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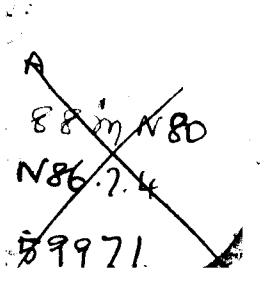

Ethylene Oxide Fumigation: Results and Risk Assessment

by MARY W. BALLARD & NORBERT S. BAER

1.0. INTRODUCTION

1.1. Toxicity and Regulatory Status

On 22 June 1984, the Occupational Health and Safety Administration (OSHA) of the U.S.A. published in the *Federal Register* a Final Standard for occupational exposure to ethylene oxide (EtO). The standard reduced permissable exposure levels to 1 part EtO per million parts of air (1 ppm) determined as an 8-hour time-weighted average (TWA). An "action level" of 0.5 ppm as an 8-hour TWA was established as the level at which employers are to initiate such compliance actions as employee exposure monitoring and medical surveillance. This represents a reduction from the 50 ppm TWA standard adopted in 1971. The basis for this action is stated to be a determination that exposure

This paper is based on a presentation made at the Annual Meeting Meeting of the Society of American Archivists, Washington, D.C., September 1984.

to EtO represents a carcinogenic, mutagenic, genotoxic, reproductive, neurologic and sensitization hazard to workers.[33]

In recent years, the use of EtO in conservation practice has come into question due to concern for the safety of those handling EtO and EtO treated materials. Other questions have been raised regarding possible damage to artifacts associated with EtO exposure and with the conditions normally employed in EtO fumigation. The following discussion traces the history of EtO use, considers the basis for the OSHA regulation, and examines the risk management problem associated with EtO use in museum conservation laboratories.

1.2. History of Use of EtO as a Sterilant/Fumigant

Discovered by Wurtz in 1859, EtO began to be used as an insect fumigant in 1928[8]. Although its primary use as a fumigant involved agricultural application to grain and grain products, it was recommended as early as 1933 for its toxicity to insects attacking museum textiles[11]. About this time, the completion of the National Archives building in Washington, D.C. provided the impetus for a review by the National Bureau of Standards, in conjunction with the United States Department of Agriculture (USDA), of the then current commercial fumigants, including an EtO/CO_2 mixture, so that documents could be decontaminated prior to the move to the new facilities[43]. The agricultural applications led to the recognition of its microbiocidal powers. During World War II, the U.S. Army Chemical Corps reviewed the use of EtO as a sterilant. The results were formally published in 1949[23,24,35,36]. Subsequently, the USDA developed a practical, low-pressure, non-flammable, stable formulation for sterilization in the field and in field hospitals for army use. This was the 12% EtO/88% *dichlorodifluoromethane* mixture introduced in 1959[21].

Ethylene oxide came to be a standard gaseous fumigant for library and museum use as a result of several factors. It provided a seemingly passive treatment for archives and artifacts; as a gas, at near room temperature, the active chemical modification that liquid insecticides or fungicides involved was avoided; and the toxicity was absolute, immediate, and limited to the exposure in the chamber itself. The efficacy of the dosage for sterilization was considered to be 10 times greater than that of the alternative, *methyl bromide*. Thus a 10% EtO/90% CO_2 or 12% EtO 88% Freon mixture would achieve comparable results using one tenth the total amount of fumigant[3]. Furthermore, EtO provided the library or museum with a broad and effective tool. Its toxicity to insects in adult, larval, and egg stages was complemented by its destruction of mold and fungi. When deemed necessary, sterilization against bacteria could be achieved as well[3,9,12]. Vacuum fumigation chambers, moreover, could be

used with fumigants other than EtO, so the initial capital investment allowed for great flexibility in treatment[42].

2.0 ETHYLENE OXIDE TOXICITY

2.1. Legislative History of the Regulation

In 1968 the American Conference of Government Industrial Hygienists (ACGIH) recommended a TLV of 50 ppm 8-hour TWA based on limited data from a six-month animal inhalation study where no adverse effects were observed at levels below 50 ppm and and epidemiologic study of employees exposed to EtO for 10 years or more at levels of 5–10 ppm with no adverse effects. At that time no evidence of carcinogenicity was available. The ACGIH TLV became the Walsh-Healey Federal Standard which was adopted as the OSHA standard in 1971. In 1977 NIOSH recommended adoption of a 75 ppm ceiling limit for a 15 minute sampling period. This extention of the standard was based on observation of changes in the genetic material of cells in some 13 biological species following EtO exposure and on the observation of covalent bonding between EtO and DNA. It was concluded that exposure to EtO might increase the frequency of mutations in exposed populations. In 1979, ACGIH published a notice of an intended reduction in the TLV to 10 ppm based on *in vitro* studies indicating positive mutagenic responses and on the incidence of leukemia in an epidemiologic study of 230 exposed workers. The proposed change was adopted in 1981. That publication designated EtO as a possible carcinogen in humans and proposed a lowering of the TLV to 5 ppm based on a rat inhalation study. In 1981, NIOSH issued a bulletin regarding the potential carcinogenic hazard of exposure to EtO. In 1982, ACGIH adopted a proposal to lower the TLV to 1 ppm effective in 1984. In 1983 the U.S. Court of Appeals for the District of Columbia ended a series of legal challenges by asking OSHA to prepare a new standard on an expedited basis. This proposed regulation was published on April 21, 1983 and following a period of public review and comment was published as a final standard on June 22, 1984[33]. The standard became effective August 21, 1984. This standard sets a Permissible Exposure Level (PEL) of 1 ppm as an 8-hour TWA and an "action level" of 0.5 ppm for an 8-hour TWA. The standard states that,

> *"The basis for this action is a determination by the Assistant Secretary, based on animal and human data, that exposure to EtO presents a carcinogenic, mutagenic, genotoxic, reproductive, neurologic and sensitization hazard to workers."*[33]

2.2. Evidence for Toxicity of EtO

OSHA's determination that EtO is a potential carcinogen was based primarily on rat studies with exposure by inhalation. These positive findings were supplemented by epidemiologic studies, and *in vitro* mutagenic tests. It was suggested that EtO exposure may cause an increase in spontaneous abortions. This was supported by animal studies. The findings for humans and experimental animals exposed to EtO indicate damage to genetic material (DNA), including hemoglobin alkylation, unscheduled DNA synthesis, sister chromatid exchange, chromosomal aberrations, and functional sperm abnormalities. Other hazards include neurotoxicity, skin lesions, eye irritation, dizziness, and nausea as acute affects[33]. In the 1984 edition of *Dangerous Properties of Industrial Materials*[38], 37 studies reporting positive toxic effects are cited.

2.3. Short-Term Exposure to EtO

In promulgating the new Final Standard for *ethylene oxide* as 1 ppm over an eight-hour period, OSHA did not effectuate a short-term exposure limit (STEL) which would restrict the total, immediate, permissable exposure to EtO for a worker. Currently, a worker can be exposed to a single high concentration of up to 480 ppm for one minute and still not exceed the long-term limit so long as no additional exposure to EtO occurs. Similarly, a 32 ppm exposure over a fifteen minute period is permitted.

Industries involved in the manufacture of *ethylene oxide*, in conjunction with the Office of Management and Budget (a federal agency of the executive branch), have argued that risk assessment studies have failed to establish a greater degree of harm to be associated with high short-term exposure than with low long-term exposure. Only cumulative effects on chromosomal damage have been studied, for example. Yet most workers are exposed to higher concentrations for very brief periods of time. Thus, studies of cumulative, short term acute exposures are needed. Given the incomplete toxicological evidence, the ACGIH has recommended an exposure limit of 5 ppm for any time period. OSHA originally asked for a 10 ppm STEL in 1984[40].

2.4. Risk Assessment in the Context of EtO

Risk assessment is the attempt to define the probability of adverse consequences due to a specific hazardous situation. The National Academy of Sciences[31] recently reviewed the subject, providing a general scheme for the characterization of risk and its ultimate application to the establishment of stan-

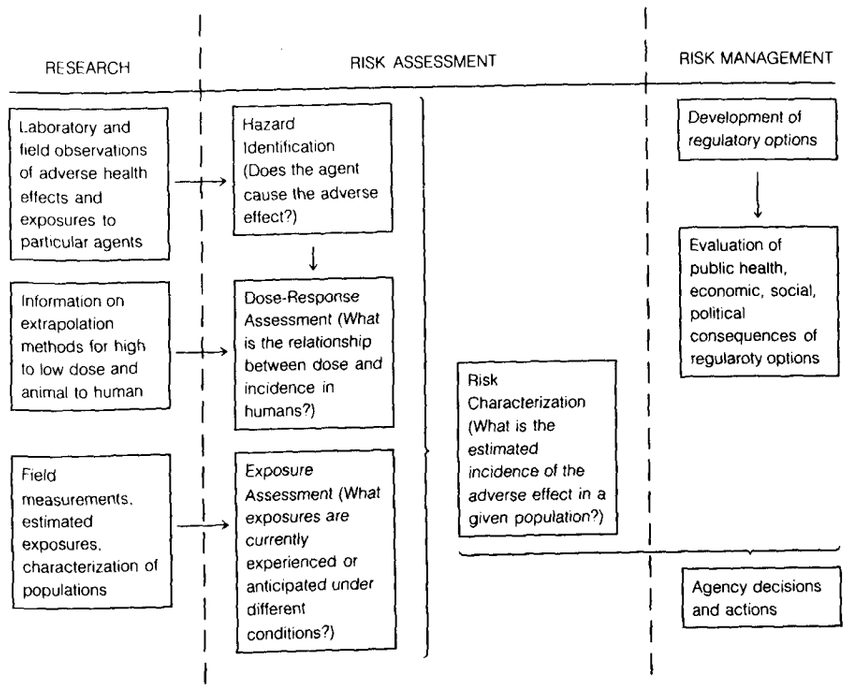

Fig. 1. Elements of risk assessment and risk management (after National Academy of Sciences, 1983).[31]

dards. Figure 1 presents a flow diagram for the process of risk assessment for human health effects. One may undertake a similar analysis for materials and human effects specific to EtO. The standard recently published by OSHA is based on such a human effects risk analysis in a court mandated quantifying risk assessment. Among the approaches used were a two-year rat EtO inhalation carcinogenicity study; a time to tumor analysis for the above rat study; an equivalent dose study to permit the intercomparison of data between the exposures in experimental animals and workers; evaluation of epidemiologic studies on workers and a Rad equivalence assessment. OSHA found that cancer risk for EtO exposure at the 50 ppm level was significant when compared to risk estimates judged significant by OSHA for other hazards including arsenic, cotton dust, and coke oven chemicals[33]. No comparable analysis has been carried out for damage to materials. Thus, even if the risk management plan affects a reduction of staff exposure to the new 1 ppm TWA standard, significant risk to the artifact may remain. Just as one must now monitor personnel exposure to EtO if the "action level" is exceeded, a prudent conservation laboratory will

undertake careful study of possible adverse effects on the artifacts subjected to fumigation.

3.0. Institutional Applications

3.1. Industrial Applications

EtO is produced by the vapor-phase oxidation of ethylene with air. Manufacture was projected to be 5.2 billion pounds in 1983. It is the source for *ethylene glycol*, *ethoxylates*, and *glycol ethers*. These are used in the synthesis of polyester fibers, films and resins; antifreeze; surfactants and solvents[5]. Perhaps 10 million pounds annually of EtO are used for fumigation.

In the bulk fumigation of grain, the (1:9) EtO/CO_2 mixture is recirculated. This technique was effective with air-tight storage containers: silos, cargo ships and steel railway cars[30]. However, the use of fumigants in transport has declined in the United States. As of 1980, a survey showed that only railroad dining cars were regularly scheduled for EtO fumigation[4]. The range of uses of EtO in fumigation and sterilization is summarized in Table 1.

Table 1: Methods of EtO Fumigation/Sterilization.

Use	Methods[a]
Agriculture	
Bulk Grain	Recirculating
Packaged Food	Vacuum Chamber
Beekeeping	Vacuum Chamber, Atmospheric Chamber
Spices, Nuts, etc.	Vacuum Chamber
Dairy Products	Vacuum Chamber
Research	Vacuum Chamber
Quarantine	Tent/Tarpaulin, No Containment (self-contained)
Cosmetics	Vacuum Chamber
Health Care	Vacuum Chamber, Atmospheric Chamber, Sterijet (single object), Ampule Liner Bag
Medical Products	Vacuum Chamber, Sterijet (single object)
Libraries	Vacuum Chamber
Museums	Vacuum Chamber, Atmospheric Chamber
Transportation	No Containment (self-contained)

[a] Compiled from Goldgraben & Zank (1981); Metcalf & Flint (1962); Munro (1969)[19,29,30].

One of the limitations of EtO for agricultural fumigation is its effect upon the germinating ability of certain seeds and its effect upon seedlings[29,30]. Often plant life is killed or seriously damaged. Also, the EtO may combine with the functional groups in compounds of the food to produce hydroxethylated derivatives[3,37].

In vacuum fumigation, EtO has been used to treat tobaccos, candies, nuts, and packaged-food products[29], spices and seasoning[20] and some dairy products. Bee-keepers use EtO to decontaminate structures[20]. The virtue of EtO for use with food products is its property as a sterilant. This is also made use of in the cosmetics industry where, in 1980, up to 84% of the raw components and 100% of the equipment was treated with 100% EtO[20].

3.2. Hospital Applications

Except for a brief and unsuccessful attempt to use EtO as an anaesthetic in 1924, its use by health services has been limited to fumigation and sterilization[18]. Although other methods of decontamination are used in many cases, EtO provides an absolute toxicity to microbiological life forms where heat-sterilization is not possible[18].

Hospitals use EtO to sterilize surgical instruments, anaesthia supplies, equipment, pacemakers and other devices intended for implementation, reusable supplies, and life-support equipment[18]. Manufacturers of medical products sterilize their equipment with EtO as well. As of 1981, an estimated 80% of the 25,000 surgical items manufactured were treated with EtO[20].

The products industry uses both the vacuum chamber and a single item sterilization system (Sterijet). With the latter method, each item is placed in a pouch which is evacuated, injected with EtO, sealed, and then treated at elevated temperature 50°C for sterilization for 12 hours and aeration for 36 hours[20]. In addition to these methods of sterilization, hospitals utilize 100% EtO with atmospheric chambers and with ampule/liner bag systems[20].

Despite some reports asserting the efficacy of EtO sterilization for medical supplies composed of plastics or rubber, extensive research demonstrates the ability of such materials to absorb EtO[6,18]. Anderson reviewed this problem and found up to 0.6 mg EtO per gram could be retained by Teflon, 0.5 mg/g by polypropylene, and 0.1 mg/g by nylon. Further, natural rubber tubing could retain 16 mg/g EtO, polyvinyl chloride tubing 28 mg/g, neoprene cylinders over 7 mg/g and silicone rubber cylinders over 6 mg/g. The rate of desorption depends upon temperature and surface area; the time involved varies from 8 to 56 hours[1]. These findings confirm other studies, from 1950 onwards, that plastics retain EtO, some in quantities not desorbed for four or five months[18]. In ad-

dition, polyvinylidene chloride tubing is reported to release toxic *ethylene chlorohydrin* up to 6 days after sterilization[18].

