of the problems facing us, of the procedures at our disposal, but above all of the responsibilities resting on us.

Finally I wish to express my thanks to the Council on Library Resources, Washington, for kindly making my participation here possible.

SUMMARIES

The Conservation Treatment of Paper

A survey is given on the normal procedures of paper conservation and restoration treatments: disinfection, cleaning, deacidification, re-sizing, mending etc., followed by a deliberation on some special restoration problems e.g. corrosive ink, varnished globes, retouching art on paper.

Le traitement de conservation du papier

Une étude est disponible sur les procédures ordinaires de conservation du papier et les traitements de conservation: désinfection, nettoyage, désacidification, mise en format, raccomodage, etc..., suivie d'une discussion sur certains problèmes de restauration spéciale comme la causticité de l'encre, le vernis des globes, l'art du retouchage sur papier.

Die konservatorische Behandlung von Papier

Auf die Beschreibung des Ablaufs der normalen Vorgänge der Papierkonservierung und -restauration (Desinfektion, Reinigen, Neutralisieren, Nachleimen, Ausbessern) folgt eine Betrachtung über einige spezielle restauratorische Probleme, z.B. Tintenfraß, Firniß auf Globen, Retuschen.

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Conservation Treatment of Rare Books

by HELMUT BANSA

HELMUT BANSA

INTRODUCTION

For two reasons I did not find it easy to prepare the paper that I have been asked to give for the First International Conference on Preservation of Library Materials. First because the topic that I have been given is either too general or too specialized; second because I have to compete with more than 40 other speakers who have similar topics.

In order to avoid undue repetition and to achieve a connection of ideas I tried to imagine what the other speakers would tell about the special aspects of their topics. There are lectures on acquisition: what kind of materials must be collected in libraries to preserve our cultural heritage for the future. In the context of Rare Books we can reduce all relevant ideas to a very simple principle: a librarian must collect any Rare Book pertaining to the special field of his library. The definition of this field is a question of general library policy. It may exclude the topic of this conference: for libraries serving the general public, preservation is reduced to careful handling. There are lectures during this conference on general aspects of preventive care: nobody can doubt that any Rare Book a librarian has collected must be protected against decay and disaster. Another group of lectures discuss preservation in the original format or format conversion: in the context of Rare Books these two are not alternatives, but supplements. To make preservation possible in the original format the librarian responsible for Rare Books will use any conversion format, such as microfilm or -fiche, reprint and facsimile. Adapting the first of this notion to Rare Books, it must be said that any measure, any precaution, any activity that makes preservation possible in the original format is to be used, starting from apt storage under suitable climatic conditions, passing through careful handling and ending in certain treatments of the paper of those books, treatments that change the chemical composition so that the paper will be less susceptible to decay.

TOPIC WORDING

Another method to prevent undue repetition of ideas and words that will be presented by others, during this conference and elsewhere, was to take the special topic that was allocated to me in its narrowest sense:

Conservation. Not restoration and not "preservation", a word which has no equivalent in other languages except English, and even then no clear distinction from "conservation."¹ Conservation *treatment*, not precaution and measures for protection. Conservation treatment, meaning concrete measures applied to a particular object by human beings using their hands and tools in order to have the object remain the way it is or at least appear that it has remained so. In our energy-filled world, everything pushes for change, every order for its own dissolution, and effort is required to soften and lessen this process. The third concept of my topic: *Rare Book*. One can have an easy time with this definition, for the idea which everybody associates with it is pretty much the same in all minds, even though not clear. A rare book is a thing which is regarded valuable. Why? Often only because it is rare. It is rare only in the sum total of its peculiarities: there are any number of objects with similar peculiarities in different combinations, some with others and none with all of them. One peculiarity acquires particular meaning, namely antiquity. This peculiarity is often the one which is the basic reason for rarity. Only very few books acquired by a library in the period of their production are actually rare ones, but nearly any of them are potentially so. I will not extend my special topic in this direction; I will restrict it to those books that are not doubted to be rare by anybody. These books are in a preeminent way objects of conservation: everything about them should remain the way it is. Above all everything about them should remain old and antique; such is their special character. It is the treatment that is problematic: what can one do so that a thing remains the way it is?

