neatsfoot oil. After application, excess Pliantine was not removed for several months to ensure good penetration. Then the surplus was removed with solvent (hexane, petroleum ether). Impregnation caused temporary slight darkening of applied colours (Gowers 1975, pp.4-5).

E. Glycerin (see 18.3.2.E.)

F. Alcohol

1. Methanol: Giuffrida describes the successful use of methanol, in a bath or as a vapor in an enclosed container, to relax badly distorted, possibly gelatinized, parchment (1983, p.32). To remoisten dried out skins and make them more flexible prior to retensioning, parchment sheets can be gently rubbed all over with cotton wool dampened with alcohol (containing some water, not absolute alcohol). Take great care not to dislodge ink particles. Do not use on illuminated leaves. Slow treatment should never be carried out using a solvent containing water because of the greater danger of bringing about (further) gelatinization (Giuffrida, 1983, p.31-32).

   Cains, p.51, describes immersion technique of vellum leaf in methanol followed by insertion in polyethylene envelope (to inhibit evaporation of the methanol and contact with this toxic solvent) followed by manipulation to ease out distortion. He uses ethanol or isopropanol and water for local dampening of horny, relatively impermeable areas of skin.

2. Ethanol: Immersion of distorted, fire-damaged parchment rolls in a water/alcohol solution of 60% ethanol for 24-48 hours permitted unrolling. This was followed by tensioning and repeated brushing with the water/alcohol solution over 3 - 4 days so the parchment never dried out. When this treatment was followed by swabbing with or immersion in PEG200 the result was more "perfectly flat and obviously more soft than similar parchments not treated with PEG" (Tanasi 1984, pp.23-26).

   Dreibholtz (1991) describes use of alcohol and water mixture (4:1) on shrunken creased Middle Eastern parchments: spray hair side first to postpone curling of edges, place between wax or silicon paper and weight edges with small weights. Repeat this process as necessary. After final spray, put parchment into press under very light weight. After one day, replace the silicon with blotting paper. The object is pressed for 4 weeks or longer.

G. Other Lubricants

1. Lanolin Emulsion: 1% anhydrous lanolin in ethanol and water to lubricate fibers (for preparation and use see O'Hoski 1976, pp.69, 76).

2. Milk: Because the original "softness" of parchment was due to its content of natural grease, the addition of small amounts of acid-free fatty substances, such as milk, were thought to be helpful. Rubbed into the parchment, milk has been reported "to clean it and make it a little greasy". An associated risk was the potential generation of lactic acid (Wächter 1962, p.24).

18.4.9 Local Treatment

There are many occasions where one might consider performing more local treatment on a parchment artifact, either prior to or in lieu of overall humidification and flattening.

A. Treatment of Folds, Creases, Pleats

One of the most direct ways to locally humidify a fold, crease or pleat is to apply a solution of either 50/50 water/ethanol or pure ethanol or isopropanol along the crease or fold line. However it is possible that tidelines may develop in discolored skins. In addition, some surface preparations (especially highly napped parchments) and coatings may be disturbed by the direct application of water or solvents. In these cases one can try more indirect methods of local humidification such as small squares of polyester web, Gore-Tex and damp blotter over the area to be relaxed and flattened. An ultrasonic humidifier with a hose attachment can also be useful for local humidification of a small area. The "Preservation Pencil," sold by University Products, comes equipped with a plastic nozzle that fits on the end of the hose. For an even finer jet of ultrasonic mist one can attach a glass eye dropper or pipet to the end of the hose with some modifications. One must be extremely careful when using an ultrasonic humidifier in this way, however, because condensation will gradually build up at the end of the nozzle and drops of water may ultimately fall on the object. In order to prevent this from happening place the humidifier on the floor so that the condensation is able to drain back into the tank. On a regular basis, vigorously shake the nozzle off to the side of the work area, in order to expel any water droplets that have collected at the tip. One can also touch the end of the nozzle to a blotter every so often to wick up any free water that might have collected at the tip.

The local treatment of pleats in a parchment artifact may not always be advisable, depending on how the pleats have formed in the skin. If they are obviously the result of some type of mechanical damage or manipulation of the object (Clarkson 1992, Figs. 54a & 54b), they can usually be locally humidified and flattened out with a certain amount of success. If, however, the pleats have formed as a result of the expansion and contraction of certain areas of the skin, with changes in the surrounding environment, they may be much more difficult to remove. These types of pleats, which are seen more frequently in full thickness (i.e. unsplit) parchments than in modern split skins, are often associated with a type of cockling that is oriented parallel to the spine direction of the animal (Clarkson, 1992, Figs. 11, 25, & 26). When these pleats are located in the blank margins of an artifact, and do not extend into heavily painted areas, they can sometimes be locally humidified and dried under tension by an experienced conservator (Lee 1992, p.48). However, the manipulation of pleats in illuminated or heavily gilt areas could easily disturb the paint or gold nearby, so it is usually best not to attempt any form of local treatment in these situations (Lee 1992, p.47 and Figs. 4 & 6).

B. Treatment of Wide Splits/Tears

Splits and tears in a parchment artifact may begin to close up once the skin is humidified overall. However, as the parchment contracts upon drying these areas of damage will open out again and may even tear further, depending on the drying

method that is employed. For these reasons it is advisable to repair any splits and tears, in either a temporary or permanent way, before overall humidification and flattening of the artifact is carried out. If the split or tear is already well aligned, and requires no further manipulation, it is usually preferable to attach a permanent mend of transparent membrane, new parchment or paper to secure the area (see Section 18.4.11, Mending and Filling for a more complete description of these methods). If, on the other hand, there is a wide gap in the split or tear or if the area is misaligned due to distortions in the skin, a temporary repair might be more suitable at this point. Depending upon the area in the skin where the damage has occurred, and the proximity of sensitive media, tears can sometimes be partially closed or realigned with the local introduction of moisture (see techniques described above) followed by hand manipulation and drying under light pressure. Before the area is very dry, however, the temporary repair is applied. This can consist of a piece of Japanese tissue applied with starch paste or an adhesive-coated tissue such as heat-set tissue which is activated with solvent. Pressure-sensitive tapes have been used by some conservators for the temporary repair of splits and tears (Cains 1982/83, p.17) yet there is always the risk ofleaving some adhesive residue behind, especially if the skin has a prominent nap. For temporary repairs it is important to choose a relatively lightweight material which is very flexible and also easily removed at a later point. Therefore mends adhered with either gelatin or parchment size are usually not appropriate for this purpose.

At the Walters Art Gallery splits and tears in a badly mold-damaged parchment manuscript were recently humidified and temporarily repaired with the help of a book suction unit (described in Quandt 1992, pp.188-189). The first leaf of the manuscript was severely perforated and torn and many damaged areas were misaligned. The leaf was positioned on the suction table and then humidified overall under polyester web, Gore-Tex and damp blotters. Once the skin was sufficiently relaxed tears and splits were gradually realigned while the leaf was held in place under slight vaccuum pressure. Small pieces of a lightweight Japanese tissue, previously coated with a viscous solution of Klucel-J in ethanol, were positioned over the tears, moistened with ethanol, and pressed in place. Each patch of repair tissue was locally weighted, under squares of blotter and Plexiglas, as the work progressed across the leaf. Some tears and splits, which could not be completely closed or realigned during the initial stages of treatment, were rehumidified locally using Gore-Tex and damp blotters. The existing repairs were removed, the damaged areas were manipulated further and new temporary repairs were then applied. After all of the necessary work on the suction table had been completed the manuscript was removed and left under pressure for a couple of weeks, to allow the moisture content of the parchment to come to equilibrium. Temporary repair patches were gradually removed and the damaged areas were mended for a final time, using carefully profiled pieces of the same adhesive-coated tissue. (AQ)

C. Treatment of Horny or Shrunken Areas

Parchment artifacts that have been damaged by water or heat are often horny and shrunken in certain areas - usually around the edges that were most exposed. (These areas often have a translucent appearance as well, especially when the damage has been caused by water.) If this type of object is humidified overall the

rate of water absorption and the resulting relaxation of the skin can be very uneven, with the undamaged areas taking up moisture more rapidly than the horny, shrunken areas. This can lead to several problems, especially if the conservator prolongs the humidification process in order to relax and flatten out the damaged areas of the skin. In these situations it is sometimes better to treat horny or shrunken areas locally, either prior to or instead of overall humidification and flattening. Moisture can be introduced locally, using some of the methods described above, and the area can then be gently manipulated with the fingers and dried under pressure using small squares of polyester web, blotters or felts, Plexiglas and weights. If moisture alone is insufficient in relaxing the damaged area one can locally apply ethanol or isopropanol, either alone or in combination with water, by brush or spray or with a dampened blotter pack. Although methanol has been successfully used in the past as a softening agent for parchment it is extremely toxic and therefore no longer recommended. Other lubricants, such as urea and polyethelyene glycol (PEG), have been found to alter the character of parchment in a variety of ways and are also not recommended for current use (see Sections 18.3.2 and 18.4.8 for further information on Lubricants and Lubrication.)

18.4.10 Flattening/Tensioning/Drying

Many factors determine the choice of technique for drying a humidified parchment artifact, including (but not limited to) the weakness of deteriorated or mold-damaged skin, the presence of tears or losses, soft or fragile media, the presence of seals and other attachments, the quantity of material being treated, and the techniques at which the conservator is practiced. Every technique of drying is more successful when sensitivity and experience are employed in carrying it out, and when the procedure is carefully monitored so that the conservator can respond quickly, and possibly alter the process, if a problem arises.

A. Drying and Flattening under Pressure

Flattening under pressure is a commonly used technique for parchment. Some practitioners are opposed in principle to the use of this approach, because they feel it is important to always dry the parchment under tension, similar to the way in which it was manufactured. The idea is that since the initial drying of the wet pelt under tension first created the parallel alignment of the fiber bundles to which parchment owes its identity, this manner of drying must be employed in conservation practice in order to avoid altering the character of the skin. Others respond that keeping a humidified parchment immobilized under uniform moderate pressure during drying is equivalent to tension drying, and that this can be done in a sensitive manner so that no significant alteration of skin character can be observed.

There are several situations in which pressing is safer than tensioning, such as when a parchment is weakened by mold or other factors, and when there are tears within the sheet which may widen or lengthen under tension (see 18.4.9 Lubricants). A parchment that is very limp when humidified is vulnerable to distortion if it is placed under too much tension, and even the slightest distortion can be especially disturbing in a manuscript written in parallel lines or a print with a rectangular border, for example. Of course, existing distortions in a misshapen artifact will not be improved and may be exaggerated by flattening under pressure,

unless the pressing is combined with or preceded by tensioning (see 18.4.10.D). Pressing is usually the best option when media extend to the edges of an artifact and would be harmed by clamps, as in the case of trimmed manuscript leaves or fragments. Pressing can be advantageous when a large number of parchment objects must be flattened, since they can be humidified in quantity and stacked under pressure (with interleaving) quickly and with little space or equipment.