3.3. Archive, Library, and Museum Applications

The need for fumigation and use of fumigants has evolved greatly in the present century. Initial usage in archives, libraries, and museums was in response to virulent outbreaks that could not be effectively matched by absolute measures to protect cultural materials or assuage public opinion over reports of biodegradative damage to artifacts[27]. Advances in chemical technology provided the means to achieve this aim[43]. However, it can be argued that improved collections management coupled with the advent of climate control were more important factors in reducing biodegradation in such institutions[19].

Table 2: Museum Fumigation Procedures in 1965 for Paper[a].

Institution[b]	Fumigant	Conc.	Time (Hr)	Temperature	Pressure
1. Brooklyn Museum	$EtO+CO_2$	1%	12	30–50°C	
(New York)	$EtO+CCl_4$	1.25%	12	30–50°C	
2. National Archives	$EtO+CO_2$	10/90%	3		
(Washington D.C.)					
3. Holsteinsches					
Landesarchiv	Formaldehyde	in H_2O		room	normal
4. BN (Austria)	CHN				
5. IRPA (Brussels)	CHN				
6. Royal Library	Formalin		72	30°C	chamber
(Copenhagen)	CS_2				
7. Mus. Lorrain (Nancy)	Formalin		72	30°C	normal
8. Private (Glasgow)	Formalin		48		
	Formalin 40%	10%			
9. British Museum	CHN		48		pressure
(London)	Formalin	40%			pressure
	Chloroform				
10. I. Patologia (Rome)	Methyl bromide			15–20°C	
11. Central Lab. (Vasovie,	$EtO+CO_2$		4	18–22°C	vacuum
Poland)	$EtO+CO_2$		24	20°C	20 mm Hg
12. Central Off. Antiq.	CHN	<6%	24–48	20°C	
(Stockholm)	Methyl bromide		24–48	20°C	
	PH_3	<1.7%	24–48	20°C	
13. Galerie Nat. (Prague)	Formalin	40%	24	18°C	
14. Hermitage (Leningrad)	Methyl bromide	8%	24	13–20°C	400 mm Hg

[a] After (Flieder 1965)[13].

[b] IRPA denotes Institut Royal du Patrimoine Artistique.

In the decades between 1935 and 1965 the fumigants used in cultural institutions became less radical – moving away from *hydrogen cyanide, ethylene chloride/carbon dioxide* and *methyl bromide*. Ubiquitous biostats harmful to the health of personnel became less prominent: *camphor, naphthalene,* tobacco *(nicotine),* and *paradichlorobenzene* were largely discontinued. In 1965, an international survey on fumigation and fungicide treatment confirmed these emerging trends (see Table 2)[13].

Fifteen years later, libraries were indeed presenting a more uniform approach. In a survey of 75 libraries and archives, 35% were fumigating with a form of EtO (see Tables 3 and 4). Another 16% planned to purchase EtO equipment. Five libraries used *p-dichlorobenzene* to control insect infestations. *Methyl bromide* was utilized by only four since leathers and sulfide-processed papers had been found to be effected by this fumigant. Other measures were also utilized. One institution froze items, another used *ethylene dichloride. Thymol* was used by thirteen institutions; contractual fumigation was used by eleven[19].

Subsequently, with the growing of concern over EtO toxicity, many institutions re-examined their programs. An informal 1983 survey showed 36% of fourteen libraries or archives abstaining from fumigation altogether, although over 50% had previously used *ethylene oxide*[39]. An outline of these results is presented in Table 5.

Clearly, there has been a significant shift in treatment strategies. Earlier changes in usage can be attributed to new information on the relative hazards of a particular fumigant to object, personnel, or institution relative to its effective biocidal properties. In the case of EtO the material effects to the object, and knowledge of the fumigant, have largely been in public domain for over two decades.

From the original review by NBS in 1935, the material effects of EtO have been subject to several reviews and investigations. Action against various insects was reviewed by Munro in 1969[30]; its microbiocidal powers, by Phillips and Kaye in 1949[35]. The comparative efficacy of dosage for various stages of insects has been examined[16]. The alkylating nature of EtO was reviewed by Bruch[3]. He noted that objection to the use of EtO in the food industry was due both to the destruction of vitamins and amino acids (niacin, riboflavin and folic acid) and to the concomitant hydrolytic residues such as *ethylene* and *diethylene glycol* formed when foods were sterilized with EtO[3].

The long-term visual, chemical, and physical effects of EtO fumigation have been known to conservators, archivists, librarians, and scientists for a number of years. Just as the critical importance of fumigant concentration multiplied by

Table 3: Survey of Fumigation Procedures in U.S. Libraries in 1980*.

Library	EtO in use	EtO to be used	Have chamber (not yet in use)	Methyl Bromide	Paradi-chloroben-zene	Other Techniques (including Thymol)	Commercial/ Contract Fumigation	No Method (inhouse)
Public Archives:								
Colorado Archives and Publ. Records								+
Delaware Bureau of Archives & Records			+					
Florida Dept. of Archives	+							
Georgia Dept. of Archives						+		
Maine State Archives	+							
Maryland Hall of Records			+					
National Archives	+				+		+	
New York State Library			+					+
North Carolina Archives & Records Section	+							
New Jersey Bureau of Archives & History		+	+					+
Pennsylvania State Archives	+							
South Carolina Dept. of Archives & History Records Section	+					+		
Tennessee State Library				+				
Texas State Archives			+					+
Washington State Archives			+					+

Table 3: (cont).

Library	EtO in use	EtO to be used	Have chamber (not yet in use)	Methyl Bromide	Paradi-chloroben-zene	Other Techniques (including Thymol)	Commercial/ Contract Fumigation	No Method (inhouse)
Research Libraries:								
Folger Library		+				+		
Huntington Library				+		+		
Newberry Library		+				+		
Pierpont Morgan Library					+			
Public Libraries:								
Boston Public Library**								+
Brooklyn Public Library**								+
Chicago Public Library**							+	+
Cleveland Public Library**								+
Library of Congress**	+							
Los Angeles County Public Library**								+
New York Public Library**					+	+		
University Libraries:								
Barry College		+	+				+	+
Brigham Young University			+					
The City College New York		+	+					
Columbia Univ.**					+			
Cornell Univ.: Labor-Management								

Table 3: (cont).

Library	EtO in use	EtO to be used	Have chamber (not yet in use)	Methyl Bromide	Paradi-chloroben-zene	Other Techniques (including Thymol)	Commercial/ Contract Fumigation	No Method (inhouse)
Documentation Center**	+							
Georgia State University							+	+
Harvard Univ.**	+			+		+		
Johns Hopkins Univ.		+				+		
Memphis State Univ.	+							
Northwestern Univ.							+	+
Pennsylvania State Univ.	+							
Princeton Univ.:								
Rare Book Collection					+			
General Collection	+							
South Methodist University:								
Degolver Foundation Lib.								+
Bridwell Lib.							+	+
Stanford Univ.:**								
Special Collections						+	+	
Hoover Institute	+							
State Univ. of New York						+	+	
Univ. of Arizona		+	+					
Univ. of California, Berkeley**						+		
Univ. of California, Los Angeles**	+			+				
Univ. of Chicago**						+		
Univ. of Georgia								+
Univ. of Houston	+							
Univ. of Illinois at Urbana Champaign**						+		

Table 3: (cont).

Library	EtO in use	EtO to be used	Have chamber (not yet in use)	Methyl Bromide	Paradi-chloroben-zene	Other Techniques (including Thymol)	Commercial/ Contract Fumigation	No Method (inhouse)
Univ. of Iowa						+		
Univ. of Louisville	+							
Univ. of Michigan	+							
Univ. of Minnesota**								+
Univ. of South Florida	+							
Univ. of Tennessee								+
Univ. of Texas at Austin**			+			+		
Univ. of Utah	+							
Washington Univ.							+	+
Wayne State Univ.	+							
Yale Univ.						+		
Historical Societies:								
American Antiquarian Society	+							
Atlanta Historical Society						+		
Chicago Historical Society	+							
Iowa State Historical Society	+							
Massachusetts Historical Society	+							
Ohio Historical Conservation Center						+		

Table 3: (cont).

Library	EtO in use	EtO to be used	Have chamber (not yet in use)	Methyl Bromide	Paradi-chloroben-zene	Other Techniques (including Thymol)	Commercial/ Contract Fumigation	No Method (inhouse)
Wisconsin State Historical Society	+							
Other Libraries:								
IBM Archives			+					+
Christian Science Center	+							
Medical & Chirurgical Faculty of the State of Maryland							+	+
Mormon Church Historical Library								+
New England Document Conservation Center	+							
New York Academy of Medicine Library								+
Total: 75	27	7	12	4	5	18***	10	23

[a] After Goldgraben (1980)[19].

** Library contains 3.5 million volumes, or more.

*** Thymol was the method used in 13 institutions.

Table 4: U.S. Library EtO Fumigation Procedures, Survey 1980[a].

Institution[b]	Equipment (ft^3)	Gas exhaust	Removal flush	Aeration (hr) d opening	Aeration (hr) d shelving[d]	EtO monitor	Inspection
Chicago H S	Vacudyne (18)	via hose	1 pv[c]	1–24	no	no	no
Harvard Univ	Vacudyne (18)	via pipe	1 pv	1–48	no	no	no
Hoover Inst	Vacudyne (100)	via pipe	2 pv	–	no	no	occasional/no
Library Cong.	Devine (420)	via pipe	2–3 pv	–	no	yes	yes
ME St Arc	Vacudyne (90)	H_2O wash	2–3 pv	6–24	–	no	no
MA H S	Vacudyne (18)	–	1 pv	24	no	no	yes, biannual
Nat Arch	Guardite (300)	via pipe	1 pv	several	no	no	no
New En. Doc	Vacudyne (100)	via pipe	1 pv	no	no	no	no
NC Arc Rec	Vacudyne (300)	–	1 pv	12	no	no	no
PA St Arc	Vacudyne (270)	–	3 pv	no	no	no	no
PA St Univ	Vacudyne (18)	via pipe	1 pv	several	no	no	no
WI St H S	Vacudyne (300)	–	1 pv	several	no	no	no

[a] After Goldgraben & Zank (1981)[20].

[b] HS denotes Historical Society; St State; ME, Maine; MA, Massachusetts; NC, North Carolina; PA, Pennsylvania; WI, Wisconsin.

[c] pv denotes post vaccum.

[d] d denotes delay after fumigation.

Table 5: U.S. Library EtO Fumigation Procedures 1983 Survey[a].

Institution[b]	Fumigate	Method	Current	Future	Type	Other
Brigham Young	yes	EtO	–	?	Vacudyne	thymol
Columbia Univ.	no	–	–	freezer	–	–
PSU	yes	12% EtO 88% Freon	–	–	Vacudyne	–
UC (Davis)	no		–	–	–	–
Dartmouth Coll.	yes	EtO/Oxyfume 12	–	–	Vacudyne	–
Stanford Univ. (at Hoover)	yes	EtO	–	freezer?	Vacudyne Vacufume 100	thymol (leather?)
UM	yes	EtO	–	orthophenyl-phenol		–
Cornell Univ.	yes	EtO	ok[d]	ok.3x vacuum clearance 3.69 ppm/5 hrs.	Vacudyne	–
Am. Antiquarian Society	yes	EtO	ok	relocate	–	–
NYU	yes	freezer	?	freezer?	–	–
SUL	no	no	no	–	–	–
Rutgers Univ.	no	no	no	–	–	–
Princeton Univ.	yes	no	no	–	–	–
Yale Univ.	yes	thymol	blast freezer	Vacudyne	–	thymol

[a] Compiled from (Strassberg 1983)[39].
[b] PSU denotes Pennsylvania State University; UC, University of California; UM, University of Michigan; NYU, New York University.
[c] ? denotes uncertain.
[d] ok denotes current procedures deemed adequate.

hours of exposure has been reported in the literature as crucial to effective fumigation[30] and sterilization[3], so have these factors been confirmed in the library and archival literature[12]. The need for moisture – above 33% – in vacuum sterilization and the influence of an object's moisture content were reported in 1964[17]. Unpublished observations have confirmed the care required in packing the artifacts to be fumigated to avoid condensation[32]. Similarly, the factors of temperature and of the presence of chlorine salts on the object are taken into account. Specific studies to observe chemical and physical effects on archival materials have been undertaken where broader topics in the literature failed to satisfy conservation inquiries. A comprehensive literature survey of reported materials damage effects due to EtO exposure has been prepared by Erhardt[10]. Bard[2] has reported on fumigants for use with photographic materials.

Flieder and co-workers[14] investigated the effect EtO fumigation on vegetable-tanned calfskin, sheepskin and goatskin, as used in book-binding. In this study, samples of the leathers were treated with EtO, formaldehyde, and gamma-hexachlorocyclohexane (lindane). The samples were aged artificially under ultraviolet light, xenon light-fading, by hydrogen peroxide oxidation, and with dry heat. They were then examined for mechanical (tear, pull and bursting tests) and chemical stability. The latter included quantifying the water content, lipid content, extractable nitrogen content, and the pH. By these tests, EtO proved a satisfactory and successful fumigant. However, EtO residue held by the lipid content of the leathers after fumigation and after "normal aeration" was not measured. Lipids or fats are said to retain EtO at high levels[25].

The correlation of ambient or environmental effects with those to the unharmed object of treatment are only now being made. Hengemihle *et al.*[22] have recently noted that the out-gassing of ethylene oxide is related to the density of the material fumigated, as well as to its chemical composition. Thus, a thin leather binding will be able to release residual EtO more quickly than a solid book or compressed, wound movie film[22]. Yet, the source of concern, is predicated less upon the problem of damage to the object than upon the assessment of the potential damage of the treatment to humans.

4.0. Ethylene Oxide Risk Management

4.1. Exposure Control

Given the possibility that the preservation of the object can be potentially damaging to one's health, the containment of this risk becomes obligatory. There are several factors that can be utilized to reduce this danger. These factors include: the maintenance and improvement of the containment and release of

EtO within the fumigation chamber itself; the reduction of the levels of EtO in the workplace environment; and the improvement of operator practices and medical surveillance. A survey of twelve archives and libraries using EtO in 1980 showed only two with regular inspection programs to check the fumigation facility; a third library had occasional checks (Table 4)[20].

According to a 1980 survey of industry, health care, and museum and library fumigation-sterilization facilities using EtO, museums and libraries had the lowest record of implementing or maintaining the equipment and the workplace environment, and of monitoring EtO exposure[20]. In order for museums and libraries to comply with the OSHA final standard of 1 ppm time-weighted average concentration for an 8-hour exposure, they must rectify these shortcomings[33]. Annual inspections of the equipment by a representative of the manufacturer are encouraged not only to assess the condition of the fumigation chamber, but also to determine the quality of on-going routine maintenance by in-house personnel.

Mechanical difficulties, condensation inside the chamber, faulty timing devices or other operating deficiencies require prompt attention. Leakages from faulty valves, for example, contribute to an ambient level of 10–100 ppm EtO at the end of the fumigation cycle. In one institution during the summer of 1981 concentrations above 2000 ppm were noted[15].

A supply line valve, close to the tank connection, can be installed to minimize the bleeding in the gas line when empty cylinders are replaced. These are known as check valves. In addition, a ventilation connection should be made to the pressure relief valve. Should the chamber's pressure exceed the specification, connection to the ventilation of the pressure relief valve will prevent the EtO contents of the chamber from being released to the workplace. In addition, the chamber purge systems and ventilation systems should be carefully examined and upgraded. The 1980 survey showed eight of the twelve vacuum chambers operated only one post-vacuum flushing, the others did two to three (Table 4)[20].