TREATMENT

The logical answer would be: nothing. Everything that one now does as new is naturally not old. This resigned notion takes a turn to the positive, thanks to the condition that was placed above on the definition of the word "treatment": if not everything can remain as it is, at least it should appear that it has remained that way. In the much larger area concerned with working to maintain Rare Books, namely working on those individual parts which are no longer the way they were and should be, that is, in the area of restoration, this latter limited goal can be pursued only with great difficulty, not to mention the unlimited one. The effort that one must expend will increase in exponential proportion to the result desired. This has led theoreticians of restoration to change the basic statement around: one must be able to see everything that is done to a rare book. In the case of conservation treatment, such a goal would not be attainable. This conflict over basic theory to which I am alluding is still

far from over, but it is not part of my topic. Continuing with the topic leads us to the question: what kind of treatment can one carry out, apart from protective measures, so that the various forms of destructive energy that surround and threaten the rare book can be softened and thereby lessened in their effect? These are forms of destructive energy from warmth, light, from strength in the hands of readers or in the teeth of small creatures, from sections and enzymes and whatever. Before I attempt to treat these matters in the general way that is required for managers, the profession this conference is organized by and for, I must make one more digression. I must point out that in actual practice involving libraries and their laboratories, these treatment procedures play a secondary role. Far more important are precautionary protective measures: temperature and humidity control, boxes and other arrangements for isolation, directions for limiting use and providing substitute copies. If we restrict ourselves to the word *treatment* we must say: far more important are efforts at restoration. In practice, conservation treatment takes place only along with these latter.

DEACIDIFICATION

Its area of effectiveness is indeed quite limited. It embraces only the limited possibilities of modifying the composition of material with complex construction – in the case of the Rare Book: paper, leather, coloring and ink – so as to offer lesser access to destructive energy. This concerns above all exposure to chemical reactions: oxidation, hydrolysis, crosslinking, or, to use other words as one finds in the mouths of researchers and in the technical literature: decomposition, keratinization, hardening, yellowing, fading photolysis, and many others. The way by which these reactions take place is nowadays understood in the basic characteristics, as well as what can be done theoretically to prevent them. Research is seeking out the best and quickest practice: mechanization and bulk treatment. The Rare Book has a share in this: in the matter of Rare Books those results are adopted which chemical imagination and practical experience indicate to be most effective in the desired direction and to avoid mostly undesired side effects. These results are modified and integrated into the overall task involving the material of the Rare Book. This modification takes into account that for Rare Books the aspect of esthetic quality has the highest priority. We will consider the deacidification of paper, by far the most important of the treatments that modify the composition of a book material, in this case paper, so as to make it more permanently durable. More precisely, deacidification is the introduction of a substance which works as an alkaline buffer against acid-catalyzed hydrolysis and also works as a catalytic blocking

agent against oxidation. It is purely a matter of conservation treatment. This procedure is an unquestioned part of rare book restoration in a number of laboratories, for example, the one from which I come,² even if it is true that just the paper of Rare Books is in less need of a relevant treatment than the paper of other books, for the simple reason that rare books are mainly old books and that old, meaning handmade paper is, generally speaking, more permanently durable than most modern machine-made paper. Nonetheless, if the paper of a book that must be restored arouses only a remote suspicion that it is exposed to oxidation and hydrolysis, including therefore all paper which was not manufactured with the above-mentioned blocking agent, the paper is deacidified. Depending on greater or lesser previous efforts at preservation, the eye and the sensitive hand of the restorer are for the most part able to detect paper in which oxidation and hydrolysis have already taken place, without the restorer needing to measure the pH factor or carry out analyses. The decomposition products of oxidation and hydrolysis promote further decomposition and so it is important first of all to remove them completely. Like deacidification, washing is an unquestioned part of old book restoration and likewise a conservation treatment technique. It is often suited for the paper of a rare book on esthetic grounds and is often preliminary to other procedures, for example, leafcasting. More about washing later. Washing and aqueous deacidification can in part be mechanized. In some places, ingeniously constructed plants are available for this purpose³. Where one can use them, it seems that the additional expense is relatively small if the rare book has already been taken apart for other reasons, namely so that it can be restored. Aqueous deacidification of paper, provided that the ink and color and other elements can sustain it, is the only treatment of paper which can qualify as basically positive. I know that this thesis, which I am not now presenting for the first time, has aroused opposition. I would gladly face this in discussion, provided it were well-argued and not based on empty phrases. Sometimes aqueous deacidification is not possible, because of the ink and the color, particularly in the case of a rare book. The fact that there can be no doubt about the positive effect of the material impregnating the paper in the process of aqueous deacidification has led to the result that non-aqueous methods, which introduce the same material into the paper, have likewise been included in the repertory for conservation treatment of rare books. The non-aqueous methods were developed for the bulk treatment of modern books. One of them has already been employed for this purpose on a large scale.⁴ For the rare book, they form a substitute when aqueous procedures are not possible. In the case of the one of methods⁵, the very one employed for large scale bulk handling, it is possible to introduce into the paper more of the material which works with a positive effect than with any other method, including the aque-