Sometimes it may not be possible to determine whether a parchment can or should be dried under pressure until the item has been fully humidified. Only then may it be possible to determine whether a previously deformed parchment lies flat enough when it is relaxed by humidification to be pressed without danger of creasing. Also, when a parchment is humidified its advanced state of deterioration may become apparent if areas look very wet, gelatinous, or translucent. This will of course happen if an artifact is over-humidified, and since mold-damaged skins are locally deteriorated, just enough humidification for some areas will cause over-humidification in others. In these cases the amount of pressure must be especially moderate, or permanent alterations may occur (see 18.2.5).

1. Pressing Between Blotters: When pressing a parchment between blotters under a weight, it is not advisable to humidify the parchment beyond the point where it is relaxed enough to lie flat. Excessively humidified parchment is more vulnerable to the hazards of excessive moisture when combined with excessive pressure (see 18.2.5). A rectangular piece of plate glass (taped at the edges to avoid injury to the conservator), or thick Plexiglas or pressing boards can be used for pressing (see 18.3.4 Tools and Equipment). If needed additional weight can be placed on top. The weight should be sufficient to discourage cockling of the blotters between blotter changes. The artifact should be placed between clean smooth pieces of polyester web such as Hollytex (see 18.3.5) to prevent bonding of the parchment to the blotter, to prevent offsetting of media and to avoid imparting the blotter texture to the surface of the parchment. As an added precaution smooth blotting paper with minimal texture should be used. Shortly after pressing begins (after a minute or less) the parchment should be quickly inspected to make sure there is no creasing or other problem. (A kitchen timer is useful for monitoring the first checks and blotter changes.) At this stage, if there is a problem, the parchment can be returned to the humidity chamber and there is a good chance the artifact will not have been pressed long enough to permanently mark it. If there are no problems, the blotters should be changed. It is important to change the blotters at brief intervals at first so that their cockling will not hamper flattening of the parchment. Blotters should be changed quickly so that the still partially humidified parchment will not begin to dry without restraint, thereby reintroducing cockling, shrinkage, or other deformation. When the blotters are no longer cockled by exposure to the parchment under weight, the item should be left under weight for a week or preferably much longer. The first 2-4 days the blotters should be changed daily.

   No matter how long a parchment is left under weight, it is not likely to remain completely flat for long once it is removed from the press. The skin will most likely reassume a natural undulation, especially when exposed to

humidity fluctuations (see 18.2.4). This must be accounted for in housing and storage of the artifact (see 18.4.13 Housing). It is helpful to make sure that humidity levels are appropriate in the workshop before removing the parchment from the press.

2. Pressing Between Felts: Thick wool felts (see 18.3.5) are often helpful for flattening because they can keep an item under pressure while providing a thick interlayer with more cushioning than blotters. They allow moisture to pass through, promoting slow even drying. They do not cockle like blotters when they are damp, and therefore do not have to be changed at intervals. When more weight is desired the felt can be doubled or tripled. The felt pile should be covered with a pressing board, and depending on the parchment, some additional light weight. Wool felts are light and impressionable enough to protect vulnerable media from crushing or flattening, especially illuminated leaves with raised gold leaf. A mold-damaged document can be safely pressed under felts in situations when flattening under glass or in a press would be out of the question.
3. Alternative Weighting Systems: Parchment is sometimes flattened in a variety of presses, such as standing or nipping presses. These presses are capable of extremely high pressures that are potentially very dangerous to parchment. However, when used with experience and sensitivity, they can be a useful tool, capable of precise amounts of pressure. The humidified object is sandwiched between polyester web, felts or blotter, and pressing boards. The sandwich is centered in the press and the flywheel is turned until the point that only platen pressure is exerted. It is unwise to increase the pressure beyond this point. Only moderate pressure is needed for flattening parchment. Remember to check the parchment after a minute or so to make certain that there are no creases or folded-under edges. (In working situations where equipment is shared by several conservators, it is advisable to leave a visual reminder, such as a sign, that the press is in use. This prevents the possibility of critical settings being unintentionally altered.)
4. Accommodation of Platemarks and Attachments: A frequent complication in pressing parchment artifacts is the presence of seals, ties, ribbons, and other attachments. Platemarks and embossings can be vulnerable to pressing, and the folded-over borders seen in many legal documents must be accommodated. Many of these accommodations are made in ways familiar to the paper conservator. Cut-outs can be made in the blotters used for pressing to allow for the extra thickness of attachments on the surface. As many blotters as necessary must be cut to accommodate the thickness of the attachment, with one uncut blotter placed on top. It is much more convenient to prepare these blotters before beginning humidification. Additional blotters for successive blotter changes should also be prepared in advance. Sometimes more than one attachment will have to be accommodated on a single document. Before humidification a parchment that is not horny can usually be spread out manually to find where these multiple attachments will be relative to each other after the sheet has been flattened, and a template can be drawn showing these locations. This template can then be used for making cut-outs in the blotters. For edges that

are folded over creating a double thickness, a single blotter on top of the document and butted against the fold-over edge may accommodate the difference in thickness. As with prints on paper, an extra blotter cut to the shape of the plate can be placed inside the platemark.In all these cases interleaving is placed between the blotter and the skin to protect the surface and media. It is also a good idea to insert spun-bonded polyester under fold-overs and beneath loose flaps of surface attachments to avoid cementing parts together during pressing which were not meant not to be adhered.

Pendant seals and ribbons can often be allowed to protrude from the press during drying. Most parchment bands and other types of attachments for heavy seals are thick and non-responsive enough to be allowed to dry unrestrained. It is a good idea to provide support for these attachments when they protrude outside the drying pack. It is generally not recommended to take apart, unlace, unfold, or detach attachments from documents for the sake of flattening. Some part or parts of the attachment may be too fragile to survive disassembly, and after the changes undergone by parchment in humidification and flattening, it may be impossible to put things back exactly as they were after the object has dried.

Approaches to flattening under pressure can be modified or combined to suit each individual problem, such as placing thick felts in a press when an object needs increased restraint but its surface or media need extra protection. Flattening under pressure can also be combined with tensioning techniques. This is routinely done in workshops where documents are tensioned until they are nearly dry, and then placed under pressure for the final stage of drying (see below).

5. Accommodation of Joined / Multiple Sheets: Multiple sheets are often legal documents which were joined using official seals or a lacing system designed to prevent tampering. Many of these systems can not be undone without doing permanent damage to these auxiliary materials or to the area of overlap with the sheets. Where the sheets are joined with cords, threads, or ribbons the condition of these materials must also be considered. Naturally if the sheets can be separated for humidification and flattening this treatment will be easier and more successful, but in most cases this is not possible. Thus, it may be preferable to settle for a document that, although not completely flat, still maintains its original configuration. If a multiple-sheet document if pressed as a unit, the amount of humidification and pressure it is exposed to should be very moderate, and a thin non-stick material such as smooth spun-bonded polyester should be inserted between all sheets to prevent their sticking together.

   Sometimes the top sheet of a multiple-sheet document may be more cockled than the successive sheets, and the treatment goal may be to increase the flatness of just that sheet. In that case the sheet can be humidified while remaining attached using Gore-Tex and blotters or any other system for local humidification (see 18.4.7 Humidification and 18.4.9 Local Treatment) and isolating it from the sheets underneath using polyester film. Similar techniques have been used for parchment book pages that remain in the

binding. The document can then be weighted under felts, or the single sheet can be dried under tension (see below). It is also possible, with careful planning and dexterity, to tension all of the multiple sheets at once (see Burns and Bignell 1994).

6. Hazards: The hazards particular to flattening under pressure should be emphasized. These include the translucency caused by gelatinization due to a combination of excessive moisture with excessive pressure, and the permanent pressing in of wrinkles and creases caused by pressing a parchment which is very distorted following humidification. Some parchments, usually very thin ones, have a marked tendency to curl when they are humidified, and if they are accidentally pressed with an edge curled in this may leave a permanent crease or possibly cause the edge to cement onto itself. There is also, of course, the risk of offsetting, or flattening softened paint or raised gold. This risk may become apparent only after humidification, at which time the conservator may decide to dry the object under tension rather than under pressure. Some conservators set up for both types of flattening before beginning humidification, so that they will be ready to proceed either way once they observe how a parchment responds to humidification. Further hazards are the crushing or bonding of seals or attachments, and the loss of relief of printing ink and platemarks.

B. Tensioning at the Edges

1. Tensioning by Weighting the Edges: This technique is less frequently used than tensioning with bulldog clips (see below), and does not lend itself as well to local adjustment/manipulation of the sheet as the latter technique, but it works well for artifacts with straight, regular edges. It may be especially practical for oversized sheets which are too large to place on a stretching board, and composite oversized sheets (larger sheets composed of smaller sheets which are attached to each other end-to-end) where the separate sections can be humidified with Gore-Tex and weighted at the edges and dried one at a time.

   Working through a protective barrier sheet such as spun bonded polyester the humidified piece or section can be pulled flat or smoothed by hand. Strips of spun-bonded polyester are laid over the edges, followed by blotter strips, then flat metal rulers or Plexiglas strips, and finally as many small weights as are felt to be necessary to provide the appropriate amount of pressure at the edges. Choosing the correct amount of weight is perhaps the most critical aspect of this procedure: too little weight will allow the parchment to slip from underneath as it contracts and dry unrestrained, and too much weight can cause marking, transparency, or damage to media at the edges.

   Refer also to Barbara Giuffrida's description of hand manipulation and local weighting (pp.35-36) as there is a difference of opinion in such working practices.

2. Tensioning with Clips and Pins on a Board: For maximum control during the drying process one should set up for tensioning before humidification begins. This way tensioning can be carried out at precisely the stage of humidification which the conservator thinks is optimal. A soft insulation board such as Homosote, or a thick block of Ethafoam, will allow for a

certain amount of movement in the pins as the skin begins to contract and dry under tension. Cloth-covered plywood can also be used for pinning out parchment yet, due to its greater rigidity, the pins tend to stay in one place once they are positioned. In order to introduce a greater amount of flexibility into the system it is common to attach rubber bands to the handle of each bulldog clip and hook the ends around the pins that are stuck into the board.

The type of pins that one uses for this method of tension drying can also affect the success of the process. The length and thinness of dissecting pins make them more prone to bending, once the skin begins to dry. This can make it more difficult to maintain an even tension around the perimeter of the object. In order to avoid this problem the length of the needle in commercial dissecting pins can be cut down to a smaller size so there is less material to bend.(NB) Alternatively, the pins can be made by hand using number 15 bookbinders sewing needles and short lengths of 1/2" thick wooden dowel. (For further description see Cains, 1982/83, p.21.)