There are three basic methods to reduce ambient EtO after fumigation. First, the entire fumigation cycle can be rerun several times without introducing EtO into the chamber. These post-vacuum exhausts can be an effective means to purge the contents of the fumigation chamber of residual EtO. Since the off-gassing or desorption of EtO is temperature and time dependent, the use of post-vacuum exhausts should be run over a period of time (days). Such a technique is favored by pharmaceutical companies and other medical product industries where identical items can be evaluated for their rates of EtO desorption and a standard procedure instituted[28].

Another method is to retro-fit existing chambers with internal external ventilation systems. These are now standard with new 100 cubic foot Vacudyne chambers, and can be installed in other chambers and older models. A blower is set outside the building and connected to the back of the chamber. Automatic switches start the blower when the door to the fumigation chamber is left ajar. In this way clean air from the surrounding area is introduced to the chamber and EtO levels in the chamber are exhausted. On the large 100 cubic foot model, additional exhaust ports are used and the duration of the cycle selected (i.e., 1 hr, 4 hrs)[28].

With such a ventilation system some care must be taken that the intake of air to the overall room and the exhaust from the chamber are dedicated units. The maintenance of a slight negative pressure in the room relative to other, adjacent rooms will insure that a back-wash of out-gassing of EtO cannot occur when the ventilation is turned off.

A third system to deal with the desorption of residual EtO employs a separate aeration chamber. After the post-vacuum evacuations and/or internal external ventilation the objects are removed from the fumigation chamber to a holding area with a dedicated ventilation system at normal temperature but again, slightly less pressure than surrounding workplaces. Objects are held here for a period of time; days, weeks, months to insure that the EtO has desorbed to acceptable levels. These are also used in conjunction with the sterilization of medical items that retain EtO[20].

4.2. Workplace Practices

Although the greatest effort must be made to contain the EtO at its source, the fumigation chamber, and its subsequent exhaust, efforts must also be made to control access to the areas pertaining to the use of EtO. These areas must be restricted to authorized personnel. Moreover, formal, written protocols should be established for various operations: maintenance procedures, changing of supply line filters, leak detection inspection; schedule of fumigation, post-vacuum evacuations, door opening, internal-external ventilation cycles, chamber unloading procedures, transferring to aeration chambers, re-storage. Spill, leak, and disposal procedures should be clearly outlined. Emergency measures should be posted, emergency equipment clearly designated, protective clothing for standard and for emergency use both supplied.

Only fully trained, licensed operators should have access to operate the chamber. OSHA requires the employer to provide exposure information and training to the employee at the time of the initial assignment, and on an annual basis thereafter[33]. This precludes two potential hazards: delegation of responsibility to junior or unauthorized staff; and operation of the chamber by authorized personnel without cognizance of all protocols.

4.3. EtO Exposure Monitoring

In order to determine the quantity of EtO present in the chamber, Vacudyne, for example, is preparing to install an EtO monitoring device with a new 100 cubic foot chamber; this system could be retrofitted on existing fumigation chambers of all sizes[28]. The installation of such a system is recommended. Manual attempts to monitor the interior of the chamber constitute a source of short-term EtO exposure to personnel, paradoxically defeating the effect of the monitoring. At least one in-house attempt to install a monitoring device has been subverted by the failure to use only non-EtO absorbing materials[34].

In promulgating its recent 1 ppm 8-hours TWA exposure limit, OSHA summarized several EtO monitoring systems considered accurate at measuring 1 ppm EtO within ± 25%. These include: OSHA's method 30; NIOSH's adaptation of the OSHA method; the Gazi-Ketcham method; the Miram infrared spectrophotometer; the 3M model 3550 passive dosimeter, and the DuPont Protek Dosimeter[33]. The first three collect EtO with activated carbon, desorb it with carbon disulfide, and analyse it by gas chromatograph[33]. The Miram IR analyser is a direct reading instrument and can be used to check for leaks, static areas of maximum concentration, and ambient levels of EtO. Lapel badges of Dupont and 3M collect EtO for subsequent analysis and can serve to provide as employee personal monitors[33]. Additional monitoring techniques, e.g., the portable photoionization gas chromatographs, can sample numerous points sequentially for EtO leaks, air pockets of high EtO concentration, and ambient levels[7].

Such monitoring devices are recommended for all operating fumigation chambers and personnel. EtO itself does not produce a recognizable ether-like odor below concentrations of 700 ppm, nor does it cause eye irritation below 500 ppm[33]. The "worst case" reading of an 18 cubic foot Vacudyne fumigator by the firm's personnel was 450 ppm at a level nine inches above the chamber floor at the completion of the cycle. At normal standing height, the "worst case" was 150 ppm[28]. These are both less than humanly detectable, yet over acceptable levels.

In addition to internal chamber monitoring and external ambient monitoring of EtO levels, other monitoring systems should be instituted. The new OSHA guidelines require medical surveillance of employees exposed to EtO at or above 0.5 ppm for 30 days/year. Specifically, every medical examination must include: medical and work histories, especially symptoms to skin, eyes, reproductive systems, pulmonary, hematologic, or neurologic systems; complete blood tests involving a white cell count (also differential cell count), red blood count, hematocrit, and hemoglobin. Pregnancy testing or an evaluation of fertility should be done at the employee's request. Moreover, OSHA urges an evaluation of the cardiovascular function and the pulmonary function[33].

Finally, positive pressure respirators and protective clothing are required. Although the use of a respirator cannot be used to avoid compliance with the 1 ppm level, OSHA has deemed it necessary for emergencies and for certain, restricted maintenance operations[33]. The use of these devices, together with the entire operation of the cycle, its venting procedures, aeration, loading and unloading, and maintenance procedures should be logged into a journal with the observed EtO levels.

4.4. Exposure Reduction

The total amount of EtO used in an 18 cubic foot Vacudyne fumigation chamber cycle is 0.3 lbs; in a 36 cubic foot, 0.6 pounds; in the 100 cubic foot, 2.2 pounds. By contrast, an 800 cubic foot medical sterilizer will consume 33 pounds of EtO[28]. Yet a comparison of available data on EtO exposures between archival or museum workers and those of medical facilities do not reflect a comparable differential.

A NIOSH sponsored study of hospitals in 1977 show generally concentrations below 50 ppm TWA in the employee's breathing zone in front of sterilizers and/or aerators. Ambient air samples were 1–2 ppm although short term exposure (less than 15 minutes) did reach 75 ppm. The highest observed exposure was a 460 ppm lasting for 1 minute after opening a sterilizer door[18]. More recent surveys cited report variously, 62.9% (1978–1983), 75% (1982–1983), and 88% compliance with a 1 ppm TWA in southern California hospitals. Over the country, 40% of the hospitals currently meet the new OSHA standard.

Libraries and archives cannot provide similar records due to a lack of monitoring and surveillance. Of the eight institutions that fumigated with EtO in 1983, only two in the survey provided even ambient EtO levels. One found 3 ppm EtO upon opening its chamber door after its cycle; the dedicated ventilation of its fumigation room is flushed 15 times/hour. Another found 3.69 ppm TWA in a 15 foot radius of its chamber[39].

4.5. Cost Considerations

The initial costs to lower EtO exposure in institutions with small chambers may reach $6,400 to $12,600; those libraries or museums with larger chambers may require an investment of $15,800 to $19,500. Part of these costs depend upon the existing conditions at an institution. Recurring costs, exclusive of the

Table 6: Estimated Costs ($) as a Result of Implementing Control Measures, 1983–1984[a].

Equipment	Library Initial	(10 cu. ft.) Recurring	Museum Initial	(100 cu. ft.) Recurring
Maintenance contract	400+	400+	400+	400+
Gas link check valves	30–60	30–60	60–120	60–120
Retrofit internal external exhaust ventilation system	4,000	n.a.	6000–6500	n.a.
Internal monitoring	(7,000–10,000)	–	(7,000–10,000)	–
Environment				
Dedicated ventilation of room	various	–	various	–
Aeration chamber	various	–	various	–
Alarm Monitor (minimum)	500	–	500	–
Personnel				
Training	400+	(400+)	400+	(400+)
Medical Surveillance	300–400	300–400	600–800	600–800
Employee Monitor	unknown	unknown	unknown	unknown
Positive Pressure Full Face Respirator	800	various	800	various
Protective Clothing	various	various	various	various
Known Totals	6,420+–12,560+	630+–1260+	15,760–19,520	1,060+–1,320+

[a] Mathews, R. J. (Sales Manager, Vacudyne, Inc.)[29] Private communication with author (MWB) July 25, 1984; Goldgraben, R. *The Costs of Measures Used to Mitigate Worker Exposure to Ethylene Oxide* McLean, Va: Mitre Corporation, Aust, 1981 MTR–81W203.

[b] (+) does not include transportation to and from Chicago, Illinois.

functioning of the chamber itself, would be considerably lower, in the range between $600 and $1,300 (Table 6)[33].

Those industries using EtO as a sterilant face annualized compliance costs from $1,500 to $131,000. The effect per employee among the spice manufacturers, hospitals, and medical equipment manufacturers is estimated to be $1,000, $270, and $3,300, respectively[33].

5.0. Conclusions

The use of EtO as a fumigant in museums, libraries and archives presents an excellent case for risk assessment and risk management. In reviewing recent regulatory action and the literature associated with both human and materials

exposure it is clear that some questions require answers before a proper risk management strategy can be developed. Further information is needed on dose-response relationships for materials damage caused by exposure to EtO under the normal conditions of fumigation. Desorption rates must be determined for the range of materials encountered in conservation practice. Given the sharply reduced OSHA exposure standard, personal monitoring should be instituted for affected laboratory staff.

In the absence of comparative human and materials dose-response relationships for EtO and possible replacement fumigants and thus given an inadequate knowledge of possible exposure risks to staff and collections, it would be imprudent to substitute some other fumigant system simply because our knowledge of health and materials effects for systems other than EtO is insufficient as to permit strict exposure standards.

6.0. Summaries

Ethylene Oxide Fumigation: Results and Risk Assessment

Ethylene oxide fumigation involves three distinct issues: the risk to personnel and institutions due to its use; the relative efficacy of ethylene oxide as a fumigant, and the chemical hazard to the artifact. Legislative history in the U.S.A., regulatory status, and individual institutional practices associated with EtO use are reviewed. Estimated costs in modifying existing fumigation methods such as the costs of leakage reduction, lowered exhaust levels, and improved recovery systems are outlined as are those for EtO monitoring systems. A comparison of EtO effective dosages to other fumigation systems is made. Potential hazards to paper artifacts are discussed. An approach to the evaluation of these issues is suggested.

Fumigation par l'oxyde d'ethylene: resultats et evaluation de son risque

La fumigation par oxyde d'éthylène amène à trois questions distinctes: le risque du à son emploi encouru par le personnel et les établissements, l'efficacité relative de l'oxyde d'éthylène en tant que produit fumigatoire et le risque chimique d'artefact.

La législation, les règlements et les pratiques individuelles des établissements liés à l'utilisation de l'oxyde d'éthylène sont en train d'être révisés. Les coûts estimatifs quant à des modifications des méthodes de fumigation existantes, tels que coûts de réduction des fuites, de réduction des niveaux d'échappement et d'amélioration des systèmes de récupération sont ébauchés comme le sont ceux des systèmes de controle de l'oxyde d'éthylène. Une comparaison de dosages effectifs en oxyde d'éthylène par rapport aux autres systèmes de fumigation est entreprise. Les risques potentiels d'artefact dus au papier sont discutés. Nous suggérons de s'orienter vers une évaluation de ces résultats.

Vergasung mit Äthylenoxid: Resultate und Einschätzung von Gefahren

Die Vergasung mit Äthylenoxid bedeutet die Konfrontation mit drei Gegebenheiten: Gefährlichkeit des Gases für den Menschen, seine Wirksamkeit gegen den biologischen Schaden, gegen den es eingesetzt wird, und den möglichen Einfluß, den es auf das behandelte Kulturgut hat. Es wird über die auf Äthylenoxid bezügliche Gesetzgebung in den U.S.A., über Anwendungsvorschriften und über die Praxis der Anwendung berichtet. Die bei einer in der üblichen Weise durchgeführten Vergasungsaktion zu erwartenden Kosten und Möglichkeiten der Kostensenkung werden besprochen, z.B. durch besser Abdichtung gegen Gasverlust, geringeres Vakuum und verbesserte Gasrückgewinnung. Ebenso skizziert werden Meßsysteme für die Gaskonzentration in der Kammer. Die Wirksamkeit der Äthylenoxid-Vergasung bei verschiedenen Konzentration wird mit anderen Vergasungstechniken verglichen. Mögliche Gefahren für das behandelte Material werden besprochen. Zum Schluß wird vorgeschlagen, wie eine Bewertung der genannten Faktoren erreicht werden kann.

7.0. Acknowledgements

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An Evaluation Method of Softening Agents for Parchment

by GIUSEPPE CALABRÒ, MARIA TERESA TANASI & GIANCARLO IMPAGLIAZZO

Among the various problems concerning the preservation of documents on parchment, one of the most important is that of the stiffness and consequent fragility acquired by such a support, not only due to calamitous events but also to the simple effect of aging.

In view of the importance and urgency of such a problem, it was decided to research this matter. Since no previous work had been made on this specific topic in our laboratory and since information available in the literature was scarce, it was considered necessary to first work out the operative method which would permit an evaluation of the effects produced by softening agents on parchment.

Stiffness was chosen as the most significant characteristic in order to control and evaluate these effects.

For our purpose it would therefore be necessary to evaluate such a property on the same sample, before and after the use of the softening agent under examination: should the sample show signs of permanent plastic deformation during the execution of the test, it would then be necessary to carry out tests only after treatment with the softening agent, and rely on an indirect method to obtain a non-experimental evaluation of the initial rigidity.

The measurement of the rigidity can be carried out by means of either a stiffness tester or by a conveniently adapted dynamometer whose advantage lies in its widespread use in technological laboratories. Both instruments were utilized in our experiments, with the aim to appraise their respective practical validity and the comparisons between the measurements carried out.

Dynamometer

An accessory was therefore designed and built (Fig. 1a), suitable to be applied to a vertical dynamometer. This appliance works as follows: a sample of parchment, with dimensions suitable for the stiffness evaluation with both types of instruments (3.8 × 5 cm), is introduced in the small frame A fixed to the lower clamp B of the dynamometer. The sample under test is therefore held at the two extremities by the frame but is left free to shift when it is forced upwards by a stirrup C connected to the upper clamp D of the dynamometer and which

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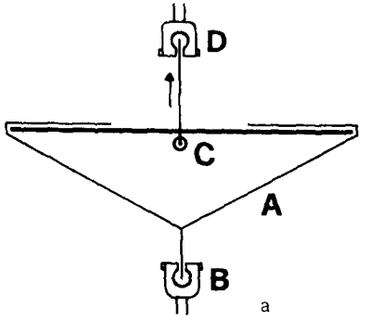

Fig. 1a. Accessory applied to a dynamometer, for stiffness measurement.