ous,⁶ and in this sense it is superior to all others. Nonetheless, one has reservations against it concerning the paper of Rare Books. These reservations may be based more on feeling than on reason. Through experience with Rare Books one cannot completely avoid the inclination to allow feeling to win out over reason. It was quite interesting for me to learn just during this conference that at the place where the very mass deacidification plant is installed that until now, as the single plant in the world has found its way from test period to daily practice, Rare Books are excluded from being treated in it (See page 97 in this issue), even if the same non-aqueous deacidification procedure going on in it is, as I am about to report, sometimes used for the paper of Rare Books.

For me, personally, and for others, aqueous deacidification of paper is preferable to non-aqueous. In seeking reasons for this one might say: with the non-aqueous procedures the products of the decomposition which has taken place remain in the paper and promote further decomposition. They are "neutralized". Completely? Permanently? In any case, it is better to wash them out, and this is possible only with water. As a second reason, one could introduce the consideration that water would wash out the molecular residue from the hydrogen bonds in cellulose which have been affected by the decomposition. Through the washing and through the removal of these decomposition products, the water would activate interfibrillary hydrogen bonding and thereby strengthen the paper. One could add that through washing out the decomposition products, a crosslinking would be avoided. The molecular residue contains reactive groups which are able to form connecting bonds between hydroxyl groups in the cellulose chain. Previously these hydroxyl groups lay freely side by side and promoted the flexibility of the paper. The discussion whether these ideas of chemical imagination correspond to reality would have to be carried out at a meeting of cellulose chemists, at which conservators and restorers and the managers of both these library activities would have a purely receptive role. Such meetings have already taken place.⁷ To return to our topic of the conservation treatment of rare book paper, one might say in conclusion that a combination of aqueous and non-aqueous procedures would be the ideal. By means of water, perhaps with high carbonate concentration and therefore with strong deacidifying effect,⁸ the harmful decomposition products are washed away; then by means of subsequent non-aqueous deacidification according to the above-mentioned method of Richard D. Smith,⁵ a maximum of helpful material is introduced into the paper.

PREVENTIVE DISINFECTION

We leave chemistry behind and look to biology: to the conservation treatment of rare book paper against biological, that is microbiological attack, concretely, against mold. In the technical literature on conservation, one can find a whole list of pertinent recommendations and procedures⁹; I do not know whether and to what extent they have been taken beyond research effort and put into actual practice, at least as preventative conservation measures. When the paper of a rare book has suffered damage from microbes, when it has been weakened by mold to the point of becoming physically endangered and has been discolored to the point of becoming esthetically disfigured, one must adopt restorative treatment: one must wash it, bleach it, resize, split, leafcast it. These are all aqueous procedures, for which it is suggested that one add a fungicide to the water as a preventative measure against future harm. This might be done here and there; it is not generally accepted the way deacidification is. There are good reasons for this. For one, we can never say for certain that a biologically disruptive agent will leave an organic substance like paper unharmed. Experiments in artificial aging with the use of otherwise recommended chemical agents have rather shown the opposite in the laboratory I am from. Secondly, the defense against biological attack, against the dangers for rare books coming from rats and mice, worms and lice, microbes and – most of all – from fungi; the defense against all this is a problem of library building and of the obvious cleanliness of a well-ordered housekeeping¹⁰, possibly, in certain parts of the world and in certain libraries, a problem of climatic control; only under very extraordinary conditions is it a problem of chemical or physical conservation treatment. If library building and library cleanliness are ordered with respect to preservation, any preventative treatment appears superfluous. It may even appear as inappropriate. All paper in all books is subject to microbiological attack, the older good paper, namely the kind that is mildly alkaline and has been sized with animal glue, even more than the modern kind which contains filler and which has been sized with resin. To give preventative treatment to all paper in all rare books, especially those in good condition is a sheer impossibility. On account of the circumstances involved in providing the treatment, it would also be sheer foolishness. To treat the paper of a book that arrives in the laboratory more or less by chance, namely because it is being restored and has to be taken apart, and not to treat all the other books merely distracts from the unavoidable necessity of building and outfitting storehouses where no mold can grow. In the laboratory that I am from, paper receives preventative impregnation against the growth of mold when it already shows signs of such growth and when the mycelium cannot be fully destroyed on account of the