The modified bulldog clips should be laid out on the board roughly in the shape of the artifact. They should all be laid with the same side down so that they will all pull at the edge of the parchment at the same angle. If using plywood as a tensioning surface loop rubber bands through the hole in the handle of each Bulldog clip. Position the pins in an accessible way so they will be easy to obtain when you need them. When the humidified artifact is laid on the board it is essential to work quickly so that it can be effectively tensioned before it starts to dry out. To this end it may be preferable to work with a colleague at opposite sides of the board, especially if the tensioning is tricky due to tears or an irregular shape, or if the item is over-sized. In such a situation some conservators are accustomed to replenishing the moisture in the artifact at intervals while they work, using an ultrasonic humidifier with a hose/nozzle attachment or a dahlia sprayer filled with a water/alcohol solution. One must be careful, however, not to apply moisture directly to an object that has sensitive media or surface preparations. For these objects is it better to raise the overall humidity in the room in order to prevent too rapid drying of the parchment and to permit a longer working time. In any case, tensioning should not be undertaken when the relative humidity is less than 50%, to avoid placing undue stress on the object as it dries out.

The clips are first attached to all sides of the sheet starting at the corners. It is important to keep the jaws of the clips level with each other along each edge to avoid creating clip marks. An unclipped gap will be left over at the end of each side. A small gap will permit easy repositioning of the clips later on (for reducing clip marks); if the gap seems large enough to interfere with even tensioning then the other clips on that side can be slightly spaced to fill in the end. Ideally no gaps are left between the clips in order to avoid uneven tensioning. When using plywood the clips are tensioned by stretching out the attached rubber bands with moderate tension and then inserting dissecting needles through the loop. In the other system employing a soft board the pins are placed directly through the lower hole in the clip handles. The needles are positioned at an angle, away from the

center of the board, so that they will hold the clip firmly and not be pulled out as the parchment starts to contract.

Most conservators work from the centers out toward the corners, placing pairs of clips opposite each other in order to keep the tension as even as possible. The amount of stress created between each pair of clips can be judged both visually and by feeling the tension of the rubber bands or the clips with the fingers. It is more important to get the entire sheet pinned out quickly than to lose drying time comparing each pair of clips as they are secured. After the sheet is pinned out one can inspect the entire sheet and again test the tautness of each rubber band or clip, making adjustments as necessary. If there are straight lines of printing or writing or straight drawn or printed borders a straight edge can be used to help with the visual evaluation.

Sometimes local deformations in a sheet can be improved by placing them under slightly more tension during pinning out. This can be risky, however, and should only be attempted by someone who is experience in the practice of clipping and pinning a piece of parchment. The whole tensioning process requires careful attentiveness, since the final shape and conformation of the artifact is being determined by the manipulations of the conservator. Parchment should not be over-tensioned to the point that it is drum-tight during this process. Although the sheet will usually not appear completely flat after it has been correctly pinned out, it will gradually become flatter as it contracts during drying. The moisture content of the skin can be checked during drying by gently touching its surface with the back of the fingers. The coolness of the parchment gradually decreases as it dries. If distortions should appear or existing distortions should worsen, the pins can be adjusted once more, or the parchment can be unclipped and returned to the humidity chamber while the conservator's treatment plan is reconsidered. If no problems arise, after a brief interval (5 minutes or so) all the clips can be moved a slight distance along the edge of the sheet in order to reduce the danger of leaving permanent clamp marks in the edges. The clips should not be moved more than once to avoid disturbing the drying process.

When the object is nearly dry (10 minutes-1 hour, depending on the thickness of the artifact and environmental conditions in the laboratory- the skin should be taut against the clips but still slightly cool to the touch) it is usually unclipped quickly from the board and placed under weighted felts or blotters for final drying. It should be left weighted for at least a week or preferably longer. This drying stage under overall pressure serves to reduce clip marks and any other deformations created by the clipping-out process. Sometimes a sheet will be placed under weight after a very brief pinning out, just long enough to eliminate the danger of creasing or wrinkling which might have occurred if the humidified parchment had been placed immediately under pressure for flattening. In rare cases a parchment may be so permanently and severely deformed that it can only be partially flattened using local treatment combined with tensioning. Even these distorted objects can, after tension drying, be padded with pieces of felt or other soft material such as polyester batting or surgical cotton for placement under felts and light weights.

3. Tensioning with Clips and Hanging Weights: In this system bulldog clips are attached to the edges of the artifact and tension is provided by small hanging weights that are suspended by strings from the "handles" of the clips. The principle of this method is that the humidified skin is held under light tension by the hanging weights. As the skin dries and contracts the clips remain firmly attached to the edges while the weights are free to move in response to the drying parchment. One of the difficulties, however, is in achieving equal tension around the perimeter of the artifact. (Giuffrida, p.34) Douglas Cockerell's technique was to support the object using a free-standing wooden frame on which strings are tensioned in either direction, making a grid-like pattern. (Cockerell, 1938, p.84 and Fig. 23) Once the parchment was humidified the clips were attached to the edges of the object and the small lead fishing weights were suspended from the clips by strings, over the edges of the stretching frame. Otto Wächter (1982, p.168) describes the use of a board to support the object during the tensioning process. The board is somewhat larger than the object all around and must be set up in such a way that the weights can hang freely from the clips, around all four edges of the parchment.
4. Tensioning on a Rigid Frame: This technique is derived from the method used in the manufacture of parchment, whereby the damp skin is tensioned on a rigid frame to dry. Giuffrida (pp.33-34) describes an Italian method that utilizes a circular hoop fitted with stainless steel clips and violin pegs. The clips are attached to the edges of the artifact while the violin pegs, which are connected to the clips by lengths of cord, are secured at 5 mm intervals around the circular frame. Adjustment of the tension on the skin is done with the violin pegs. Otto Wächter later perfected this technique by replacing the cord with chains, which could easily be adjusted in length according to the size of the object being tensioned. (Wächter, 1982, pp. 167-168) One of the main advantages of this system is that, because the frames can be positioned vertically, it is possible to view the object from both sides during the drying process. (Giuffrida, p.34) A more recent modification of this technique was developed by Smith and Bunting (see Special Considerations 18.6.6). They use a stretching frame similar to that designed by Cockerell (see above) which consists of a wooden strainer with fishing line tensioned across in a grid pattern. In this case, however, the nails that hold the nylon line around the perimeter of the frame also act as rigid points against which the skin is tensioned. Rubber bands, instead of lengths of cord or chain, allow for more flexibility in the attachment of the bulldog clips to the object.
5. Accommodation of Attachments: Many attachments do not interfere with or influence the tensioning/drying process. Some seals, however, which are attached to the surface with water-sensitive adhesives could pop off during drying and would have to be reattached after the artifact is dry. Pendant seals that are laced in close to the edge may interfere with the placement of clips. When objects with unusual shapes or irregular edges are tensioned the process is still the same for the most part, although not all the clamps will extend at right angles from the edges of the artifact. By observing the

surface of the item during pinning out it should become apparent which arrangement of clips will achieve the most level surface possible.

6. Accommodation of Joined Multiple Sheets: Although the technique requires a certain amount of skill and confidence it is possible to dry and flatten joined parchment sheets using a tensioning method. (See Burns and Bignell, 1993.)
7. Hazards: Tensioning of parchment is not without its hazards. Improper tensioning can cause distortion of the plane or the shape of an artifact. Excessive tensioning, especially in combination with excessive humidification, can permanently increase the dimensions of an object (overall), cause tears in weak areas, or enlarge existing tears if they are not adequately secured beforehand. The clips can damage softened media. In addition, the following problems can occur when using some of the tension-drying methods described above.
   a. Splits, Tears and Weak Areas: Tensioning is riskier, or at least more complicated, when a sheet is weak or torn. These areas should be watched closely to avoid over-tensioning during the pinning out and drying process (See 18.4.9.B Tensioning at the Edge). Weak or torn areas should be mended or reinforced before humidification and flattening. The mends which are applied can be temporary, to be removed immediately after tensioning is completed, or permanent, if applied to areas which will ultimately need reinforcement. If the mends are meant to be temporary, they do not need to be aesthetically appropriate. They need only be strong enough to withstand the stress they will be placed under during tensioning. If they are temporary, the mends should be removed before placing the parchment under pressure, after tension drying is completed.
   b. Transparency Caused by Excessive Moisture and Tension: Depending on the degree of moisture in the skin, and the type of weights used in this method of tensioning, it is possible to create transparent areas in the skin. In order to avoid this problem it is important not to overly humidify the skin and to use relatively light weights for the tensioning process.
   c. Clip Marks and Distortions: There is always the danger of leaving clip marks and distortions at the edges yet they can usually be dealt with in the following ways. The modification of the bulldog clips can be improved by adding more cushioning and by making sure that the jaws of each clip are parallel to each other (see 18.2.4.A.1). The clips should be repositioned during drying (see above). Distortions and scalloping at the edges can be alleviated by making sure that the jaws of the clips are level with each other along each edge, and by not leaving gaps between clips. Isopropyl alcohol or alcohol/water can be applied locally to the marks during repositioning and/or prior to weighting. Also, a final local humidification and flattening can remove clip marks.

C. Stretch Drying on Terylene

This method of drying was originally developed in Europe and is currently used in many large libraries and record offices in the U.K. A large sheet of Plexiglas is

roughened slightly so as to adhere better to the terylene. A piece of terylene cloth with a smooth surface is then pasted to the Plexiglas and an additional coating of paste is applied on top of the fabric. The parchment artifact is humidified and then smoothed out on to the terylene, while the paste is still moist. Although flour paste is typically used for this step it often leaves a rough greyish film on the parchment surface. In order to avoid this unpleasant residue parchment size has been recommended as a substitute. (Giuffrida, p.36)

D. Vacuum Suction Table Flattening

1. With Gore-Tex Over Object: Flattening parchment on a vacuum suction table can often be the best method available to the conservator. It provides even support under the piece at all times critical when handling fragile, damaged parchment. It can be easier to obtain successful results with none of the caveats of the traditional tension or pressure drying methods, such as planar distortions, clip marks and increased tearing of fragile and weak artifacts.

   The parchment is humidified overall using whatever method that is appropriate for the object. Since the suction table is part of this treatment, humidification using a dome and ultrasonic humidifier on the suction table (with the suction turned off) can be a convenient option. If only one piece of parchment is in need of flattening it can be humidified directly in place on the suction table. Otherwise a humidity pack set up near the suction table can facillitate the treatment. (See 18.4.7 Humidification.)