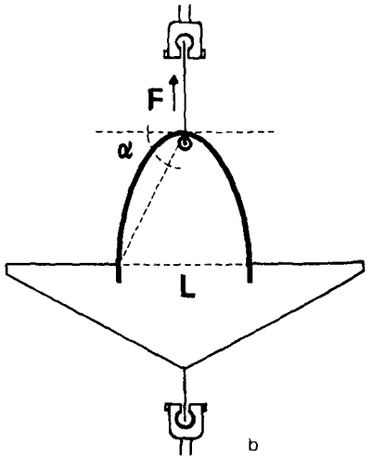

Fig. 1b. Operation scheme of the accessory applied to a dynamometer.

acts on the middle of the sample. The traction of the stirrup causes the bending of the sample (Fig. 1b) until it leaves the frame. The bending moment or otherwise the maximum applied load given by the instrument, multiplied by its arm, is taken as the stiffness value of the sample. In this type of appliance, in order to calculate the bending moment, only one half of the load F given by the dynamometer should be considered; moreover, the value of the arm corresponds to one half of the distance L between the fixed points of the frame supporting the sample. Therefore: Rigidity = F × L/4, where rigidity in the SI international system is expressed in milliNewton × meter (mN × m).

Stiffness Tester

The stiffness tester is an instrument expressly designed for this type of measurement. In this specific case, a Lorentzen and Wettre type 16D stiffness tester (Fig. 2a) was used. The equipment consists of a clamp with a vertical margin to which a sample of standard dimensions (3.8 × 5 cm) is fixed with the longer side horizontal. The clamp, operated by a motor, can rotate a variable angle around a vertical axis which coincides with the margin of the jaws. A vertical wedge, connected with a load-cell, can be moved with a knob till it grazes the sample; it can be fixed at a variable distance from the margin of the jaws. Also in this case, the value of the bending moment, i.e. the resistance F' of the sample to the bending, multiplied by the arm L', is taken as the stiffness value. Due

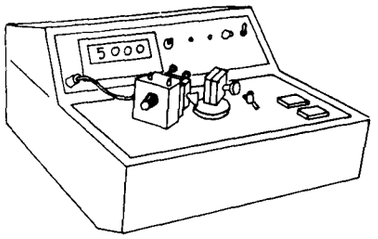

Fig. 2a. Lorentzen and Wettre type 16D stiffness tester.

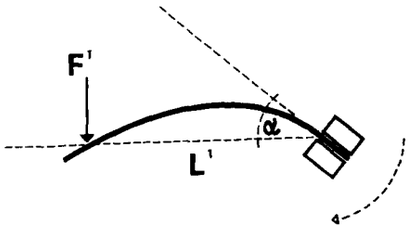

Fig. 2b. Operation scheme of the stiffness tester.

to the geometry of this apparatus (Fig. 2b), the arm is given by the wedge-jaws' distance and the force F' must be taken entirely. Therefore, Rigidity = F' × L'.

Problems of Parchment

The actual carrying out of the measurements, however, set forward a series of problems concerning the anisotropy and heterogeneity of the parchment.

As for the anisotropy, in order to avoid an excessive number of samples, it was decided to test only one direction and only one side of the parchment, arbitrarily chosen.

As far as the heterogeneity of samples, a problem deriving from both the variability of thickness and the anisotropy of the parchment, an attempt was made to overcome the problem by relying on a non-random method of sampling. Six or more rectangles were obtained from each parchment (depending on its size) with the longer sides parallel to the spine of the animal and taking care to exclude parts of the legs, the neck, the spine itself and any other part with manufacturing defects such as superficial abrasion, thinned parts and holes caused by skin parasites. From each rectangle a given number of samples of standard dimensions (3.8 × 5 cm) were obtained; the samples were then grouped in series, so that each series included a sample from each rectangle; in this way a single series was representative of the whole parchment.

Preparations of Samples

Since the parchments used in these tests were of recent manufacture, and modern production methods often differ from the old ones because of the addition (as verified by a qualitative investigation) of foreign substances like fats, plastics, etc., it was necessary to treat the samples with proper solvents before carrying out the stiffness tests. Isophorone (3,5,5-trimethyl-2-cyclohexen-1-one),

acetone, diethyl ether, chloroform and a hydroalcoholic solution (60% ethanol) were used in that order. The samples were washed in each solvent for 2 h.

Parchment is an extremely hygroscopic material; therefore the environmental relative humidity (R.H.) and temperature strongly influence both its weight and the technological characteristics: in particular, small variations of R.H. cause small variations of the weight but a larger one of the rigidity. A preliminary study showed that the parchment reaches equilibrium with the environment only after 48 h; therefore, before carrying out any measurement, the samples have to be conditioned for this period of time at 23°C and 50% R.H.

Limitations

The dynamometer stiffness tests have shown the lack of sensitivity of the instrument; by using this method it is, therefore, necessary to utilize thick and stiff samples and to keep a limited distance between the fixed supports. The bending angle (Fig. 1b) will then be rather wide (in our appliance, it is close to 65°).

As for the choice of the side, since the parchment tends spontaneously to curve with the papillary layer on the inside, in order to have a greater resistance, the samples were placed in the frame in such a way that the stirrup touches the reticular layer. Samples that are too curved have to be rejected in any case.

The bending with the dynamometer, under the described conditions, causes plastic deformations of the parchment. In effect, by repeating the tests on the same samples, different and smaller results were obtained; for this reason it was not possible to carry out the measurements on the same sample before and after softening.

Therefore, in order to know the initial value of the rigidity, we tried to use a series of samples not treated with softening agents, from which to derive an average value of rigidity to be taken as a reference for the following evaluation of the softening effect on a different series of samples. The high dispersion found in the average rigidity values of different series, due to the heterogeneity of weights and thicknesses of the samples, have brought, however, scarcely significant results.

Relationship

These results have induced us to investigate the possibility to find out a relationship between stiffness and thickness or between stiffness and weight.

From the plotting of a great number of measurements carried out on different

parchments, it was shown graphically that it is not possible to obtain a valid correlation between rigidity and thickness; in effect, the difficulty to obtain an exact evaluation of the thickness of the curved samples and the use of partially calendered parchments led to values of little reliability.

On the other hand a good correlation was found between rigidity and weight. By plotting log R (R = Rigidity in mN × m) in function of log W (W = Weight in grams of the parchment sample) we get indeed a straight line (Fig. 3-curve a), in agreement with the relationship $R = a\,W^b$ where "a" and "b" are constants whose values are 135.17 and 2.39, respectively, in the case examined by us.

Thus, by means of the relationship just given, it is possible to calculate the initial value of stiffness from the weight of each parchment sample; this stiffness value will be confronted later with the experimental value taken after the softening treatment.

Sensitivity

The use of the stiffness tester, which has a larger sensitivity, has allowed to choose less servere test conditions and, in particular, to reduce the bending angle. The experimental conditions utilized for the rigidity test are: 25 mm as the

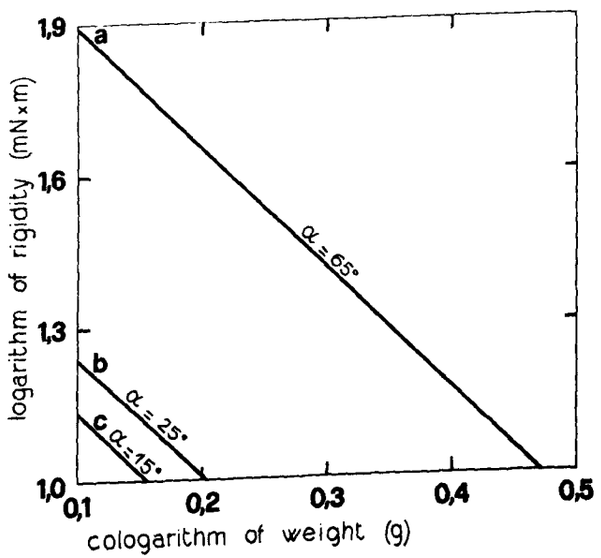

Fig. 3. Relationship between rigidity and weight of parchment samples at different bending angles.

distance wedge-clamp and 25° as the bending angle; as to the choice of the side, the parchment sample is inserted in the clamp in such a way that the wedge is in contact with the reticular layer. This choice was determined by the fact that the possible width of the initial adjustment of the measuring wedge, which tends to bring the wedge itself in contact with the sample, is not symmetrical in the two directions; therefore, in the case of very curved samples, the compensation of the initial curvature is possible only when the latter is directed outside.

An important point in favour of the stiffness tester, is that if the apparatus is utilized under the described conditions, it allows the compensation of the initial curvature of the sample and the use of smaller bending angles. In spite of the reduction of the bending angle, the experimental tests have shown that even in this case the test leads to irreversible plastic deformations. A correlation between rigidity and weight had therefore to be applied also in this case, as previously described.

By plotting the logarithms of the stiffness values as a function of the logarithms of the weights of the samples, also in this case it is possible to draw a straight line (Fig. 3-curve b), which appears to be parallel to the one obtained with the dynamometer. In the case of the stiffness tester, the equation of the power curve results as $R = 30.21\ W^{2.37}$.

Therefore, with the stiffness tester a power curve is obtained equivalent to that of the dynamometer; this is because the values obtained with the two instruments are proportional to each other. The proportionality factor depends on the measurement conditions and on the mechanical characteristics of the instruments. This kind of curve has, therefore, a general validity for different parchments and different instruments.

Bending Angle

The practical execution of the tests showed that the sensitivity of the stiffness tester was exorbitant with respect to the samples examined; therefore it was decided to try experimental conditions in which the bending angle, although quite limited in order not to cause irreversible deformations of parchment, could still permit significant results. More particularly, it has been shown that by keeping constant the 25 mm distance between the margins of the clamp and the measuring wedge, a 15° bending angle meets such requirements. It was then decided to carry out a sufficiently ample experiment in order to confirm in a statistically significant way that the 15° bending does not cause permanent modifications of the parchment and therefore the repetition of the bending test on the same sample results in the exact repetition of the stiffness value, within the repeatability limits of the method.

These experiments, which were in line with our expectations, supplied the data for the plot of a new curve similar to the former two: the resulting straight line (Fig. 3-curve c) is, once more, parallel to the ones before and satisfies the equation $R = 23.47\ W^{2.38}$.

This result confirms the general validity of the power relationship between the stiffness and the weight of parchment, where the exponent "b" always remains constant, at least until we use different parchments but of the same kind, manufacture and age, while the coefficient "a" seems to be tied to the geometrical conditions of the test.

With the aim to investigate the dependence of the coefficient "a" on the geometrical conditions of the test, in particular on the bending angle, as the distance wedge-clamp enters in the calculation of the bending moment and the sample dimensions are kept constant, two other series of rigidity measurements were carried out with the stiffness tester, in order to have available a larger number of data.

The values of the chosen angles were 30° and 20° for which were found respectively the two equations: $R = 37.46\ W^{2.42}$ and $R = 25.90\ W^{2.39}$.

A plot of the values of the coefficient "a" as a function of the tangent of the bending angle α gives, with a good approximation, a straight line (Fig. 4), which corresponds to the equation $a = 66\ tg\alpha$.

Therefore, the power curves which correlate the stiffness to the weight of the parchment standard samples can be described by a single expression: $R = 66\ tg\alpha\ W^{2.39}$, where 2.39 is the average value of the exponent "b" in the five series

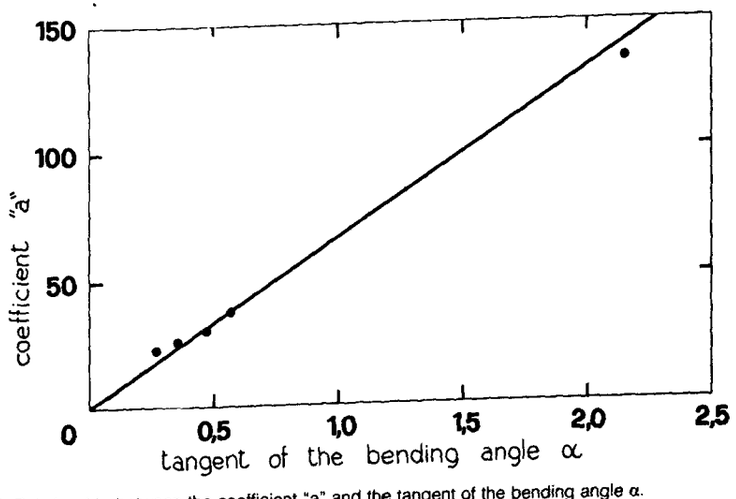

Fig. 4. Relationship between the coefficient "a" and the tangent of the bending angle α.

of measurements. Now we can calculate the theoretical stiffness values, given only the angle α and the weight of the samples that will be later utilized for the bending tests, after the treatment with the softening agent.

Naturally, it is evident that, also if the general form of the above reported expression could remain valid, the particular coefficients found will fit only to one kind of parchment and cannot have any general validity. Moreover, also within the limits of one kind of parchment, it is supposed that the above reported expression tends to be less strictly valid as we gradually move away from the reversibility field of the measurements and thereby as the angle α gradually assumes greater values.

However, we wish to point out that, as long as we utilize the stiffness tester with a 15° bending angle, it is not necessary to apply the equation found in order to get the initial rigidity of a sample because the stiffness test does not cause any plastic deformation: therefore it is possible, and anyway preferable, to repeat the measurements on the same sample before and after the treatment with the softening agent to be taken under consideration.

Softening Effectiveness

After the evaluation method of the softening effect was settled, our attention was then turned toward finding a method to characterize the different softening agents by expressing their effectiveness in numerical terms.

The softening undergone by a parchment can be evaluated by calculating the difference between the stiffness before (R_i) and after (R_f) the treatment, with reference to the initial stiffness value: $(R_i - R_f)/R_i = \Delta R/R$ (*softening effect*).

The value of R_i can be either theoretically found, by means of the above reported power equation, or measured by utilizing the stiffness tester with a 15° bending angle and a 25 mm wedge-clamp distance.

Obviously, the evaluation of the softening effectiveness of a substance cannot neglect the role played by the quantity of softener absorbed, a quantity which can be measured by the weight increase in each sample: $(W_f - W_i)/W_i = \Delta W/W$. Of course, the softening effectiveness increases with the increase of the $\Delta R/R$ values for a given $\Delta W/W$ and with the decrease of the $\Delta W/W$ value necessary to get a given $\Delta R/R$.

At this point it seemed advisable to visualize the plot of the softening effect as a function of the relative quantity absorbed, for a given product, in order to evaluate whether the softening effectiveness (ratio between $\Delta R/R$ and $\Delta W/W$) remained constant and could be expressed by a single numerical value, or underwent sensible variations in relation to the quantity of the softening agent or its concentration.

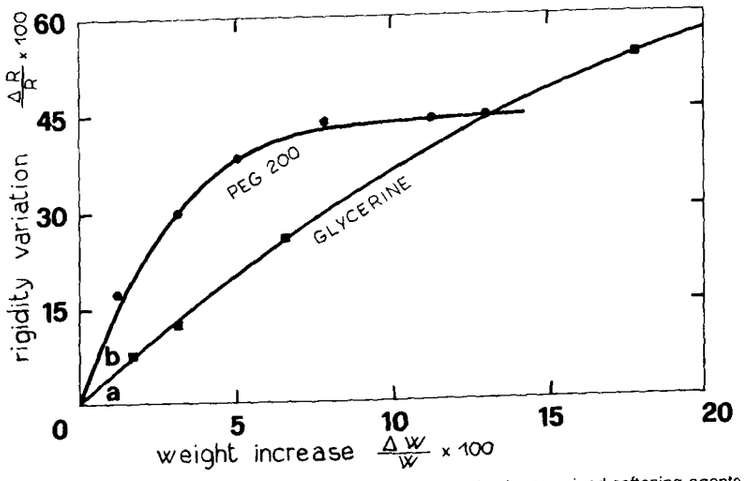

Fig. 5. Relationship between rigidity variation and weight increase for the examined softening agents.