condition of the ink or the color or for whatever other reason. In such a situation, we let ourselves be guided by the realization that a mycelium living in the book needs less moisture and warmth for new growth than the spores, which are everywhere, need for sprouting. The mycelium can generate from its own growth the moisture it needs for further growth. If one uses an inhibitor in the case the mycelium will not be fully destroyed, it will be possible to stay within the wider temperature/moisture limits that prevent spore growth, but could allow the growth of the mycelium.

ACTIVE INFESTATION

The topic "Conservation Treatment of Rare Books Against Biological Attack" may also cover possible methods to disinfect the stockrooms for rare books and the rare books themselves if there is an active infestation. What is the best in such a case? Poisoning, fumigation, freezing; what poisons or fumes or gases are most harmful for the animals and fungi and least harmful for men and rare books? Such technical details are to be discussed by technical experts. Library managers must take part in these discussions and emphasize what the specific character of Rare Books is exacting against mere technical aspects. For this purpose they must be, to some extent, familiar with relevant technology.

LEATHER TREATMENT

As a final aspect of conservation treatment of Rare Books, the treatment of their bindings should be touched; specially and concretely, their leather. I would not know what else to mention. Leather treatment, definitely impregnating the leather of the bindings with a fatty substance or, using the technical term of the English language, dressing the leather, is the most frequent kind of conservation effort carried out in libraries with old volumes. It is burdened with high expectations even though its effects cannot be described exactly: the ideal starting point for a variety of methods and prescriptions as well as for bitter arguments about which are the best or which is the only correct one.¹¹ This argument leaves its mark on the pertinent technical literature. It is not wrong to say that in principal, correct use as prescribed by the producer presupposed, that nearly any dressing suggested in the technical literature is good for leather, at least from the esthetic point of view. But even more it is true that by dressing only and neglecting all the other and more important aspects of conservation no leatherbound book will be preserved.

Finally it can be reported: treating leather with oil, wax and water as the basic elements, and with various additives which achieve a biological and

chemical balance, applied either in one or in more mixtures used successively, is always the obvious final step in working on a leather binding in either the restoration or the repair laboratory. Moreover, such a treatment is occasionally carried out on a large scale with all the leather-bound volumes in a storehouse. Reservations against such a procedure are appropriate. Such actions are almost always measures for creating work. They are carried out by workers who have not been trained for the task and who have been only partially instructed in it. They are not able to distinguish properly among the various types and conditions of leather. Mistakes occur: mostly the one whereby water and oily material are not applied in the right proportion; too much oil is applied and too little polishing is done so that the treated book afterwards becomes a sticky dust catcher in the storehouse. Actions of this kind are suited rather to pacify, in a deceptive way, the conscience of the responsible librarians. Conservation, however, is not a matter of isolated actions: it is a matter of constant striving that must pervade the entire workday in the library.

CONSEQUENCES

This last sentence may be the start for a final statement on conservation of mainly, but not only, rare books: What must or should be done to preserve rare and other books is well known. What we need is to carry it out. Carrying out conservation is not only (and possibly not so much) a problem of funds. An international conference of librarians is not the place to struggle for funds. Really, those conferences are often used as a platform to cry for better funds, but this is the wrong way. Having cried loud enough the librarian responsible for conservation gets a feeling of having done something, of having transferred responsibility that really is his own and not transferable. Claims for funds must be presented to the representative and the sponsor of the library. To present them in an irrefutable way the librarian needs good arguments. He himself must be sure of these arguments. They must be based on clear knowledge and on clear consciousness. The librarian must clearly understand the course of chemical, of biological, of mechanical processes of damage and decay as well as he must understand the course of chemical, of biological, of mechanical processes of the means against them. He must have a general idea of the different methods to carry out the different conservation techniques, and mostly he must have a clear understanding of what can be done by these methods and techniques and what can not be done by them. He must combine this technical and scientific understanding with his knowledge in the field of librarianship, and from this combination he must develop conservation policies; a policy for the whole and a policy for the role of his very own library within this whole. What