   The suction table is prepared with a thick piece of blotter covered with a piece of polyester web. To close off the airflow the perimeter of the suction table is covered with a silicone rubber membrane or polyester film. Once the skin is relaxed, the parchment is laid on the blotter. Turning the suction table on a low setting the skin is carefully manipulated, usually from the center outward, to pull creases and distortions into plane and to close splits and tears. (Low suction will provide more working time and is appropriate for medium to thin skins; higher suction may be necessary for thicker skins.) Parts of the parchment can be protected from the suction until the conservator is ready to deal with them by placing a piece of Mylar under the area. A plastic ruler can be used as a guide to ensure lines of text are straight. As the skin is manipulated into plane, the edges are covered with strips of Mylar to hold them down and prevent curling. The working time, rate and eveness of drying can be adjusted by working inside a plexiglas or polyethylene hood with an ultrasonic humidifier to provide the desired level of overall humidity. Certain areas of the parchment can be covered with polyester film to retard drying, especially when there are joins or areas of the skin that vary significantly in thickness. A hose attached to an ultrasonic humidifier can be used to provide moisture locally as necessary.

   As the flattening progresses one turns up the suction until it is at its maximum setting. The drawing out of distortions usually only takes a minute or two, during which time the skin is beginning to dry. After the distortions have been worked out, the parchment is covered with a dry sheet of Gore-Tex (slick Teflon side in contact with the object), which provides an even overall restraint for the parchment as it gradually dries on the table. The Gore-Tex

material is an excellent filter and will inhibit any impurities in the air that might otherwise be pulled into the parchment surface. After five to ten minutes uncover the parchment and turn the skin over; it will have stabilized by this time but will not be fully dried. Recover with Gore-tex and continue to dry for another ten to twenty minutes. The skin by this time will probably still hold approximately 15% moisture which can be tested with a moisture meter. (The Digital Mini Protimeter, available from Museum Services Corporation, is very accurate, easy to use, portable and reasonably priced. The meter has interchangeable sensor surfaces, one of which is a soft foam head that is extremely appropriate for the delicate surfaces of parchment. (LP)(JFM)

The next step is to turn the suction table off and place the parchment between blotters and cover with weights. After several days recheck the moisture content; ordinary parchment with no coatings contains 10% moisture at 50% RH, while at 75% RH parchment can contain as much as 25% its weight in water. At the Folger Library single documents that have been flattened on the suction table are frequently encapsulated in polyester film at this time. There are several advantages to flattening on the suction table. This procedure is very useful in reducing creases and severe distortions that might tend to crease if the parchment were placed under pressure. The skin can be observed and adjusted until all the distortions have been returned to plane; at that point it is usually covered with Gore-Tex. When working on severely damaged artifacts it may not be possible to remove all distortions before the skin begins to dry. When this occurs the distortions are simply allowed to remain. Upon rehumidification the previously flattened areas will lay out flat, thus allowing the conservator to concentrate on the remaining distortions. This can be repeated several times until the practitioner is fully satisfied. This procedure is very helpful in closing and aligning tears in parchment. It is also useful for skins with sensitive media when the sensitive areas do not require direct manipulation. Gore-Tex has a very smooth surface that discourages offsetting.

Some conservators feel that, for media that has become softened during the humidification process, the momentary application of warm dry air can be used to prevent off-setting on to the polyester web or Gore-Tex. Under very specific and controlled circumstances the wafting of warm air (delivered by a hair dryer) can be used to reharden softened media. This is particularly important if the painting is on both sides of the object, but must be used with such care as to prevent any drying of the parchment's surface. With this method, however, the possibility exists that the softened binder (usually gum or glaire) will shrink and ultimately crack in reaction to localized drying with warm air from a hair dryer.

2. Hazards: The hazards are similar to those encountered in flattening distorted paper objects on the vacuum suction table. Distortions can collapse into creases if the initial suction is too great, manipulation can cause tears, stretching and additional damage to the support. Manipulation can also damage sensitive media. Softened media (especially thickly applied paint layers) can be offset onto adjacent interleaving and there is the danger of flattening raised gold leaf, especially if the gesso layer has been softened.

Water-damaged parchment documents with water damage that have gone translucent cannot be made more opaque as is sometimes possible with the traditional stretch drying methods.

Parchment should never be completely dried on the vacuum suction table. If the parchment is left to dry on the suction table on one side only, when it is removed it may have a tendency to curl and this situation can be difficult to rectify.

E. Combination Methods

1. Temporary Tensioning with Tape and Placing Under Weight: When the conservator wishes to press a parchment artifact but there is enough distortion after humidification which could cause creasing in the press, temporary tensioning with tape can be considered. This technique is more appropriate for archival material where parchment and media are not deteriorated and when flatness of the document will contribute to its safety in storage and use.

   A piece of spun-bonded polyester such as Hollytex is cut to the size and shape of the artifact. The polyester is placed on a blotter on a pressing board, and then the humidified item is placed face-down on the polyester. Working quickly, usually with a colleague working opposite, the artifact is tensioned by hand just enough to expand areas which may crease, and secured to the blotter underneath using masking tape. Masking tape is used because its thick paper carrier and relatively low-tack adhesive permit it to be quickly and easily removed from the parchment. (To speed up the process this tape should have been torn up into small pieces and attached to the edge of the work table ahead of time.) The masking tape is secured very lightly only to the extreme edge of the parchment and only on the verso. Depending on the nature of the deformation, tape may be needed along all edges or only adjacent to the areas of local distortion.

   The taped item should be covered with a clean sheet of spun-bonded polyester, blotters, and a board or glass plate for pressing. The pressure must be light as in all pressing procedures, but especially in this case to avoid bonding the tape permanently to the artifact. The item should be checked very shortly afterwards (1 minute or less) to make sure that creasing has in fact been avoided, and that the flattening is otherwise satisfactory. (If not, the artifact should be returned to the humidity chamber and the treatment reconsidered.) The top blotters can be changed at this time, and the item should be replaced very quickly under pressure. After another short interval (2-3 minutes) the item should again be uncovered and the tapes very quickly peeled off, permitting the the bottom blotters to be changed. At this time the ease of removal of the tape is crucial. If the artifact begins to dry before all the tape can be removed, it should be returned to the press and the remaining tapes removed during the next blotter change. If the tapes are left in place too long or pressed too hard, there is a danger that they could skin the parchment when they are removed.

2. Tensioning During the Process of Humidification: Although not widely practiced a combination method of humidification and tensioning has been used by some conservators. With this method the skin is first tensioned on a

frame using Bulldog clips and hanging weights. Moisture is then introduced into the skin using damp blotters, sandwiched on either side of the object, or by positioning the object over a tray which contains water or a saturated blotter. The humidity level is maintained by draping the object with a sheet of polyethylene.

3. Hazards: Tensioning with tape would not be suitable for artifacts that have media which extend to the edge of the verso; that have media which are liable to smear or offset after humidification; or that have a nappy or otherwise delicate surface that would be damaged by removal of the tape or the tape adhesive. It is also very likely that some of the tape adhesive residue will remain, (even though it may not be visible to the eye.)

F. Flattening/Tensioning in Incremental Stages between Humidifications

Sometimes a difficult flattening/tensioning problem can be solved by either repeating the same procedure after rehumidification of the object, gaining incremental improvement of the results with each repetition, or by using different approaches successively, such as local treatment followed by tensioning followed by pressing under weight. Barbara Giuffrida was able to flatten a badly damaged manuscript by easing out the skin with her hands and then placing small pieces of plexi and light weights on the outer perimeter of the sheet. The object was allowed to air dry under tension and it was then rehumidified and the tensioning process was repeated until most of the deformation had been removed from the skin.(NS) A similar process using gradual tensioning involves clipping and pinning out a humidified skin on a piece of soft board, yet one must be careful in the beginning not to put too much tension on very distorted areas. These distortions can often be worked out of the skin if it is dried under light tension and then humidified and tensioned again for a second or third time. In certain cases however, when the distortions are related to naturally loose areas in the skin (such as the axilla) rather than to damage by water or heat, it can be extremely difficult to achieve a flat planar appearance.

G. Emergency Drying (Disaster Salvage)

Water in an emergency situation can cause stains and dimensional changes that will permanently disfigure parchment. If a saturated skin is allowed to dry unrestrained it will develop horny and translucent areas that usually are impossible to reverse later on. Media softened by moisture is prone to smearing and off-setting. Elevated temperatures and high humidity also create an environment that encourages mold activity, with mold growth occuring within 24-48 hours in these situations. For these reasons parchment should be dried as soon as possible if it is wet.

Parchment artifacts that are wet or very damp are extremely susceptible to mechanical damage and must be handled carefully. When removing them from a disaster scene they should be transported using an auxiliary support. In an emergency situation parchment should, if possible, be identified and segregated from paper and other materials. Where large quanti-ties of parchment are affected a separate area should be set up for triage of parchment, because its emergency treatment may be quite different from that appropriate for other types of material. Books with vellum pages or covers should be included in this grouping. Framed

artifacts should be unframed as soon as possible, while remaining alert to the danger of adhesion of the skin or media to glazing. Some framed objects may be tensioned on strainers or drummed on to board. If allowed to air dry they are subject to severe warping and splitting as the skin contracts against the rigid support. Therefore controlled drying is especially important for these objects.

The immediate goal of emergency treatment is to stabilize the artifact before any further damage occurs. In some situations heavy deposits of wet mud can be lightly blotted off or removed mechanically, but there is a risk that the media, surface preparation, or skin below the mud could be damaged in the process. Usually it is safer to remove dirt after the parchment has been dried. Water-damaged media may also be best treated after the artifact has been dried. Freeze drying and vacuum drying usually cause some dessication of the binder, leaving the media loose and powdery and in need of consolidation. After the water-damaged parchment has been dried rehumidification and controlled drying and flattening will often improve the dimensional characteristics of the skin and return it to plane.

The chosen method of drying will usually be determined by the number of artifacts that have been water damaged in a disaster. In most situations a large volume of material will require immediate attention and methods of mass treatment such as freezing and freeze drying are preferable. If, however, only a single artifact or a very small number of artifacts have been water damaged the conservator may consider some of the more standard methods used for drying parchment. For example, small quantities of damp parchment documents that are not seriously deformed and with media that are not vulnerable can be dried and flattened under light pressure between polyester web interleaving and thick blotters or blankets. (See 18.4.10 Flattening/Tensioning/Drying) Parchment that is wet, however, must be pressed with extreme caution as its vulnerability to the hazards of excessive pressure are heightened. (See 18.2.5 Potential Alteration/Damage to Object in Treatment.) Also, pressure on parchment can cause a heavy accretion such as mud to embed itself in the surface. Uneven wetness may also be a problem, causing localized cockling or swelling, and complicating drying procedures. Wet areas may also crease or turn translucent under pressure. In one case a single waterlogged parchment document was successfully dried on the suction table (Logan and Young 1987.) Unfortunately, in an emergency situation the time or the facilities for suction table drying are often not available.