Experiments

With this aim, five series of parchment samples, after having been washed with the above mentioned solvents, conditioned, weighted and submitted to stiffness measurements, have been treated with five solutions of different concentrations of glycerine, a softener which is often mentioned, especially in the traditional restoration formulas. For each series the average percentage $\Delta R/R$ and $\Delta W/W$ were calculated (Table 1a); by plotting $\Delta R/R$ as a function of $\Delta W/W$ (Fig. 5-curve a), a curve was drawn which, steep at first, flattened at higher $\Delta W/W$ values. This pattern was expected theoretically, because the initial effect of the softener easily increases with the increasing absorption of the substance but, when the sample reaches saturation, any further addition of the softening agent does not cause sensible variation of the R_f.

In order to confirm this kind of pattern, another 6 series of samples of parchment were treated with six solutions in alcohol of polyethylene glycol 200 (PEG 200) of different concentration (Table 1b). By plotting the average percentage values of $\Delta R/R$ against the average percentage values of $\Delta W/W$, a curve is obtained with a pattern similar to the former (Fig. 5-curve b).

Of course, with these plots it is possible to compare the effectiveness of two or more softening agents by fixing an arbitrary value of $\Delta W/W \times 100$ and working out for every substance the corresponding value of $\Delta R/R \times 100$: obviously the softening agent which presents the highest $\Delta R/R$ value would be the more effective.

Table 1: Rigidity variation correspondent to weight increase after treatment with the softening agents.

GLYCERINE	
$\frac{\Delta W}{W} \times 100$	$\frac{\Delta R}{R} \times 100$
1.74	6.82
3.22	11.70
6.52	25.79
17.90	54.00
44.30	75.00

a

PEG 200	
$\frac{\Delta W}{W} \times 100$	$\frac{\Delta R}{R} \times 100$
1.13	17.41
3.14	29.47
5.14	37.91
7.88	43.00
11.55	43.10
13.10	43.21

b

In the specific case of glycerine and PEG 200, by setting, for example, $\Delta W/W \times 100 = 7$, a practical increase of weight still agreed, the corresponding values of $\Delta R/R \times 100$ are 26.49 and 42.11, respectively. It is evident that the PEG 200 has a softening effectiveness notably larger than that of glycerine and is thereby preferable, as a softening agent, also without considering other negative effects of glycerine.

We suggest therefore the use of a "softening effectiveness index" of a substance towards the parchment, as given by the ratio $(W \times \Delta R)/(R \times \Delta W)$ measured in correspondence of a $\Delta W/W$ value still far from saturation.

Of course, if the first part of the curve is a straight line, the index value of the softening effectiveness would be constant in such a tract and therefore independent of the particular value of $\Delta W/W$ chosen. On the contrary, since even the first part of the curve is not perfectly straight, it is necessary to fix a given $\Delta W/W$ value. It is considered that a value of $\Delta W/W \times 100 = 5$ could be in keeping, in most cases, with practical requirements.

For what constitutes the two substances examined, we have measured the index values of the softening effectiveness in correspondence to $\Delta W/W \times 100 = 5$; these values, which we indicate with the symbol E_5, are:

Glycerine $E_5 = 3.92$
PEG 200 $E_5 = 7.68$

SUMMARIES

An Evaluation Method of Softening Agents for Parchment

Stiffness is the characteristic of choice for the evaluation of the ageing of parchment and of the effectiveness of softening agents. Therefore, a research was undertaken to evaluate the problems connected with the stiffness measurement on parchment.

A sampling method was set up and many series of measurements were carried out both with an expressely designed accessory applied to a normal dynamometer, and with an electronic stiffness tester. This last apparatus allows exact compensation of the initial sweep of the sample and possesses a higher sensitivity that allows the use of smaller bending angles.

A relationship was drawn between weight and stiffness for any bending angle: this allows deduction of stiffness from weight for standard samples of a given parchment.

The softening effect of an agent on parchment can be derived from stiffness variations consequent to samples treatment. Such variations can be directly measured with repeated testing of the same sample only if the bending angle is small enough not to produce permanent deformations; alternately, the original stiffness has to be calculated through the beforesaid relationship.

Lastly, a formula is proposed to appraise the "softening effectiveness index" of an agent, taking into account the quantity absorbed by parchment.

Une méthode d'évaluation des agents assouplissants pour le parchemin

La rigidité est un des traits caractéristiques les plus distincts pour l'évaluation du vieillissement du parchemin et de l'efficacité des agents assouplissants. Donc des recherches étaient faites pour évaluer les problèmes relatifs à la mesure de la rigidité du parchemin.

Une méthode d'echantillonnage était établie et plusieurs séries de mesurage étaient effectúes soit avec un appareil spécialement dessiné et accouplé à un dynamomètre normal que avec un mesureur électronique de la riqidité. Ce dernier appareil permet une compensation exacte de la courbure initiale de l'echantillon et possède une sensibilité plus élevée, qui permet l'emploi d'angles de flexion plus restreints.

Un rapport était établi entre le poids et la rigidité de tout angle de flexion, ce qui permet de déduire la rigidité à partir du poids d'échantillons standards d'un parchemin donné.

L'effet d'assouplissement d'un agent sur le parchemin peut être calculé à partir de variations de rigidité relatives au traitement des échantillons. De telles variations peuvent être mesurées directement par des contrôles répétitifs sur le même échantillon, seulement si l'angle de flexion est assez restreint pour ne pas produire des déformations permanantes. Dans le cas contraire, la rigidité doit être calculée par le moyen du rapport sus-mentionné.

Finalement, une formule est proposée poir déterminer «l'indice efficacité d'assouplissement» d'un agent, en prenant en considération la quantité absorbée par le parchemin.

Verfahren zur Abschätzung von Erweichungsmitteln für Pergament

Der Begriff »Steifigkeit« gilt als Kriterium des Alterungszustands von Pergament und der Wirksamkeit von Erweichungsmitteln. Deshalb wurde nach Methoden gesucht, diesen Begriff meßtechnisch zu erfassen.

Es wurde ein Auswahlschema für die Proben aufgestellt, und es wurden mehrere Testreihen durchgeführt, sowohl mit einem normalen Dynamometer, das mit einem speziellen Zusatz ver-

sehen worden war, als auch mit einem elektronischen Gerät zur Messung der Biegesteifigkeit. Dieses zuletztgenannte Gerät erlaubt die Kompensation der Anfangskrümmung der Probe und die Wahl kleiner Biegewinkel.

Es ergab sich eine Korrelation zwischen Gewicht und Steifigkeit bei jedem Biegewinkel. Dies ermöglicht es, die Steifigkeit als Funktion des Gewicht einer Probe zu definieren.

Die Wirkung eines Erweichungsmittels auf Pergament kann beschrieben werden als Veränderung der Steifigkeit infolge der Behandlung. Solche Veränderungen können direkt und wiederholt an der gleichen Probe gemessen werden, wenn nur der Biegewinkel so klein ist, daß er das Pergament nicht deformiert. Anderenfalls muß die ursprüngliche Steifigkeit wie angegeben aus ihrer Korrelation zum Gewicht errechnet werden.

Es wird eine Formel zur Beschreibung des »Erweichungseffekts« vorgeschlagen, die auch die Menge des von der Probe aufgenommenen Erweichungsmittels berücksichtigt.

Acknowledgements

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Sewing and Endband in the Islamic Technique of Binding

by BARBARA FISCHER

Exhibition work is laborious, but it can also be exciting, stimulating, rewarding – for each of the persons involved in his or her special field.

In the Bavarian State Library in Munich, the exhibition "The Book in the Orient" was held from November 1982 to February 1983, and it gave one a good survey of the stocks of the house which, in addition to all other basic aspects, offered to the small circle of spectators interested in book technique the opportunity of forming an impression of the variety and copiousness of the non-European book forms[1]. The book restorer receiving the exhibition items in the period prior to the opening is not merely a spectator, but directly involved in the exhibition. Time is usually at a premium and this may lead to conflicts between what is desirable and what is possible. But the work also gives him or her added experience – and pays dividends in the form of an uncertainty that will make the old hand at restoration reconsider everything he or she has learned and acquired.

An account will be given here of observations and experience in connection with restoration work on the so-called Oriental or Islamic Codex.

The Islamic Codex

The term "Islamic" indicates that it is found in the Islamic religious and cultural community and is in contrast to the Western form of binding. The historical Islamic area reached from Southern Spain to India; it comprised the countries around the eastern Mediterranean, Anatolia, Persia, Arabia, all of North Africa down to the Sahara, and even further south. However differently the Islamic book culture has developed with respect to script, illumination and ornamentation of the cover, there are still points of resemblance in the form of the binding and in the structure of the binding.

In general, the typical outer distinguishing features are a straight back, boards cut flush with the leaves, a flap at the lower cover reaching over the fore-edge underneath the upper cover, and endbands lying flat on the edge. Characteristic of the structure of the binding in the classical technique is, moreover, the sewing without raised cords, normally at two sewing stations in the spine-

Restaurator 7: 181–201

folds. When passing from one gathering to the next the thread most often is looped around the preceding one.

The more specific theme of this treatise will be the sewing and endband, and their importance in the binding technique of old Islamic manuscripts.

If the restorer is entrusted with the task of treating a damaged book of such an unfamiliar construction, he will first have to do some detective work. Available parts, remnants of same, or any single available traces must be identified and recorded, put the store of experience from one's predecessors to good use, and find one's bearings on models and earlier examples.

Sewing

From available models, from Persian, Turkish or Arabian manuscripts dealt with in earlier years at the Institute for Restoration of Books and Manuscripts of the Bavarian State Library, a sewing on flat bands of frayed hempcord has been ascertained, not the so-called "Oriental sewing"[2]. On that behalf, Karl Jäckel writes: *"The original sewing of manuscripts from the Near East is quite uncomplicated (Cod.arab.4,150,310). Raised cords were not used, but a sewing thread, often of coloured silk, would be conducted from one gathering to the next. Even kettle-stitches would most often be omitted. The sewing thread only served to keep the individual pages of this gathering together. The strength of the sewing was achieved by lining the spine with the leather of the cover. The tough Oriental paper lends itself quite well to this simple kind of sewing. It would nevertheless be worth considering, whether in the restoration of an Oriental manuscript one should still not deviate from the original sewing by adding thin cords of hemp which later will not be noticeable at the back."*

The "original sewing of manuscripts from the Near East" often covers but a small area at the centre of the gathering, about one third of the height of the book. By the working of kettle-stitches a link-stitch appears which differs from the classical chain-stitch in Greek and Coptic bindings[3]. It only forms half a chain, so to speak. This type of sewing is not too strong, and its durability will to quite an extent depend on the quality of the sewing thread which more often as not is only a very thin silk thread. In the course of the centuries old manuscripts mostly have been rebound several times, so they will show signs of several sewing stations at the centre of the gatherings. Even if the earlier stitches should have been patched and repaired, a different distribution of the stitches will provide relief for the worn centre of the gatherings. A deliberate change of the way of sewing is not just accidental. For main clients, the librarians as custodians of a public collection, the durability aspect alone, the renewed usability of the item by restoration of a book, had for long been considered more weighty than today; for the technician it was plausible from the very beginning.

Endbands

The endbands of Islamic manuscripts show an unmistakeable zigzag-pattern, mostly in amazingly lively colours and combinations. The making of them is -summarized- described as follows by Karl Jäckel: With threads of embroidery silk twist in two colours, for instance red and yellow, you twist six cords. Their length should correspond to the thickness of the textblock. The upper closed ends of them are placed next to each other in a row on a thread prepared for the purpose; the lower open ends are tied into a knot for now. The twisting of the individual cords takes place alternately in opposite directions. They are now fastened over a leather base onto the book's edge. For this purpose the thread prepared before will go through the cords crossways and sew them onto the book, taking its way through the spine. With each stitch the thread passes a twist of the same colour in the cords, so that a zigzag-pattern emerges on account of the twisting taking place in opposite directions. The protruding cord ends on one side of the textblock are cut back and glued down[4]. You might say that the working method of the twisting of cords constitutes a bookbinding function from the ropemaker's or trimming-maker's trade, as one in the case of Western endbands plaited with leather thongs may talk of borrowing from the saddler's trade.

Reference Material and Literature

Once you have digested the first satisfaction and pleasure derived from the making of such a different and interesting endband, you are affected somewhat adversely by the abrupt method of cutting back and glueing down the loose ends. The Islamic binding technique may witness some signs of simplification, but no other detail shows this kind of "open end". Too little is known about reference material as yet. The specimens up till now have been too defective to be able to follow the course of the threads in the making of the sample with certainty. However, in the collection of fragments of old endbands dating back to the early days of the Institute for Restoration of Books in the post-war period, there are an endband bearing the signature Cod.arab.896 and two other endbands without signature from which it can be seen that the coloured silk threads are turning and running back at both ends. They form ribbons with a fixed closure at both ends.

In the next study of a Persian manuscript (Cod.pers.335), at the centre of the last gathering, about 1 cm away from the edge, there are fragments of red and yellow threads that are tied up with each other. The remnants of the endbands show the same colours: they must be their knotted thread ends.