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part of the immense stacks of printed and written paper in the libraries of the world, of their own country, of their own library must be treated? In what way must this treatment be carried out? The top of the hierarchy of what can be done is careful and costly work to preserve and restore not only the original format, but the original appearance of a book as if it were an object in a museum or an antiquity; the end of the hierarchy is neglect. Not every book in any library deserves everlasting life. Knowledge and understanding of this kind and, as their result, a real and realistic conservation consciousness must penetrate the whole professional life of the librarian, so that his whole work will be oriented towards conservation. This is what we need. If any activity and process in daily library work is oriented with a view to conservation, then the funds the human society can provide for library conservation will be used much more effectively than they are used now. Those funds are limited in any event. Nobody can think to bring about a social and cultural situation comparable to the last phase of the Pharaonic culture. A greater part of the national product can never be invested either into the cult of the dead or into old books.

RANGE WITHIN POLICY

Conservation is an important library activity, a task of high, in national libraries possibly of the highest importance. In any way its importance at this type of library has a higher rank than the reader's comfort. In a national library and in other libraries having rare and unique collections a reader must wait until a book endangered by decay and loss is microfiched. If the reader only needs the information stored in the book, if he is only interested in the information he must feel satisfied with the microfiche. The microfiche makes possible to separate a book that is endangered by decay and loss, to wrap it and to wait for the day the book can be restored – if one day it seems to deserve restoration. This separating and wrapping is a very important measure of conservation, even though not a conservation treatment and therefore not the topic of this paper.

In a national library the reader must accept getting the costly print from the microfiche instead of the cheap direct xerox copy. He must even accept paying higher prices for the copy he gets and to contribute in this way to build up a microfiche collection of rare books in the national library or in another library with unique collections. For our rarest books, that is for manuscripts, this is just the usual condition of library management, and it is necessary to extend it to printed books. Printed books do not have the deep respect as manuscripts do but often they are just as rare and mostly they are more endangered by damage

and loss. Sending books around for exhibitions and for interlending is quite contrary to conserving them. National libraries should not take part in interlending actively, but only passively. Maybe as a compensation they must take over the duty to microfiche any book they borrow: two copies of a quality comparable to the master, two copies of a quality that allows duplication and to make prints of single pages; one copy for the national, the other for the loaning library, so that the next demand for this very book – that seems to be a rare one only from the fact that it is not present in the national library – can be satisfied by a conversion format; and the original can be further protected by any suitable means of preventive care, of conservation or even restoration treatment.

SUMMARIES

Conservation Treatment of Rare Books

As the only techniques that are covered by the term "conservation treatment" deacidification, disinfection and dressing of leather are discussed together with their range within the work of a laboratory engaged in conservation and restoration of rare books.

Traitement de conservation des livres rares

Comme seules techniques couvertes par le terme "traitement de conservation", la désacidification, la désinfection et l'habillage de cuir sont discutés ainsi que leur portée dans le cadre de travail d'un laboratoire lancé dans la conservation et la restauration des livres rares.

Konservatorische Behandlung seltener Bücher

Als einzige Maßnahmen, auf die der Terminus "konservatorische Behandlung" zutreffen mag, werden Neutralisierung, Desinfektion und Lederpflege sowie ihr Stellenwert in der Praxis einer Werkstatt erörtert, deren Aufgabe die Konservierung bzw. die Restaurierung seltener Bücher ist.

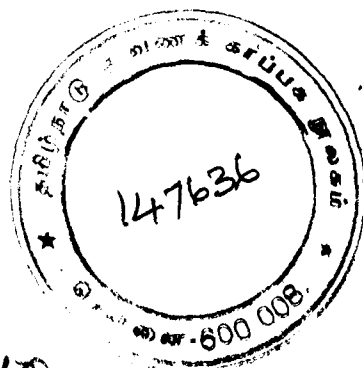
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