Tensioning is very dangerous for wet parchment because of its weakened state and must not be used. (See 18.2.5 Potential Alteration/Damage to Object in Treatment.) Tensioning would also be inappropriate for partially wet parchment, as stretching would concentrate in the wet areas, causing local distortions. If none of the usual drying techniques are feasible in an emergency situation, then the parchment artifacts should be frozen. Freezing "converts the water to ice, halts distortion in position and arrests (but does not kill) mould growth. Freezing buys time to think, to respond sensibly to problems and to make unhuried decisions." (Parker 1993, p.176.)

If time permits single parchment artifacts may be interleaved with freezer or waxed paper before they are placed in containers such as plastic milk crates to be frozen in groups. (The presence of holes in the crates allows for the passage of air during

freezing. Crates or boxes with solid walls can slow up the freezing process by insulating the material inside, so these should not be used.) The crates should not be overfilled or there may be too much weight on top of wet artifacts at the bottom. As in any emergency situation, the contents of the crates should be identified and kept track of as best as possible. Books with vellum covers or leaves can be wrapped tightly to help prevent distortions from developing during freezing and subsequent drying. Bagging books in polyethylene or interleaving them with plastic before they are put into crates will help in later retrieval of the material. In some situations, it may be appropriate to remove vellum covers before freezing to avoid distortion of the text block and permit separate treatment or replacement of the cover material.

In the case of books with parchment leaves and media that are water-sensitive, strapping the volumes may increase the extent of offsetting of the media. At the British Library recent tests with a variety of freezing and freeze drying methods have shown that illuminated parchment must be handled in a particular way to avoid further damage to the media. During initial salvage of water-damaged material books that are already flat should be removed from water horizontally. If, however, the books are still standing on a shelf they should be transferred to a crate in an upright position "so that water will not flow onto fresh pigment, but will only move slowly by absorption due to the hygroscopic nature of vellum." (Parker 1993, p.182.)

After freezing there are four possible ways to dry parchment. The first is to thaw the parchment at room temperature in a closed humidity chamber. This conditioning may include a period of exposure to air-drying which stops short of allowing the parchment to dry out, followed by returning it to a humidity chamber. The advantage to this approach is that skin which is too wet or unevenly wet can be moderately and evenly humidified, so that one of the customary drying techniques can be employed. It also permits monitoring of water-sensitive media during drying.

Freezer drying, vacuum freeze drying,and vacuum thermal drying are three additional ways frozen material can be dried. All these techniques can be expected to result in some shrinkage and embrittlement of the parchment, although the embrittlement reportedly recedes as the parchment acclimatizes to moderate environmental conditions. Shrinkage can usually be remedied with rehumidification and controlled drying of the artifact. For some archival material, however, the shrinkage may be considered unimportant. These three techniques do not improve distortions, and can cause further dessication of media and adhesives.

Freeze-drying occurs if frozen material is left in a self-defrosting blast freezer long enough. (See Ogden/Buchanan 1992, for a description of all three freeze-drying processes). This method requires temperatures below -10 degrees F. and may take up to several months. Vacuum thermal drying dries material under vacuum above 32 degrees F. and is likely to cause additional distortion of parchment during the drying process. This distortion can be especially marked in the case of complex artifacts such as books and scrolls. Vacuum freeze drying is carried out below 32 degrees F. and is not supposed to create any new swelling or distortion while it dries by sublimation of the ice content.

18.4.11 Mending and Filling

A. Considerations in Mending Parchment

1. Mending is not needed for flat parchment as often as for paper because tears or breaks in healthy skin are not as likely to increase by lengthening or branching during normal storage, handling, or flexing. Fragile modern split skins are the exception to this rule. On the other hand, if stretched, the parchment will expand and contract with the changes in relative humidity, putting a strain on an unsupported tear.
2. Often when a break occurs in parchment a gap widens more than one would expect in a paper sheet because of the parallel alignment of the collagen fibers in parchment. Reaction of the skin to temperature and humidity can increase this widening. It is usually necessary to accept a wider gap when a tear is mended because forcing the edges to meet will cause cockling throughout the sheet which can not be corrected. Even if this cockling seems to be corrected by flattening or tensioning, it will often return very shortly after treatment. (See 18.4.9.B Local Treatment of Wide Splits/Tears.
3. Parchment requires a stronger adhesive than paper does, because smooth healthy parchment provides a surface that is less easily bonded. The presence of grease in a skin will also affect the bonding of a repair. The bond must be strong enough to withstand the increased movement to which parchment is prone in response to humidity changes. However, a seriously mold-damaged or otherwise disintegrated parchment may have lost so much of its integrity that it may respond only weakly to humidity fluctuations, and a weaker adhesive will be adequate. In fact, a too-strong adhesive can introduce tension into a weak skin that can lead to tearing. Also, the surface may be so crumbly or powdery that a stronger adhesive may pull material from the surface of the parchment, creating a skinned area.
4. The moisture content of water-based adhesives should be carefully controlled because of the hydroscopic nature of parchment. (See 18.2.5.A. Problems Caused by the Use of Water or Excessive Moisture.) This may require using dryer, more viscous adhesives, and drying the mend under weight with stricter attention to the amount and duration of the weighting. Excessive weight on a wet mend could conceivably introduce the hazards associated with excessive pressure during flattening (see 18.2.5.B.) Inadequate weighting can lead to cockling of the skin and failure of the mend. A tacking iron must not be used to dry the adhesive of a mend because the heat of the iron will damage the parchment see 18.2.5.D.
5. Unlike paper, the thickness of an animal skin can vary considerably. These variations, which may be more evident in a large piece of parchment, may be from natural differences between areas of a skin (i.e. neck and butt being thicker than the belly or axilla) or from the manufacturing process, such as uneven scraping. Therefore the thickness of mending material, the strength of the adhesive and weighting of the mend may also need to be adjusted for repair of tears and losses in different locations within a sheet.

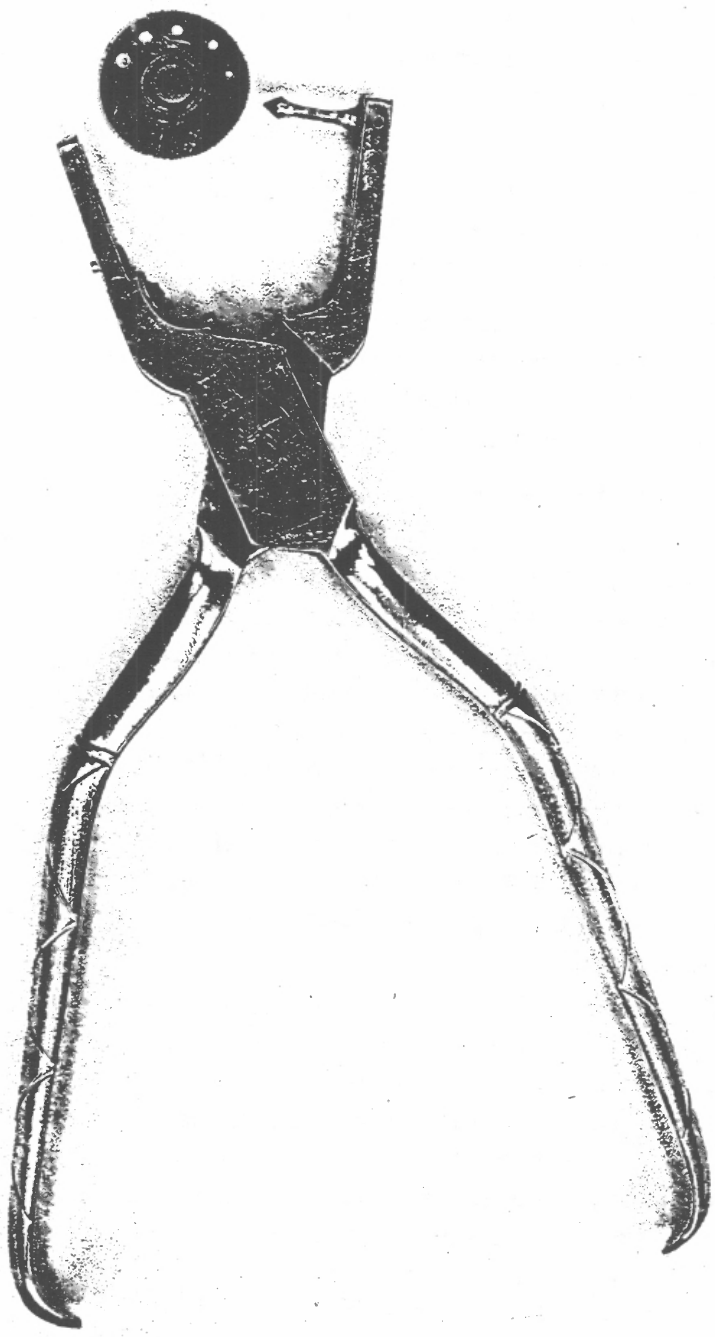
6. Due to the strength and reactive nature of parchment it is often necessary to mend both sides of a tear or split.
7. Knife cuts which originated in the manufacture or preparation of a parchment sheet should not require mending unless they are contributing to loss or damage. (See 18.2.2 Technological Features and Clarkson 1992).

B. Sewing

Repair by sewing derives from the original repair methods carried out by parchment makers on ruptures inherent in the skin or which arose during the course of manufacture. The need for this type of repair is generally due to a specific set of circumstances and occurs only occasionally. The most common reasons for sewing are to satisfy visual or physical requirements of the object. Sometimes it is necessary to resew original repairs when the thread is missing (although this is usually only needed when the rupture occurs at the outer edge of the sheet). Thread may also need to be replaced in oversized or rolled artifacts where the individual sheets were originally joined by sewing. Sewing is sometimes used for previously unsewn parchment manuscripts where a particularly strong join is desired, or where there are no overlaps along the repair, as in a knife cut. Sewing may be particularly appropriate for tears when the parchment must be stretched over a frame, such as in a work of art on parchment that is on an original strainer.

The traditional nature of sewn repairs is appealing to some conservators and curators. However, there are several problems with this technique when it is used for repairs other than replacing original sewing. It will only work where the area to be sewn is strong and healthy. (Some conservators have dealt with this problem by reinforcing the edges of the knife cut or tear with transparent membrane before sewing across the break.) A sewn repair might cause distortion or tearing if it hinders the natural movement of the parchment in response to humidity fluctuations. However, this problem has not yet been observed in situations where new sewn repairs have been executed on parchment artifacts. The method involves perforation of the object, which is generally objectionable in most types of conservation treatment. However, there is a difference of opinion among conservators of parchment on this particular point. While some individuals feel that the practice is unacceptable, due to the fact that new holes are being created in an original artifact, others are convinced that, in certain situations, sewing can be more suitable (and also more appealing to the eye) than other forms of patch repair using transparent membrane or new parchment.