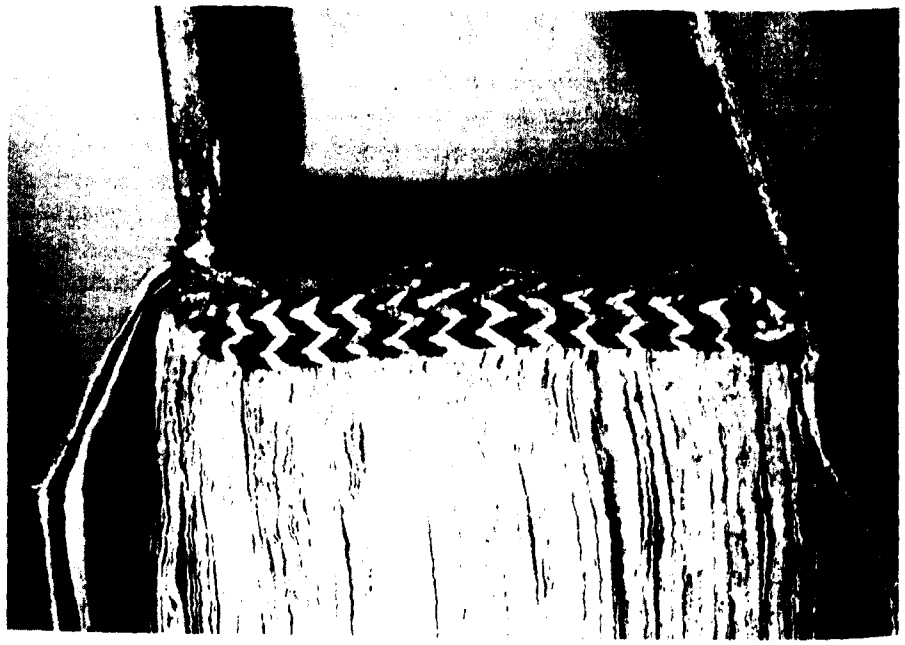

Fig. 1. Islamic woven endband with weft threads in natural colour and dark blue. Cod.pers.351

Fig. 2. Endband with starting knot between textblock and flyleaf. Cod.pers.351

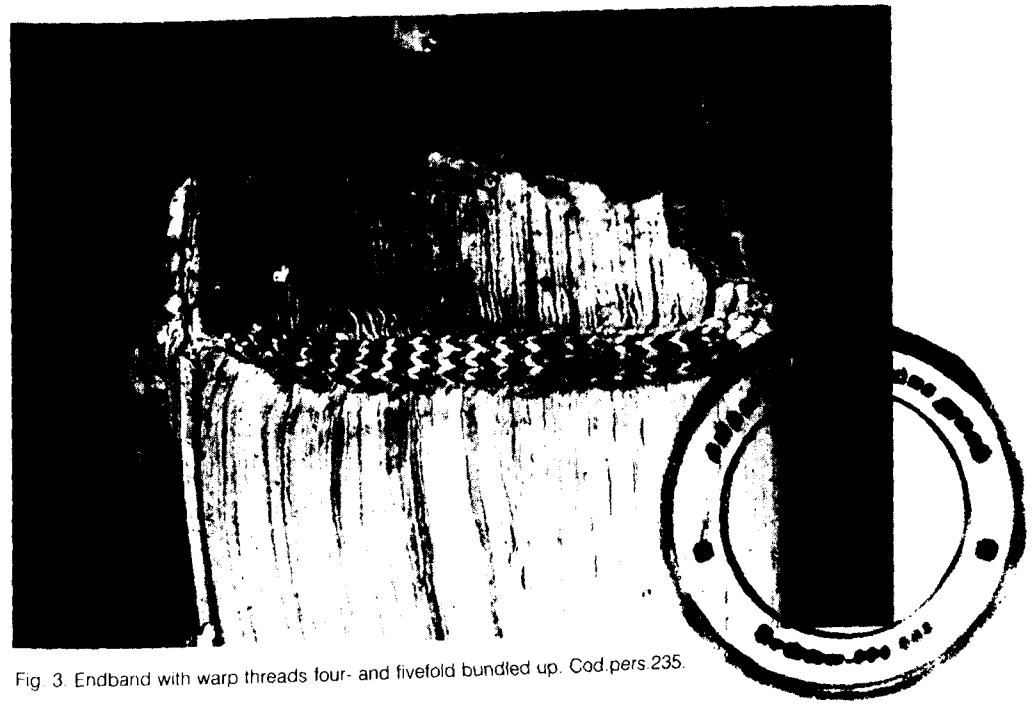

Fig. 3. Endband with warp threads four- and fivefold bundled up. Cod.pers.235.

This beginning at the centre of the gathering cannot be brought to harmonize with the course of the threads, when previously twisted cords are attached. In this manuscript you can moreover, in addition to the sewing thread at the centre of all gatherings, see the threads at the top and bottom that have held the endband. At the centres of all gatherings – this would mean that not the distance created in the cords by the twisting of the two coloured threads, but the distance from gathering centre to gathering centre would be decisive for the path of the thread when the cords are attached, if you take the method described by Jäckel for a basis. Is this really true? And is this always the case? At this stage of your considerations and doubts you start looking for other sources than the basic studies of Karl Jäckel.

Paul Adam[5] gives a description in his memoirs[6] of the overwhelming impression the first glance at Oriental books in the Düsseldorf Art Gallery had made on him in the year 1886: *"Frauberger has always told of my arrival in Düsseldorf, that is of my performance in his room, with glee. The many Oriental covers and bindings had just been received, and were piled up on the floor. When I arrived, Frauberger said to me – apparently not inadvertently – that he had some work to do at the moment, and could I in the meantime have a look at the bindings? I had then flung my overcoat on a chair, thrown my*

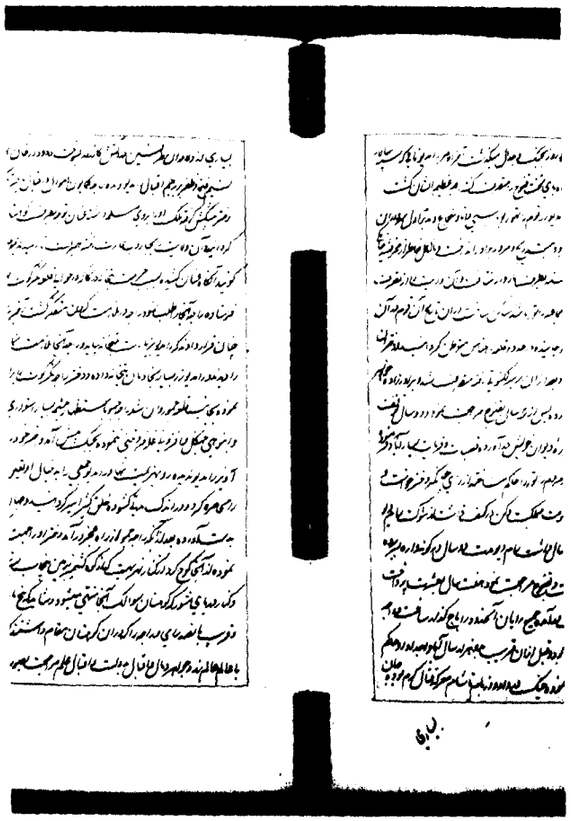

Fig. 4 Centre of gathering with sewing thread and two endband sewing threads, to show it more clearly, black paper has been placed underneath it. Cod pers 235

top hat on the floor, kneeled down next to the books, and picked them up and caressed them one by one. Frauberger has probably laid it on too thickly, but on the whole I suppose that's what it was like. But these things were so completely new and strange to me, and now I had to restore them."[7]

In the following years Adam has again and again told of his experience with bindings from Greece and the Near East in technical journals and his own publications[8]. In his last book[9] the following observations are found in the sections named "The Endband" and "Sewing": *"The Islamic bookbinders made an equally broadly placed endband, but in contrast to the upright Greek one, it was placed flat on the edge at the back. Here the inner threads were used as in a fabric, and the sewing thread in yellow silk like a weft thread wound its way through the warp threads, forming in this way a kind of twill pattern. This Oriental method was also a part of the sewing, actually, as the*

silk thread used for sewing the headband was at the same time the outermost stitch of the sewing, replacing what we call the kettle-stitch."

"Much less known and only found in Oriental bindings is the endband which is customary there, and which also deviates greatly from our western type. While it is a core in the endband here, it is in the Oriental version placed beneath same: A narrow strip of leather is placed flat on the edge at the spinemost edge, and is then sewn on in the special Oriental way, where four threads lying next to each other are interwoven with yellow silk, and the thread will all the time engage with the centre of the gathering, in fact it will interlock with all the gatherings and in so doing create some kind of a kettle-stitch fastening. Sewing takes place from two sewing stations, but raised cords in our sense of the word are unknown to the Islamic bookbinder. The body of the book is only attached to the cover by means of a sewn-on hinge of leather and the lining material of the back."

"The sewing of Islamic bindings is the same everywhere, i.e. a sewing at two sewing stations, whether the bindings are big or small. At each station the previous section is fastened with a loop, so that here too there will be chain-stitch sewing. Kettle-stitches are not made at the top and bottom of the spine, but the endband fastened to each gathering takes the place of the kettle-stitch, though in a different manner than in western countries."

Adam describes the sewing and the placing of the endbands as connected working operations. He mentions chain-stitch sewing at two sewing stations without kettle-stitches, "final stitches" at "all gatherings" or "at each gathering", in other words the endband takes the place of the kettle-stitch. He uses the concepts "weave", "weft thread", "warp threads". He furthermore mentions the strips of leather placed flat on the edge, on which "four threads lying next to each other are interwoven with yellow silk". As weft thread the yellow silk continually engages with the centre of the gathering, winds its way through the warp threads – which are accordingly stretched across the book's back – forming in this way a kind of "twill pattern".

Now, if it is the rule that a proper sewing thread and two endband threads go through the centre of each gathering, then the fixation of the textblock would not only depend on a sewing thread and the "lining of the spine with the leather of the cover", as described by Karl Jäckel. Anyhow, Paul Adams describes the working operation of attaching the endbands differently: during the sewing he is "weaving some kind of a twill pattern". The classic twill with its characteristic diagonal stripes, though, has an appearance other than the zigzag-pattern with rows of oblique threads, even when modified to chevron twill. The threads are staggered, to be sure, but they run at right angles to each other[10]. However, with the working method described by him, an explanation can be given of the function of the endband threads found at the top and bottom of all gathering centres.

The principle of sewing over the upper and lower edge of the spine of the

book reminds one of something similar in Europe, viz the sewing of books from the 15th to the 17th century, approximately, which were bound in limp envelopes (UB Augsburg ÖW,Ink.A 93; Staatl. Bibl. Neuburg a.d.Donau, 4°Theol. 412). In this simplest form of the so-called long-stitch sewing, the gatherings are held together by two separate sewing threads running parallel along the spine of the cover on the outside and to the gathering centres on the inside. The sewing on of endbands was not the purpose of this procedure; there are at most rows of little knots for stabilisation. So the idea of sewing across the edge of the spine is not all that unusual or unique.

Another author, Emil Kretz[11], points out[12] that sewing with chain-stitches has been replaced by sewing with raised cords in the Western technique of binding, but it has been retained in the Oriental technique, and he adds: *"An important element of the sewing is the endband which like a fabric is resting flat on the edge, and always goes from gathering centre to gathering centre"*.

Two voices carrying weight; moreover, the coloured thread remnants with knots, the numerous manuscripts with intact endbands that are always and at every gathering centre provided with endband sewing threads, which have been brought to light through applied research; enough, no longer to consider the subsequent sewing on of cords as the only right way, but not enough to find another way with certainty.

Old Sources

Luck and chance led on. In an out-of-the-way place[13] the translation of two manuscripts from Arabic was found. The first, more extensive one bears the title: *"Book of the Staff of the Scribes and Implements of the Discerning with a Description of the Line, the Pens, Soot Inks, Līq, Gall Inks, Dyeing, and Details of Bookbinding"*. The author is al-Muʿizz ibn Bādīs (1007–1061), a North African from a royal house, a patron of arts and sciences. His work was completed around the year 1025, and the present manuscript owned by the Oriental Institute of the University of Chicago is the copy made in 1908 of a specimen found in the Egyptian Library in Cairo. The last chapter starts with an enumeration and description of bookbinding tools and implements, and moreover contains instructions in sewing, pressing, preparation of adhesive, lining of the spine, right up to the preparation of the leather for the cover. These instructions are rather irregular, unfortunately, often very detailed, but sometimes so summary that they are almost unintelligible. The author describes two kinds of needle, for example, and what they are used for. The needle used for "sewing" had to be thin, the other one for "binding" had to be shorter and thicker. With "binding" he probably means the fastening of the endband. In the chapter on sewing, ibn Bādīs tells us

of different methods, a fast one with two sewing stations, and another one with two or three needles that he saw the Greeks working with, but which he could not approve of, nor describe.

The second manuscript deals with the *"Art of Bookbinding and of Gilding"*, and dates back to 1619. The author of it, al Sufyānī, also a North African, was a master craftsman. He gives a detailed, often circumstantial, but always an exact description with practical experience of the procedures that have to be carried out during the binding and the decoration of a book. In connection with this report we are only concerned with what he writes about the sewing and the endbands. A summary of it is reproduced as follows: before sewing is commenced, two lines are drawn across the spine of the book which will indicate the location of the stitches. The author then gives some hints about the quality of the sewing thread. Fastening of the endband is carried out in two stages. The needle with the sewing thread is guided over a glued-on strip of leather to each gathering centre. At the beginning and end of the procedure the thread must be fastened thoroughly to the book spine. Finally: "Complete the remainder weaving it with coloured silk until you complete the work of the headband from the two sides". So the author of technical literature in the 17th century distinguishes between the first procedure, "sewing", the moving of the thread to the centre of the gathering, and the second procedure, "the remaining weaving" with coloured silk, and he does it consistently, and in that sequence.

According to Paul Adams the pattern is woven from laid-up cross threads (as "warp threads") and sewing thread (as weft thread"). In contrast to this, it is stated in the old text that after the actual sewing, the first tie-up of the gatherings under each other, the sewing of the gatherings (all the gatherings), at head and tail, takes place. Only then follows the weaving of the sewing threads (here, warp threads) with the coloured cross threads (here, weft threads).

Textile Technique: Flat Weave

Applied research into the stocks of Persian, Arabian and Turkish manuscripts of the Bavarian State Library, now intensified, has led to the conclusion that textile structures like endbands cannot stand alone in the broad workmanlike or craftsmanlike context of the textile traditions. To the bookbinder skilled in the handling of needle and thread, the making of a ribbon, a braid trimming, a reinforcement of a border in the broadest sense of terms presents itself as an adoption from another craft.

The endbands of the Islamic binding may be related to the flat weave products. Among them are weaves made according to the Kelim technique, where each warp and weft are, however, at right angles to each other. Fabric, the weft

threads of which run obliquely round the warp threads in the so-called weft wrapping[14], has been made in the Soumak technique. By means of this weft wrapping, the forward and backward moves will produce a zigzaz formation. This is clearly visible when threads of different colours are used. But if you compare the course of the threads in old endbands and in Soumak fabric, you will discover a basic difference. In the latter the weft thread is most often guided over four warp threads at the front in a forward movement, and at the back over two warp threads in a backward movement. This is easy to accomplish on a loom, but not on a workpiece which must sit tightly on a firm base. The endbands are also less voluminous, so the technique must be simpler. The thread does not move forward, then back a bit, and then forward again, but only in one direction. Workpieces in the Soumak technique as well as endbands of sewn-on cords according to the technique described by Karl Jäckel display the same pattern as the old endbands, but differ in their construction.

It is true that the author, al Sufyānī, informs us thoroughly about the correct pressing, trimming, glueing, also about the fastening of a small leather strip onto which the endband is woven, and furthermore about the sewing through all the gatherings with the endband threads – but he makes no mention of how the "remaining" weaving of the endband should be carried out. One is inclined to believe that the making of a small piece of fabric, interdisciplinarily so to say, was something known, something normal, something which did not have to be described separately.

In Islamic covers that have seen the light of day at widely different times and places, it is possible to ascertain significant differences, despite common technical features. A book from Yemen with strong boards, a coarsely worked leather cover thick sewing thread, coarse uncoloured endband threads, descends from a spiritually and materially different world than an elegant, sophisticated binding with a lacquer painting from Persia, the endbands of which have been produced of the finest silk threads. But in both cases the threads of the fabric have been placed next to each other with such matter-of-fact regularity as can only be achieved in work one is very familiar with.