Sewn repairs are most commonly carried out with either parchment strips and linen thread. Descriptions of the technique are given by Cains (1982/83) and Giuffrida (1983). Both these articles contain diagrams of the technique. The sewing material should be as fine in proportion as possible. The leading end is tapered and the thread is stiffened, using parchment size for parchment or PVA emulsion for thread. The sewing material is pulled and lightly tensioned through pre-perforated slits. The slits are created with a small chisel made by modifying a sewing needle. They should be staggered for a less bulky repair, and a figure-eight sewing pattern is used so that the edges will butt and not overlap, which would also make the repair bulky.



In a related technique round sewing holes are created using a dental tool (see photocopy). Some conservators prefer the physical integrity of a round perforation to a slit. The "baseball" stitch is an alternative sewing pattern and some conservators prefer sewing with sinew. (To prepare the material for use the sinew should be soaked in brine to remove blood followed by rinsing in fresh water to remove salt. Press the sinew out to dry on formica. See Reed 1972, p. 107 for further information on sinew production.) Create the "sewing thread" by fraying out the sinew and then strip off as much as is needed. Moisten the leading end with saliva to harden for sewing. At the completion of the sewing pattern the leading end has returned to the point of beginning. Secure the two sinew ends by overlapping, moisten and weight until dry. The sinew is self-adhering so there is no need for bulky knotting. (JT)

One advantage of sewing up tears is that one can place the holes vis-a-vis the text and thus avoid obscuring anything. It can be less obscuring than using overlays of fish skin or other thin skin.(NP)

Hazards: permanent alteration of the skin occurs when it is perforated for sewing. The raised surface of the thread or parchment lacing and knotting can imprint or abrade the surfaces of adjoining leaves. As the ends of slits are prone to splitting round holes are preferred by some conservators.

C. Transparent Membrane Repairs

1. Goldbeater's skin and Fish skin: Transparent membranes such as goldbeater's skin and fish skin are usually employed for the repair of small tears and perforated areas in a parchment artifact that do not require a great deal of support. Although a variety of adhesives can be used for attaching the membrane gelatin or parchment size are most common. Natural membranes are particularly useful for overlaying damages in text or image areas because they are so transparent. However, some conservators find that these materials are too shiny when applied to parchments that have a very pronounced nap. Goldbeater's skin or fish skin can also be very useful in supporting a large parchment fill, especially when the loss occurs in an area of text or image. (See 18.4.11.H Parchment and Transparent Membrane.)

   Since both goldbeater's skin and fish skin are very thin and reactive to aqueous adhesives the use of a temporary support can greatly facilitate the cutting out and attachment of the repair. Anthony Cains first introduced the technique of mounting transparent membrane to heat-set tissue as a temporary carrier. (See 18.3.3.B Animal Membrane.) In this process the heat-set tissue is adhered in advance to a large piece of membrane. The repair patch is cut out using scissors, a scalpel or an architect's swivel knife. Adhesive is applied to the membrane, which is then positioned over the area of damage and gently pressed in place. The heat-set tissue can be released immediately after the repair is secured by simple peeling, if the adhesive has not cooled too much during the repair process, or by applying organic solvent (usually ethanol or acetone) to the tissue with a brush.

   Several other techniques of temporarily supporting a mend of transparent membrane during the repair process are currently in use. One method

employs polyester web which is attached to the membrane with Tylose MH300 (a cellulose ether) in advance and then dried under pressure. The patch is cut out of the laminate, adhesive is applied to the goldbeater's skin and the patch is adhered skin side down. Once the repair has dried in place the lining of polyester web is removed using moisture.(UB) Another technique uses a piece of light weight polyester film as the temporary support. The goldbeater's skin is pasted out on the polyester film and excess paste is wiped away from around the edges of the membrane. Holding the edges of the Mylar support the goldbeater's skin is positioned over the damaged area and pressed in place. The Mylar is peeled away and the repair is dried under pressure with polyester web and blotter.(DE)

2. Sausage Casing: Sausage casing is currently used in many large libraries and record offices in the U.K. (See 18.3.3.C Reconstituted Collagen.) It is less expensive and more readily available than transparent animal membrane, and because it is made from a variety of materials including collagen, it does not react as strongly to moisture and is therefore easier to handle than the natural products. The use of sausage casing for the repair of parchment is described in detail by Giuffrida 1983, pp.30-31.

   Among many present day conservators of parchment there are several objections to the use of sausage casing for repair. The material usually has a distinct yellow tone that makes it more visually apparent than goldbeater's or fish skin. It has a relatively poor tensile strength when compared to the natural membranes; with some products the strength of the material seems to decrease upon aging and it gradually becomes very brittle. The variety of methods of manufacture (natural casings, reconstituted collagen casings, non-edible sausage casings, thermoplastic casings, etc.) make it important to know how the casing under consideration was manufactured. (See Karmas 1974, for further information on the manufacture of sausage casing.)

D. Parchment Repairs

A widely-accepted method of filling losses involves the use of new parchment . A loss is filled with material that is as similar as possible to the original so that the sheet and the fills will expand and contract uniformly in response to humidity fluctuations. Skin is chosen for the fill that is similar in thickness and appearance, from the same animal species, and if possible, conforming to the orientation and location of the skin on the original animal's body. There is certainly an aesthetic appeal to the preference for filling like materials with like. However, identifying the species of old parchment is sometimes extremely problematic. (Sometimes it can even be difficult to distinguish parchment from paper- see 18.2.1.B) Also, there are numerous factors that influence the physical behavior of parchment. These include the age and physical condition of the animal, biological variations and breed differences within the species, and injuries, scars, bruises and other anomalies in a particular skin. Country of origin, age and extent of deterioration of the parchment artifact, the history of its storage and use, and innumerable variables in the method of manufacture are further influences on the character of parchment. Contemporary parchment manufacturers have thus far been unable to replicate the quality of ancient parchments, and ancient parchments in general respond very differently than modern ones to humidity fluctuations. Maria Cristina Berardi's

1993 study of parchment deformation Why Does Parchment Deform? Some Observations and Considerations(see bibliography), concluded that the individuality of behavior of a particular parchment prevails over its species characteristics, and supported the use of Japanese paper as an alternative fill material.

Some practitioners advocate the use of a more generic parchment fill material which is dyed, trimmed, and thinned to suit each particular parchment artifact. Anthony Cains in his article Repair Treatments for Vellum Manuscripts (see bibliography) describes the preparation and use of fetal calf parchment (i.e. slunk) for infilling. According to Cains, the fill should be thinner and more flexible than the original. If necessary the skin is taped to a glass and placed over a light box for thinning with a very sharp spoke-shave blade, always from the flesh side. Any other surface preparation can then be carried out, such as sanding or pouncing. The material can be toned a sympathetic color with aniline dyes, either by surface application or by immersion. (See 18.3.3.A for further information on toning parchment for repair.) It is best to carry out toning before beveling so that when the fill is inlaid the overlap will not create a dark border. Bevelling ("scarfing") is done widely (3-5 mm.) so that the bonding surfaces are wide enough to ensure a firm attachment. Bevelling can be done using scalpels, knives, or flexible-shaft drills. Sanding sticks made by gluing fine sandpaper to wooden dowels can also be used. Generally only the infill is bevelled, never the original.

Some conservators do feel, however, that the original may be bevelled. Roger Powell always bevelled the original where possible. This was not done on Kells, though, because the custodians didn't want any original material removed (see Powell, 1956). Nicholas Pickwoad has often bevelled the original, believing it gives excellent visual results with great strength. This is only done where there is no text or decoration that would be removed or put at risk. Multiple repairs that lie over each other in bound books can give serious problems with swelling without such scarfing (more a problem when using parchment for repair than paper). (NP)

E. Japanese Paper Repairs

Japanese paper is used by some conservators for mending tears and filling losses in flat parchment artifacts. Although Japanese paper is a material that is foreign to parchment, with dissimilar behavior and appearance, it can function well. The paper conservator used to repairing with Japanese paper may choose to repair a tear in his/her customary way (see Paper Conservation Catalog Mending), but must take into consideration that a stronger and dryer adhesive is necessary in order to get the paper to stick. As mentioned above, a tacking iron should not be used for drying the repair. The paper should be thinner and weaker than the parchment, so there is little danger of it straining or deforming the skin over time. For weak, degraded, or thin parchment, a thin paper may be the best mending choice, because any new parchment or animal membrane is likely to be too strong. A repair that is too strong can also skin the surface of a degraded parchment.

For thicker paper to fill losses, as many layers as desired can be laminated together. For the sake of appearance the paper fill should be thick enough to approximate the opacity of the original; it is not necessary for any functional reason for the fill to be as thick as the original. If the fill paper is laminated alternately crossing the grain,

this and the presence of the adhesive will reduce the response of the infill to humidity fluctuations. It is true that such a non-responsive fill will not move in unison with the surrounding parchment, but if one accepts the difficulty of matching the movement of parchment fills to parchment artifacts (see Berardi 1993), one might settle for a fill which can at least be predicted not to move in conflict with the artifact.

Paper mends and fills can be toned a sympathetic color using watercolor or acrylic paints. (see 18.3.3 Mending Materials for further information on toning paper for repair.) In order to imitate the surface appearance of parchment paper surfaces can be burnished (before inlaying) with a bone folder. Very good imitations of the appearance of those parchments that have a hard, smooth surface can be achieved by loading the surface of the fill paper with starch paste or PVA dispersion, drying, and burnishing the surface. SC6000 (an acrylic polymer and wax emulsion) has also been used to improve the appearance of a paper mend. (see 18.3.3.D) Japanese paper adhered with PVA dispersions mimic parchment very well in flexibility and texture. When toned with acrylics the repairs can be virtually indistinguishable from the original.

When adhering Japanese paper with PVA a medium viscosity seems to work best. If too thick, the adhesive is difficult to handle and doesn't seem to improve the transparency of the repair. If too thin, the Japanese paper doesn't become as transparent as with the thicker solutions. At the Folger Library, Klucel G in ethanol is used in combination with the PVA method, after applying the tissue to the parchment a coating of Klucel G is applied to the surface and the tissue is then rubbed down. As the mend progressively dries, further Klucel G is applied; this acts as a lubricant to the teflon folder being used and it seems to make the repair less visible, frequently negating any need to tone the paper afterwards. If inpainting is needed acrylics seems to work well. (Note this method of repair is suitable only for finished parchment surfaces; it is not intended for the soft nap surfaced parchments.)

F. Western Paper

Many flat parchment artifacts have been infilled in the past using western paper. Often they are reasonably attractive in appearance, secure in attachment, and have not created any puckering or other deformity over many years. However, innumerable cases have also been seen where Western paper used to infill parchment has caused severe puckering and distortion. There are examples in the New York University's Conservation Program sample collection students. (JFM) Therefore, since current opinion diverges, the use of Western papers for repair should be carefully considered.

G. Adhesive-Coated Tissues and Membrane (Solvent-Activated)

1. Heat-set Tissue: Library of Congress heat-set tissue can be used for simple repairs of parchment. It can also be used as a temporary repair during tensioning. This material is the only heat-set tissue which at this writing that has been thoroughly evaluated for archival stability. Both LC Heat-set and the leafcast Gossamer Tissue are commercially available. The chief difference in the use of these papers for parchment repair is that heat cannot be used to activate the adhesive due to potential damage to the parchment

(see 18.2.5.B). Instead the tissues are activated by wetting out with either ethanol or acetone depending on the nature of the adhesive and media, positioning the tissue, lightly burnishing through a protective layer of non-woven polyester web, and then weighting it to maintain contact until dry. This provides a mend that is unobtrusively translucent and may be suitable for areas where soluble media preclude the use of aqueous adhesive. The mend is not aggressively strong, but where increased strength is desired its light weight and translucency suits it for use on both sides of a skin. The Gossamer Tissue is often selected for its aesthetic qualities in lieu of animal membrane. When used for overlaying damaged areas of text or illumination (in particular to both sides of the piece) the tissue will provide support without the visual distraction (sheen) that other materials like fish skin and goldbeater's skin can have.

2. Heat-set Membrane: Heat-set adhesives can also be cast onto animal membranes such as goldbeater's skin, or even parchment which has been thinned, for unobtrusive mends which can also help hold degraded, crumbling surfaces of a skin together. Heat-set membranes are not commercially available, and have to be prepared in the conservation workshop. (See Cains, 1992.)

H. Combinations of Above

1. Parchment and Transparent Membrane: Parchment is sometimes used in combination with animal membrane when large inserts require stronger adhesion to the original. By allowing the membrane to extend beyond the parchment fill, it provides an overlap which is secured with an appropriate adhesive to the borders of the loss. Alternatively, strips of membrane can be attached only to the borders of the parchment infill in order to secure it in place. Another technique which is described by Anthony Cains in Repair Techniques for Vellum Manuscripts (see bibliography) is to build up a three-layered stepped membrane flange in which the middle layer will fit inside the bevel of the new parchment and the outer membranes will extend beyond its edge. The infill can be secured in position with one overlapping membrane secured to the front of the artifact and one secured to the reverse. Using transparent membrane in this way should not obscure text that is overaid.

2. Japanese Paper and Membrane

   a. Technique currently used by Nancy Southworth and Marnie Cobbs which uses gelatin to laminate Japanese paper and goldbeater's skin. They have also used Jade 403 to laminate Japanese paper and goldbeater's skin.

I. Pulp Fills

1. Technique using Purified Hide Powder: This pulp filling technique was recently developed in Belgium (Royal Institute for Cultural Heritage, Brussels) by a group of scientists and conservators responsible for the treatment of an early medieval illuminated manuscript on parchment. The manuscript had been severely damaged by mold and by a careless restoration that was carried out in 1957 (Wouters, et.al., 1990, 1992 and 1993). In this process an aqueous suspension of purified hide powder is

prepared in 0.03% Tylose MH300. Mild pretreatment with formaldehyde and additional calcium carbonate may be used to tune the opacity of the final preparation. Since the Tylose will be eliminated during casting on the suction table, no materials foreign to parchment will be present in the final dry reconstituted parchment. The pulp mixture is not toned in any way prior to use.

The repair work is carried out on a custom-built suction table provided with a totally porous polyethylene cover plate. Illumination may be provided by a bank of flourescent lights below the table. An ultrasonic humidifier with a hose attachment is available nearby, for the local humidification of the original parchment during pulp filling. The parchment is relaxed for a short time using the Gore-tex sandwich technique. An area slightly larger than the one to be filled is cut in a polyethylene sheet. On top of this is placed a piece of polyester web and then the parchment. With the suction table turned on the liquid pulp suspension is cast on to the area of loss by pipetting. The progression of the casting and the local humidification of the damaged parchment may be easily followed by the lighting provided from below.

Upon drying, the pulp may shrink by 2 to 5%. Therfore, sufficient overlapping between pulp and original parchment should be provided in order not to loose the bonding between both materials. The total amount of pulp material needed may be calculated beforehand. Once the pulp fills have been cast the area is dried under local pressure, between polyester web, blotters and weights. Infills at the edges are given the same thickness as the original surrounding parchment. Central perforations are cast with reduced thickness to compensate for shrinkage upon drying. The suppleness of the dried pulp is high. The bonding with original parchment may be strengthened by covering the binding area with goldbeater's skin, without any adhesive.

Any discoloration or dimensional changes in the dried pulp could not be detected after several ageing experiements, involving exposure to varying degrees of relative humidity and illumination. (JW & LW)

2. Technique using Hide Powder and Eukanol Glanz N: This method of pulp filling was originally developed by Per Laursen, a paper conservator in Denmark, and is currently practiced in his workshop and also at the State and University Library in Bern, Switzerland. (Laursen, 1985). The technique is especially appropriate for parchment artifacts which are heavily damaged (by mold or fire) in areas of writing or illumination. The advantages are that there is no water involved in the actual application of the pulp. However, if the dried pulp fill needs the additional support of a layer of goldbeater's skin, an aqueous adhesive is used for its attachment. With this method the fill material is limited only to the area of loss and does not overlap to any extent on to the original. The disadvantage is that large areas of cast pulp can often be very stiff in comparison to the rest of the treated artifact.

   Pieces of blotting paper and polyester web are placed on a suction table and the parchment artifact is set on top. The whole surface is masked with strips of polyethylene, leaving an open space around the losses. While the suction

table is turned on, the parchment powder is sprayed evenly onto the losses, either with a mini-vac cleaner converted to a blower or with a flock-spraying jet. Excess powder is gently wiped away from the areas around each loss using a soft brush. Before impregnating the fill with a binding agent the parchment powder must be fixed in place with a spray application of ethanol. After placing a transparent strip of polyethylene over the area, the layer of powder is smoothed down with a bone folder.

The binding agent, Eukanol Glanz N 103 543, is then applied to the fill with a brush. This is a synthetic casein product which is diluted with ethanol to make a 40% solution. (see section 18.3.3.G.2 Mending, Filling and Lining Materials: Pulp Filling Materials) Depending on the condition of the original parchment, this solution could be further diluted up to 50%. (The use of more dilute solutions of Eukanol make the final pulp fill more supple and brighter in color once dry.) After about 10 minutes of drying on the suction table the artifact is removed, using the polyester web below as a support. The object is placed in a sandwich of clean polyester web and blotters to dry under slight pressure for about 12 hours.

If the area of loss is large, the pulp fill usually requires some additional support. This can be done by covering both sides of the fill with goldbeater's skin, while the object is held in place on the suction table. The transparent membrane is first degreased (see 18.3.3.B.2a) and then lined with polyester web as a temporary support (see 18.3.3.B.2c). The shape of the loss is cut out of the goldbeater's skin/polyester web laminate with an overlap of about 3 mm, depending on the condition of the original parchment in the area of loss. The mend is pasted out and adhered skin side down to the pulp fill using a 1:1 mixture of parchment size and wheat starch paste. (The suction is turned on at this point, in order to prevent the artifact from cockling with the application of the aqueous adhesive.) The goldbeater's skin is smoothed in place using a bone folder. The polyester web is then peeled away from the membrane, the artifact is turned over and the opposite side is treated in the same manner. Finally, the artifact is dried for several days under slight pressure, with the blotters changed at regular intervals to speed up the drying process.(UB)

3. Technique using Parchment Powder and Ftorlon: This technique, which was developed in the former Soviet Republic, is used primarily for the repair of mold-damaged parchment manuscripts. (Margotieva and Bykova, 1992) A fine powder, made from grinding and sifting new parchment, is mixed with a 5% solution of Ftorlon 26L in 1:1:1 ethyl acetate/butyl acetate/acetone to make a pulp. (This adhesive, which is presently favored by many Russian conservators for the repair and consolidation of parchment, consists of a copolymer of fluorolefins. See section 18.3.1.D Adhesives and Consolidants for further details.) The parchment pulp is applied to the area of loss while working from the reverse side of the artifact. After most of the solvent has evaporated the fill is covered by "a specially prepared film of Ftorlon" and then dried under weights. (Margotieva and Bykova, 1992, p.4)
4. Technique using Hide Powder and Paper Pulp: This pulp-filling method was developed at the National Library in Budapest, Hungary as a means of

repairing an important collection of illuminated manuscripts on parchment that had been severely damaged by mold. (Beothy-Kozocsa, et.al., 1987 and 1990) The pulp contains a wide variety of materials including hide powder, paper fiber, parchment size, hydroxyethylmethylcellulose, water, ethanol, isopropanol and a fungicide called Preventol CMK. (See section 18.3.3.G.4 Mending and Filling Materials: Pulp Filling Materials for further details on the contents of this pulp.)

Three different methods are used in the application of the pulp, depending on the condition of the original artifact. In the first method the manuscript leaf is lightly sprayed with an ethanol/water solution and left to humidify for several minutes between damp blotters. Once relaxed, the leaf is laid in place on a custom-built suction table, which is covered with a nylon screening cloth and then with a piece of Diolen - a fine silk fabric similar to crepeline. With the suction turned on, and with illumination provided from below, the pulp is cast on to the areas of loss using a flexible plastic bottle fitted with a top that resembles an eye dropper. Once the casting process is completed on a single leaf the suction is turned off and the parchment is covered with another layer of Diolen fabric, followed by two sheets of blotter and a pressing board. After about 10 minutes the artifact is removed from the suction table and transferred to a table top where drying under pressure is continued, with successive changes of blotters and a gradual increase in the amount of weight that is applied.

In the second pulp filling method practised in Budapest a layer of pulp is cast in a roughly circular shape on to a support of Diolen fabric, blotting paper and felt. After a few minutes most of the moisture in the cast pulp is removed by light pressing with blotter paper. The "sheet" of damp pulp is then carefully removed from the support and applied to an area of loss on the original parchment, which has been slightly humidified using the techniques described above. The pulp fill is pressed in place with the fingertips and/or a bone folder and the artifact is then sandwiched between Diolen fabric, blotters and pressing boards for final drying under pressure. In the third method small discs of pulp are cast on to the fabric/blotter/felt sandwich as before, yet this time they are allowed to dry completely under pressure. Once dry the cast pulp is applied to a completely dry artifact, using paste around the edges of the losses for the attachment of the fills.