Models

With models, with textblocks with Islamic sewing, with strips of leather on the edge and overlying endband sewing through all gatherings, attempts were now made to translate theory into practice, and to weave endbands the original way. To do this, the textblock is held in a finishing press in such a way that the fore-edge points downward and the head or tail edge toward the worker. Two threads of different colours are attached to the first gathering centre with a

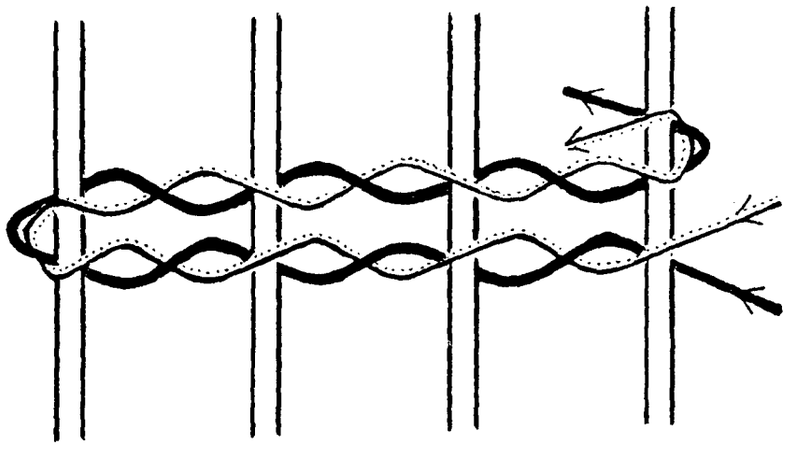

Fig. 5. Diagram of thread paths.

knot, and are drawn out through the spine. The first row, the first passage of the needle, should be at *that* edge of the leather strip which turns toward the fore-edge. In this way there is more room for the needle coming from the spine area. The first thread is now guided underneath all the warp threads, and between them the first and the second thread will wind or wrap each other. The second thread runs over the warp threads. Only one needle for the first thread is required. On its way back the direction of the loop changes, and in this way the first row of chevrons[15] is created. With five or six passages back and forth, two-and-a-half or three chevron rows will emerge, as one will most often notice in the originals. Of importance is the simultaneous work with both threads which, in this way the rows can be placed more regularly than with two threads that are moved back and forth after each other.

Control

These woven structures, ribbons with a firm end at both sides, have to be checked by experts, and in this case by textile restorers at the Bavarian National Museum in Munich. It turns out that these experts – after their initial surprise at activities of this nature on the part of bookbinders – find that the work was carried out correctly. Actually, spontaneous mention is made again of the resemblance to Soumak which, however, with the simpler thread path is only an outward appearance. It would appear that the established term, "weft wrapping", for the Soumak technique may in principle also be used to describe this simpler working method.

13 Restaurator

The examination of original fragments, the production of imitation models, and the verification of their identity thus led to an experimental reconstruction of an old technique. Would it be beyond the possibility to find specialists who, according to unbroken, handed-down tradition, still master the Islamic art of binding? The search for one in Munich was fruitless – or almost fruitless, for the owner of a "Specialist Workshop for the the Restoration of Carpets"[16] could at least confirm that from a specialist's point of view the weaving method was correct. About fifty years ago Mr. Salama had been an apprentice in Istanbul to a Greek bookbinder, but even at that time he never manufactured endbands of the classical type.

Once more the preparations for an exhibition proved to be an important incentive: Arabian manuscripts from the Bavarian State Library were needed as a loan for a planned exhibition in the State Museum of Ethnology in Munich. The Museum of Technology also has a workshop for the restoration of textiles. The work with textiles in an ethnographical collection requires specialized knowledge, and enquiries were therefore made with the expert at the Museum of Ethnology on the strength of her general knowledge of weave types and the manufacture of textile commodities in or around the North African or Arabian communities. She possesses this knowledge in actual fact, in this case thanks to a current exhibition on Ethiopia: the path of the threads of many endbands corresponds to that of carpets from Ethiopia. In fact these do not have a two-coloured zigzag-pattern, but rather a flattish decoration.

Although the items have been made in the 20th century, they conform to the Ethiopian tradition with respect to materials, colouring patterns and type of weaving. It is tempting to think that here a link may have been found to the sources, an approach to the Coptic influence on the early Islamic manufacture of books. But the first requirement is that this subject be debated and examined.

New Literature

It is almost impossible to find literature on the Islamic binding technique of recent date, in contrast to the great number of works on, for instance, characteristic styles of the decoration of bookcovers, from the Orientalist's and the art historian's point of view.

In his report "Blind Lines with the Front-Door Key"[17], Günther Brannahl describes the making of a leather cover in a bookbinder's shop in Saana in the Arab Republic of Yemen. Only the cover and its decoration with blind tooling are described here, partly with traditional, partly with improvised materials and tools. Based on Karl Jäckel's studies is the article by Monika Gast, "A History of Endbands"[18]. In the section on the Oriental endband, she quotes his explanations, and continues: *However, during my research on Oriental manuscripts I came to the conclusion that these particular endbands most probably were not worked in the manner described. One main reason is that end knots cannot be found anywhere, so overall it seems more likely that the threads were directly woven on to the book (fig. 19). First of all, a piece of leather is sewn on to the bookblock with thin thread but, sometimes, in original examples, just the extended linen of the backing was used as the core. The sewing should not be too close together but should leave some space between the threads. The two colours of silk are tied together at one end and pulled through so that the knot is caught inside the first section. Similar to the headband illustrated in figure 16, one coloured thread now goes once under and once over the previous sewn-on thread until the whole leather strip is covered. Now, the second colour is twisted round every single one of the other coloured threads, changing direction of the twist when going back. This technique seems to produce a much tighter headband than the one described by Jäckel.*

Oriental endbands are very pleasing to make and the originals have the most beautiful colour schemes. Here again, there are many possible variations and I discovered examples in which two to twelve single threads were used on each one, depending on the size of the book (sample 21). The twisting can be done without changing direction, which gives a completely different result (sample 22), and the weaving itself can make a different pattern (sample 23). These endbands are not incorporated into the sewing or binding, they hardly give any protection to the book itself and they are fairly easily damaged, so their main purpose is to provide a beautiful piece of decoration.

The final version of the endbands worked with embroidery silk twist, described by Monika Gast, looks somewhat looser than the endbands according to the method of Karl Jäckel with tightly twisted cords. For the picking up and twining of the cross threads first put down, some space is required which cannot be determined exactly beforehand. If in this process the first threads could also be regarded as elements of the sewing and conducted through each gathering centre, then it could, even if there are changes, be seen as a successor of al Sufyanī. Such extremely fine cloth, like the endbands of Persian lacquered bindings, can, however, not easily be made by this method of twining afterwards. But if both threads are moved from side to side simultaneously, an endband with a genuine regular pattern will emerge.

Book Construction with Straight Back

Although we are only concerned with sewing and endband here, we will invariably have to touch on the preceding and succeeding procedures. According to the old sources, the gatherings of a book are sewn, and the swelling resulting from it during and after the sewing is then thoroughly knocked down. Ibn

Bādīs as well as al Sufyānī discuss this point in great detail. The sewn book – without rounding – is placed in a press and then pasted and lined. After drying follows the trimming of the textblock, and then – as Adam calls it – the final sewing, the "weaving" of the endband.

The clue, "Book without Rounding", gives rise to a comment on how difficult it is to restore the typical form of textblock with straight back. Repairs in the spine folds, reinforcement strips and the thickness of the sewing thread will cause, especially with thin and hard paper, more swelling than, despite every possible effort, can be reduced. The textblock will on its own assume a more or less pronounced rounding, also if it is only weighed down during the glueing of the back, and not placed in the press. This swelling could no doubt be balanced out during the binding process by means of temporary inter-leafing which could be removed when the work has been completed. But after that the textblock would fall in at the fore-edge and inevitably make the back go round.

With what is demanded: a reconstruction of the original form with a straight back – and what is given: too much swelling – the restorer may be faced with an almost insoluble task.

Old, frequently read manuscripts betray the opposite extreme: they are bulging the fore-edge. Although the used adhesives, pastes, glues or mixtures of same may have a strong adhesive power, they will not be capable of keeping a textblock in shape, not even with several layers of paper and fabric as a lining. On taking it apart, one will occasionally encounter a thick layer of dark-brown, hard dried-up glue at the back of the gatherings which is very difficult to dissolve. It lies near at hand that it may deliberately have been used for stiffening the back.

On account of their construction, textblocks with straight back will not retain their shape by completely horizontal opening. In Islamic books with straight backs, the endbands in the form of a sturdy fabric on a leather base will in a way support the back, but in the long run this construction will hardly be able to live up to the tension arising when the book is opened up completely and paged through, especially in the case of heavy, voluminous textblocks. The sewing thread will hardly stretch; more likely it will cut into the paper, and the binding will be correspondingly looser. It is not without reason that the use of the Oriental, X-shaped, hinged bookstand which accommodates books gently, has continued right up to our day and age, at least during traditional lectures and lessons[19].

NEW TRANSLATION

Very late, though not too late, the authoress received a copy of an exhibition catalogue, "Islamic Bindings and Bookmaking", Chicago 1981[20]. In its chapter *"The Materials, Techniques and Structures of Islamic Bookmaking"*, this rich fund of information contains new translations of the texts of Ibn Bādīs and al Sufyānī, the often long-winded, obscure passages of which have here been translated from Arabic into something more closely related to practice. It contains comments, reproductions of old illustrations of bookbinding, and it contains photos of the contemporary making of an endband: "A craftswoman at the Topkapu Saray, Istanbul, sewing a traditional Islamic chevron endband"! The detailed description confirms the working method with two threads that are moved back and forth simultaneously, and also the principle of weft wrapping. So at last al Sufyānī may explain in his own words the "way of weaving the endband":

You should have in your possession gum arabic dissolved in water to the consistency of thick honey. Then place some of it at the tops of the gatherings at the edges of the cuttings under the little band of leather on which you weave the endband, in order to place upon it the band. And the band itself should be of tanned leather covered by gum arabic beforehand so that it dries. And you begin by taking from it the band which you will need for the endband. Then when the gum which you have placed at the top of the book dries, you moisten it with your saliva and moisten the band and place it upon the part containing the gum arabic. Then both will stick together tenaciously. And the threaded needle enters the center of the gatherings along the right side after you have fastened the end of the thread in the back of the book at its back edge in the place where the point of the needle started from, then you entered it in the midst of the last folded paper and follow along with the sewing of the gatherings until you finish to the end section and tie the thread in the last stitch very meticulously. In order that the sewing holds tightly and correctly and finish what remains of the weaving with coloured silk so that the endband is perfectly worked from both sides.

ZIGZAG-PATTERNS AND CHANGES

The density of the zigzag or chevron pattern is linked up with the volume of the gatherings. The thinner gatherings a textblock has, the narrower may the twinings of the warp threads with the two weft threads and the mutual twistings of these be. With identical course of the threads the appearance of the pattern is found to be modified to a great number of variations. The warp threads may be entwined in bundles of two, three or more, then the chevrons will become longer. The warp threads may be doubled up, then the fabric will seem fuller. Of the two weft threads, one colour may be worked with a single thread, the other colour with a double thread, or one thread may be thin, the other thick.

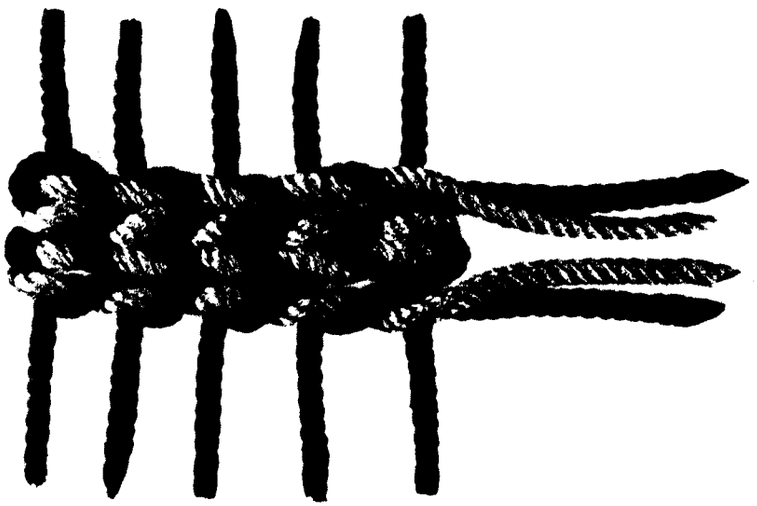

Fig. 6. Model with single endband sewing thread (warp thread).

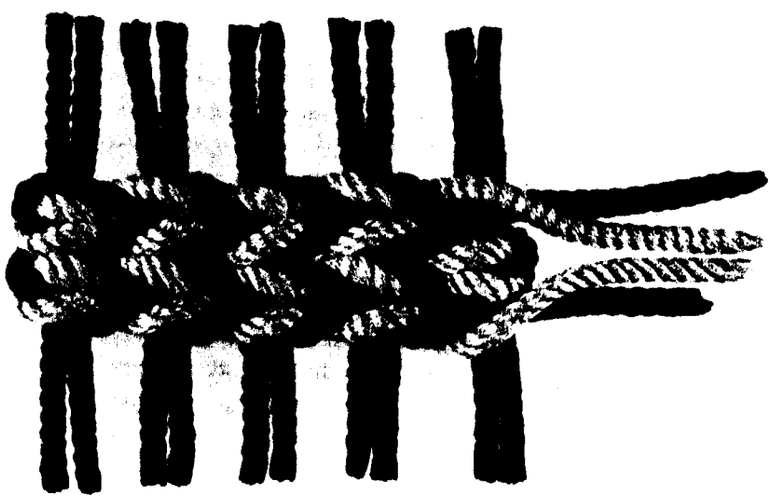

Fig. 7. Model with double warp thread.

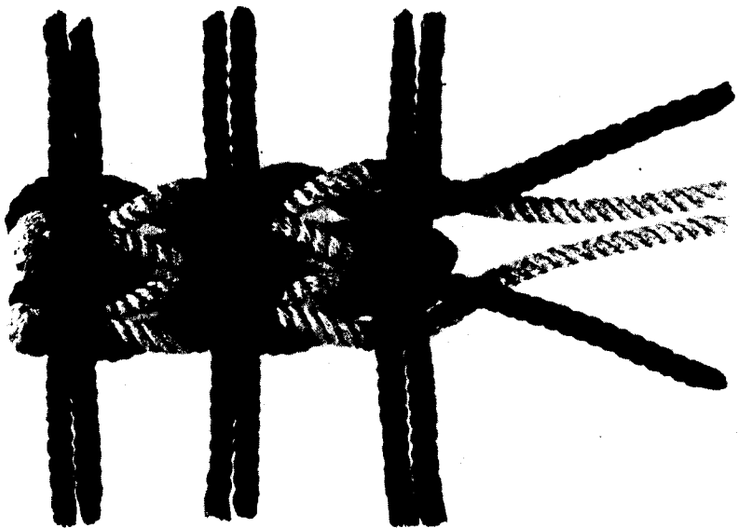

Fig. 8. Model with two twisted warp threads bundled up. In the long run the chevron will become stretched.

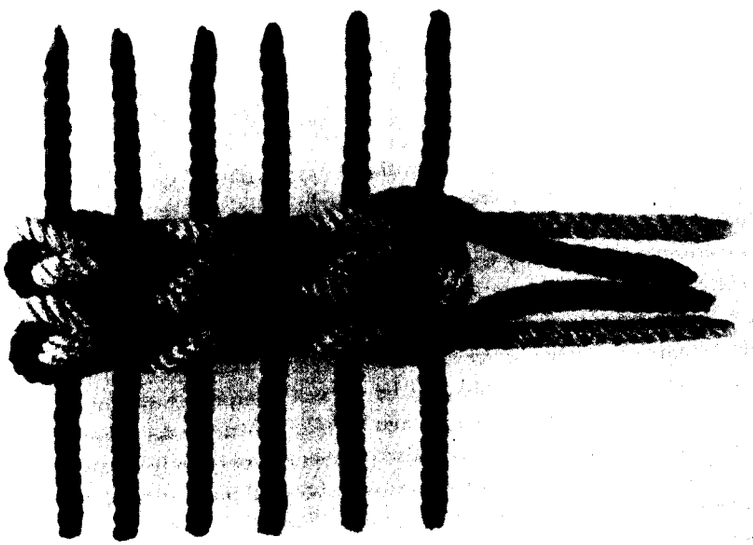

Fig. 9. Model with "Ethiopian" thread course. Every other weft thread lies above the warp threads.

Cores of cord instead of a leather strip – only found exceptionally in the Islamic bindings at the Bavarian State Library – give the endband, as such, a rounder form.

Other variations come about as a result of a changed course of the threads, like the examples of Monika Gast shown as "sample 22" and "sample 23". They seem to be rarer, and to appear mainly on bindings from the 19th century.

Simplified and Improved Binding Structures

Likewise on bindings from the 19th century one will occasionally find structures of the binding that have been simplified at the expense of their wearability. In a printed item from 1852 (Bavarian State Library, 2°A.or.165) the gatherings were sewn two-up, and each time only along a very short section of the centre of the gathering. The endbands had no core, and with their few stitches made at random they were, in this case, only attributes without any function. The bookbinder had, however, let the stitches be accompanied by "bands" of thin cord across the spine which, when the sewing thread changed direction, were incorporated into the kettle-stitches.

This is an effective way of stabilizing a simple connection of gatherings like the kettle-stitch, the "half chain". It has been described as a modern improvement by Philip Smith[21]; in heavy books of large format he lets the sewing of the kettle-stitches be accompanied by a reinforcing cord.

Demands Made to the Restorer and to the Client

The restorer will be confronted with the demands made by the owners and by the objects – demands to materials and techniques and demands for preservation of the substance of the book. The aim of all efforts is to stabilize the book and to restore its usability with the utmost protection or regaining of its outer appearance[22]. In the restoration of Islamic bindings, the relation between technique, outer appearance – here related to a book with a straight back – and usability should in particular be considered.

Most often the old bindings can be opened completely without any resistance; the inside structure has long ago been loosened. Books restored with the traditional binding technique can also be opened completely horizontally with a bit of help, but the sewing structure, and above all the sewing of the endband, will then be subjected to much more stress. These books have been designed for another kind of use, viz for opening of the textblock at an obtuse angle. On this background the restorer may expect that the owners and keepers of Islamic

books know what they want done: either a new binding with a different Western type of sewing, or a restorative reconstruction, where the typical characteristics of the bookform are recreated. This of course will not allow the irresponsible and thoughtless use which is predominant today. In this connection it seems twice as laudable when arrangements are made for the development and use of cradle-shaped supports or mounts for books without completely flat opening, whether European books with round but rigid backs, or Islamic books with straight backs[23]. In this connection one thinks with dismay of Islamic books at exhibitions, on tables of users, collectors or dealers – which have been put out flat, and which may even have been forcibly pressed down. Even if the sewing and binding of old Islamic books is often already loose and slack so that they may be opened flat and horizontal without any difficulty, but such books with a still intact binding would be subjected to unnecessary stress and strain, were they similarly opened.

Conclusions

A current event, namely the concentrated work done on numerous exhibition items, on different kinds of old books with not too well-known binding techniques, offered the opportunity of collecting data about the construction of Islamic bindings, to a greater extent than had been possible up till now during the work on individual items at great intervals of time. It came to light that there is still a lot of research work and clarification to do. Special types of endbands, any regional and temporal variants that may be detected, should in future be recorded systematically.

But one point of view in particular looms very large: original parts should be used whenever it is possible and sensible, also on movable parts of the binding. Weakened, damaged fabric – Islamic endbands in contrast to European ones may be defined as such – may be reinforced, and if not fully restored, then at least secured in or on a piece of newly made fabric.

The restorer of books should, therefore, as well as with the techniques of the brass moulder and the silversmith for the work on clasps and bosses, or the techniques of the carpenter and turner for the work on wooden boards and globestands, acquaint himself with the technique of textile restoring.

Summaries

Sewing and Endband in the Islamic Technique of Binding

The old Islamic book in codex form differs from the Western codex in some characteristic details in the structure of the binding. In the treatise, the classical techniques of the sewing and weaving of

the endbands are examined, reconstructed and checked. Both these procedures are closely connected. The Islamic endbands are classified with flat weaves of which the weft threads form rows of slanting stitches. The construction of the Islamic binding requires that the book is opened at an obtuse angle. When the book is used or exhibited, a cradle-shaped support would be appropriate, rather than a horizontal base.

Couture et tranchefil dans la technique islamique de reliure

L'ancien livre islamique sous sa forme manuscripte diffère des manuscripts occidentaux par des détails caractéristiques quant à la structure de la reliure. D'après le traité, les techniques classiques de couture et de tissage des tranchefils sont examinées, reconstruites et controlées. Ces deux procédures sont fortement connexes. On classe les tranchefils islamiques dans les tissus dont les fils de chaîne et de trame se croisent obliquement. Le façonnement d'une reliure islamique requiert l'ouverture du livre sous un angle obtus. Lorsque le livre est utilisé ou mis en exposition, un support en forme de crèche serait plus approprié qu'une base horizontale.

Heftung und Kapital in der islamischen Bindetechnik

Das alte islamische Buch in Kodexform unterscheidet sich durch charakteristische Einzelheiten der Bindeweise vom abendländischen Kodex. Es werden klassische Techniken des Heftens und des Webens der Kapitalbänder untersucht, nachvollzogen und geprüft. Beide Arbeitsgänge stehen in engem Zusammenhang. Die islamischen Kapitalbänder werden den Flachgeweben mit schräglegenden Schußfadenreihen zugeordnet. Die Konstruktion des islamischen Einbands bedingt ein Aufschlagen des Buches in stumpfem Winkel. Bei der Benützung oder während Ausstellungen ist eine wiegenförmige statt einer horizontalen Unterlage erforderlich.

Acknowledgements

Reproduced manuscripts: Owned by the Bavarian State Library in Munich.
Photos: Photo Department of the Bavarian State Library.
Drawing and models: B. Fischer.

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IFLA Principles on Conservation and Preservation

by HELMUT BANSA

The IFLA (International Federation of Library Associations and Institutions; Secretary General: The Hague, Netherlands) has recently published a booklet containing general rules or principles, or a statement of principle facts regarding the vast field that is called "preservation" and/or "conservation" of books and other library materials. Such a publication can be of good use and benefit if it intends to be a primer or a compendium summarizing the basic knowledge a librarian must have if she or he meets relevant problems, and if it shows various ways to employ this knowledge. A librarian who comes into contact with preservation and conservation problems may be as a staff member participating in the general responsibility of a greater and/or national library (and any such librarian who daily works with not only key board and screen, but books, shares general responsibility) or as the responsible officer in a smaller one. It must be added: if this smaller library has books that are intended to be used not only *actually* (this word in the context of books can be defined as any period less than twenty years and possibly up to fifty), but also in the *far future* (that is any space of time, the end of which cannot be described by a number).

The correct catalogue entry of the publication reads as follows:

> Dureau, Jean Marie: Principles for the preservation and conservation of library materials / by J. M. Dureau and D. W. G. Clements under the auspices of the Section on Conservation. – The Hague: IFLA Headquarters, 1986. – 29 p.; 30 cm. – (IFLA Professional Reports: 8) – ISBN 90-70916-11-8, ISSN 0168-1931.

History

There has just been another publication with a similar title: "Principles of Conservation and Restoration in Libraries", edited 1979 and 1980 under the name of a collective author: the Members of the Standing Committee of the IFLA Section on Conservation, in five languages: English, original version: IFLA Journal 5,4 (1979) pp. 292–300; French translation: Bulletin des Bibliothèques de France 25,4 (1980) pp. 161–166; German: Zeitschrift für Bibliothekswesen und Bibliographie 27,3 (1980) pp. 227–238; Italian (with comments): Principi Generali di Conservazione del Libro, ed. Piero Innocenti, Florence 1982, pp. 9–22; Russian: Bibliotekovedenie i Bibliografija za Rubezòm 81 (1981) pp. 70–81. This publication was accompanied by an invitation to send comments to the author, e.g. to the chairman of the named Section, at this time Peter Brown († 1984), Librarian of Trinity College in Dublin.

Restaurator 7: 202–206 © 1986 Munksgaard, Copenhagen

To elaborate principles as a result of cooperation of those libraries that are active in the field and have a good experience in it to be used by those others that will become or need to be active in it: this was among the first activities of the Section. It was challenged in 1973 in Grenoble by Franz Georg Kaltwasser, director of the Bavarian State Library in Munich and at this time a member of the Standing Advisory Committee of the IFLA Section on National Libraries, one of the promoters of the body that later became the IFLA Section on Conservation. As early as 1974, on the occasion of the 40th IFLA General Council Meeting in Washington the first draft was discussed. It took five years of difficult discussions to find a wording that, on the one hand, is precise enough to be useful and, on the other, general enough to be accepted by all.

Comparision

If we compare the text of 1986 with the text of 1979 we must say: in spite of the different title it is the same publication. In the main parts (1979: §§ 1–5) 70% or 80% of the wording has been taken over (1986: §§ 3, 23–24, 32, 35–36, 52–55, 57–58, 60, 68–70, 73–75, 77–78). Just this enumeration makes quite clear another fact: the main difference between 1979 and 1986 is an enlargement, and if we remember the aim and the primary intention of the principles we must say, this is not necessarily a benefit. A definition has been added (§ 5): according to the philosopher Wittgenstein, mostly a boring and useless strain: in anybody's mind the words "preservation" and "conservation" provoke certain ideas that are partly the same and partly different. We will try to separate these fields of meaning making use of the words of Dureau and Clements:

1: "P. includes *all the managerial and financial considerations* including
2: "C. *denotes those specific* policies

1: *storage ..., staffing levels*, policies, techniques and methods
2: and practices

1: involved in preserving library and archive materials *and the*
2: involved in protecting library and archive materials *from deterioration*,

1: information contained in them."
2: *damage and decay* including the methods and techniques".

To make clear the difference, the words that have no equivalent in the other text is given in *italics*.

Additions

Long paragraphs on general library function and policy have been added (§§ 6–18): quite an ambitious undertaking and not just covered by the words "preservation" and "conservation" as defined. Nearer to these definitions are the added paragraphs that deal with protection against fire (38–44), water (45–46), disaster (51), theft (48–50) and war (47). Maybe by reading the 1,000 or 1,200 words of these paragraphs, a librarian will find some help to prevent a book from being stolen and being destroyed by fire and by other dangers, and maybe the thirty-nine words on war will help a book to survive this catastrophe.

New wording

The essential content, the true object of the Principles is not altered by these changes. This is only the case with those paragraphs that have found a totally new wording, e.g. *Temperature and humidity* (1979: §§ 2.4–2.6; 1986: §§ 25–28), *Light* (1979: 2.7; 1986: 29), *Exhibitions* (1979: 2.16.; 1986: 63–64), *Restrict use and substitutes* (1979: 2.12–2.15; 1986: 65–67). In any event, the new wording describes the scientific facts on which the instructions given by the Principles are based more precisely, even if it must be said that striving for scientific incontestibility can lead to prolixity. What is said, e.g. 1986 in § 29 on the cumulative effect on light is correct without doubt. But the result, that "library materials with sensitive design material should not accumulate more than 50,000 lux hours per year" is less useful than the rough and general rule of 1979, § 2.7, that any light is dangerous and the suggestions given there how to prevent unnecessary lighting. What library, even what national library is equipped to check lux hours, to say nothing of the smaller ones who do possess ten or twenty books "with sensitive design materials" and with a famous reputation so that there is a demand for permanently exhibiting them? Another result of the strive for a new and more exhaustive wording is the fact that the Principles 1986 touch the same item in different paragraphs, e.g. transfer to other media in §§ 6, 12, 67 and even others, restrict use in §§ 52 and 65, general perishability of library materials §§ 23 and 69, separating rare and precious books from general

collections §§ 36 and 53, etc. Even such a new and, until now, only theoretical means of preservation (that is not used anywhere and that will possibly never be used for this purpose) as the optical disk is named two times in the Principles 1986: §§ 12 and 67. Such an inattention caused by undue aspiration to be very modern displaces the weight of information: it would be a bad result of the Principles if a librarian takes their relevant words as advice to wait for the optical disk as a better means of preservation than microfilm and microfiche, which can be used today.

Omissions

What must mostly be *deplored*, and the author of this word has a right to *deplore*, because he is one of the two main editors of the Principles 1979, mostly deplorable is that the new edition repeats and even intensifies the faults that could not be avoided in the first. We remember what can be the use and benefit of such Principles: to be a primer or a compendium summarizing the basic knowledge a librarian must have if he gets in touch with conservation and preservation. This knowledge is not: transfer the responsibility to, trust in and always ask the experts! (§§ 21, 68, 69, 70, 76). We must realize that those experts do not exist. For some actions of preservation the advice, the arrangement or even the work of a chemist is indispensable, but almost never the chemist available in a given case is an expert, neither for conservation nor even for the materials that must be preserved. The bridge from chemistry, microbiology, entomology and even special conservation technology to librarianship and library preservation must be built and done by the librarian, and the Principles should be a means for this. Sometimes the cry for the expert sounds quite ridiculous, in the Principles of 1979 (for which the author of these words bears a good deal of responsibility) as well as in those of 1986. Why must a species of insects or of fungi that has damaged a book be identified, if the means are the same against any species? These words must not be misunderstood as refusing scientific – microbiological and mycological – research in the context of and as a basis for library conservation. But the expert's research – there are very few real experts for this field in the world – and the librarian's preservation practice are two different things. In practice we need the advice of what to do if there is no expert and, in the case where an expert's advice and work are indispensable, we need advice on what to do before the expert arrives. We also need advice that enables us to distinguish the occasional appearance of a silverfish or a beetle from the first sign announcing a catastrophic infestation. It is not right to say that "assistance must be sought from an entomologist as a matter of urgency to identify the species" if a cockroach has been seen scurrying under the shelves: it should be said that

this is a sign of urgency to look for better cleaning and better climatic control and to check the books for possible damage, and some basic knowledge should be given to qualify the librarian responsible for conservation for a discussion with the officer of the normal pest control service, who in most cases will be the only "expert" available.

Restoration

Again deplorable is another omission the new Principles have in contrast to the old: nothing is said on restoration (1979: §§ 6–8). For restoration alone, those libraries that have been active in this field for many years and that have accumulated their experience by both good and unsatisfactory results can give very useful advice to a newcomer, as were the efforts in 1979. It is the wrong policy to cede this field to the restorer: the librarian is the very person responsible for the historic substance of the books and other items he collects. He is the very person who must insist that this substance will survive the restorer's treatments. He must discuss intelligently with the restorer, and for discussion he needs some knowledge and good principles: precisely those principles the edition of 1986 witholds from him. If he will find them he must go back to the 1979/80 edition. He can do this without hesitation, and without drawback for other objects, too, even if the 1979 Principles are far from being satisfactory. Let us hope that one day soon there will be a third edition, and that this will be nearer to the ideals of both the first and the second.

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RESTAURATOR. *International Journal for the Preservation of Library and Archival Material,* presents original papers on subjects mentioned in the titles, as well as reviews and news of interest to scientists, conservators, archivists, and librarians.

Articles for RESTAURATOR are published in English, with *Summaries (Abstracts)* in French and German. However, manuscripts written in French or German are welcome, as they will be professionally translated by Munksgaard after acceptance. Contributors writing in any of the above three languages, which is not their mother tongue, are particularly asked for linguistic and stylistic accuracy. After acceptance for publication, all articles are linguistically revised by Munksgaard before printing.

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

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