18.4.12 Lining (see AIC/BPG/PCC 29. Lining)

Lining is rarely needed and seldom carried out for parchment artifacts. Probably the most likely occasion for lining would be in the case of weak, perforated, or degraded (i.e. mold-damaged) parchment. Normally, parchment is too strong to require the structural reinforcement of lining, and lining can drastically alter the character of parchment. Also, parchment is more penetrable to most adhesives, and the adhesive can not be removed again through immersion techniques. As discussed above, severely weakened parchment may be better served by consolidation or encapsulation, or by benign neglect.

If, however, the decision is made to line a parchment artifact in the tradition of paper conservation using wheat starch paste, the hazards of exposing it to excessive moisture

must be born in mind. (see 18.2.5.A) These same hazards render the reversibility of a paste lining problematic at best. Humidifying a parchment artifact before lining is risky, because its softened surface will form a more permanent bond with the adhesive and lining material, and render it more susceptible to gelatinization or transparentization during pressing. In most cases the lining paper would have to be applied in the traditional stick-and-brush method with dry paste (see AIC/BPG/PCC 29. Lining 4.1&2) in order to conform to the undulations of the artifact. The artifact must be dried with careful attention to the dangers of excessive pressure (see 18.2.5.B) when it is dried under pressure, or it can be dried on the suction table. The lined parchment must not be allowed to "air dry", or it will be permanently deformed.

Parchment artifacts have also been lined in the past using non-aqueous adhesives such as heat-set tissues. These lining materials usually require the use of overall application of either solvent or heat, both of which can be harmful (see 18.2.5.D and G). Solvent or heat may also be required to remove these linings. Moreover, most conservators of parchment would find these linings aesthetically unacceptable, so this practice is now viewed as outdated.

18.4.13 Housing

A. Considerations in Housing Parchment Artifacts

1. Size and shape of object: bulkiness or weight of object or its attachments, thinness or thickness of the sheet
2. Format: multiple superimposed sheets (must all sheets be available for easy reference?), multiple contiguous sheets, sewing/lacing/binding, attachments, fold-overs, integral mounts (e.g. original stretchers, Portolan chart boards)
3. Physical condition: state of degradation (integrity or strength of the sheet); friable media, coating, or parchment surface; mold; responsiveness to humidity fluctuations; extent of cockling)
4. Future use: exhibit, research, reference, legal, or combination of the above
5. Storage/Display Environment: are the environments stable or will the parchment be exposed to extremes, ie. fluctuations in humidity and/or temperature? (see 18.4.14 Storage and Display)

B. Polyester Film Encapsulation and Sleeves

Polyester film encapsulation is the sealing of an artifact on all four sides between two sheets of transparent polyester film suitable for archival use such as Mylar-D. The films are bonded only to each other (either along the edges or at a seam) and not to the artifact. A polyester film sleeve is sealed only on two adjacent sides or on three sides. This option is often chosen for artifacts which are to be periodically removed from the sleeve, and is especially useful for multiple-sheet documents where access to all the sheets must be readily available. Housing an artifact inside a sleeve affords considerably less protection from environmental influences and is often unsuitable for highly cockled parchments, which can slip out more easily than flatter artifacts. Provided there is no information on the verso a leaf of archival bond or light weight mat board can be placed behind the parchment for additional support. Nevertheless, the presence of open sides on a polyester sleeve necessitates somewhat more care in the handling of the artifact by researchers.

Polyester film encapsulation is a relatively easy and cost-effective solution for effectively protecting parchment from rapid humidity fluctuations, and it provides minimal physical restraint against cockling. It should be carried out when the ambient relative humidity is satisfactory, and with documents that are relatively flat. Cockled documents will cause an encapsulation to have more pronounced distracting reflections. In the extreme case it may be physically impossible to weld polyester film together near the edge of a very cockled item. Some custodians find all encapsulations aesthetically unacceptable, particularly for artifacts that are to be displayed. For research and archival material, however, encapsulation is invaluable for protecting an artifact from negative environmental influences and from the inevitable stresses and contaminations of handling.

Sealing parchment inside an encapsulation has not been shown to cause accelerated chemical deterioration as is the case with encapsulated acidic paper. Just as with paper, however, housing of parchment in polyester film is not recommended when flaking or powdery media, coating, or support is present, because of the electrostatic attraction of the film.

Encapsulation of documents with substantial attachments is difficult. Within the encapsulation pendant seals can be supported with ultrasonic spot welds. When they are extremely thick and attached at a distance from the artifact they can be allowed to protrude outside an encapsulation. Of course in the latter case the entire document will require a secondary support or housing. (see 1.4.13.E Problems in Housing Parchment Artifacts with Pendant Seals)

Three methods of encapsulation currently in common use are: ultrasonic welding, heat welding, and adhesion with double-sided pressure-sensitive tape. Heat welding could be problematic because of the high temperatures used in close proximity to the artifact, the solution is to leave more space between the document and the seal. Double-sided tape produces the least attractive package, and exposes the artifact to possible future contact with the sticky adhesive. It is also possible to join two sheets of polyester by means of sewing with an industrial sewing machine. For encapsulation of extremely large oversized collection materials staff at the Library of Congress have come up with a method of using the Ultrasonic Welder to seam polyester film. The largest width of polyester film available on rolls is 60" (from Taylor Made) which in many cases cannot accomodate oversized posters and maps. Using the Ultrasonic Welder, the polyester film is rolled like a scroll to fit under the bridge. The challenge lies in preparing the material to fit in the frame under the horn while keeping the polyester free of dimples, creases and scratches. Information on this method will be presented by Carol Paulson and John Bertonaschi, in a poster session at the annual AIC Meeting in Nashville, Tennessee, June 1994. A printed copy of this information is available by a written request addressed to the Phased Section in the Conservation Office of the Library of Congress.

C. Window Mats (See also AIC/BPG/PCC Paper Conservation Catalog 40. Matting and Framing)

Sometimes documents, especially those that are several centuries old, were marked on the reverse with annotations and stamps with historical or legal importance by owners, officials, and archives. Such evidence should be available for viewing and

study by scholars, even while the artifact is mounted in a window mat. To this end, it has been suggested that the document be attached to the reverse of the window mat, instead of to the backboard.(HS) An alternative solution would be to cut a window in the backboard and adhere a piece of transparent polyester film over it. A deeper window mat is generally needed to accommodate the thickness and movement of a parchment sheet.

1. Object Secured in Encapsulations or with Polyester Film Corners, Slings, and Straps: If an artifact is encapsulated it can easily be secured to a window mat backboard using double-sided tape. The window can be cut to a size which reveals the entire document but conceals the weld or join of the polyester. Reflections from the polyester will always be discernible to some extent, however, and some custodians will find this aesthetically unacceptable.

   Polyester corners, slings, and straps have the advantage that they can be overmatted (unless the artifact must be "floated" in its mat) and would therefore not disturb the viewer. They do not require any adhesion or attachment directly to the artifact. These systems are not appropriate for very cockled pieces or for artifacts with friable paint. There is also the risk that a humidity-responsive parchment will pop out of its restraint when excessive movement occurs in an uncontrolled environment.

   The polyester film sling mount, described more completely in Matting and Hinging Works of Art on Paper, Library of Congress, 1981, could be considered appropriate under certain situations. Polyester film circles, about 1" in diameter, are folded in half and placed at the edges of the artifact. A piece of double-sided tape, placed on the reverse of the other folded half of the circle, allows one to secure the sling to the back mat. Polyester, polyethylene, and polypropylene films can all be used to fashion photo corners or straps as mounts for parchments. Some parchments with pendant seals which lace through a fold-up at the bottom can be held very securely to a mat with an unobtrusive strap placed under the fold-up and brought through to the back of the mat board via slits. Some give in the length of the straps and the positioning of photo corners allow for dimensional changes in the parchment. Corners and straps should not be placed over friable media. Polypropylene and polyethylene are softer than polyester and can be folded without creating a cutting edge. Polyester can be very sharp and is very shiny. Abrading it with emery paper will lessen reflections but will also make it less transparent. (EO)

2. Object Secured with Paper Hinges: A stronger or thicker adhesive is required for hinging parchment with paper hinges than is necessary for most paper artifacts. The hinge must be weighted for a considerably longer time in order to avoid puckering or cockling of the parchment; the hinges should never be dried using a tacking iron (see 18.2.5.D). Hinges which are too thick can leave an impression and/or cause puckering over time.

   Hinging only across the top of a parchment artifact is insufficient for all but the thickest and least humidity-reactive parchment. Most parchment must be hinged also at the bottom, and perhaps at the sides as well (see below). Otherwise a "floated" sheet may move forward in the window, perhaps

touching the glazing, and a slightly over-matted parchment could escape from underneath the window. When hinges are placed at opposite ends of a document they must not pull the sheet taut, but should allow sufficient movement to avoid creating draws in the sheet or tearing the hinges when the parchment contracts.

Solvent-activated adhesive-coated tissue can also be used as a hinging material, as long as heat is not used to attach the hinge (see 18.2.5.D and 18.4.11.G Adhesive-Coated Tissues and Membranes).

3. Object secured with Paper Straps: This mounting system is especially suitable for large documents. It was designed for temporary exhibition and for archival rather than fine art materials. It will function well in any relatively stable environment, the important requirement being the built-in break-point which allows the parchment to detach from the support board if it is placed under excessive tension. The requirements of a mounting system for such material are necessarily quite simple, and must simply be able to perform satisfactorily on a large scale, be strong enough to restrain the skin under modest fluctuations in relative humidity and allow a little movement as it does so, yet at the same time not be so strong as to threaten to split the skin if it shrinks significantly in overly dry conditions.

The support board

The support board needs to be rigid, light in weight and chemically stable. Acid-free honeycomb board can be used, or sheets of multi-purpose acid-free double-wall corrugated board (E-Flute). If corrugated board is used it should be lined on both sides with 4-ply museum board to provide dimensional stability and a smooth surface. A single sheet of the corrugated board will be sufficiently strong for smaller items, and extra sheets can be laminated together with PVA for larger material. To finish the board, it can be 'wrapped' in acid-free paper adhered with a finely sieved wheat starch paste. The "wrapper" should be taken over the cut edges of the corrugated board to hide them. The resulting board is comparatively lightweight and very rigid.

The mounting system

The sheet of parchment is held to the support board by straps of long-fibered Japanese tissue, the weight and width selected according to the size and weight of the skin to be mounted. The strap width normally used is in the range 5-10 mm and sufficient straps are cut to allow them to be placed perpendicular to the edge of the document at intervals approximately equal to their own width. This close spacing keeps the edges of the parchment under control, provides enough strength to hold it under sufficient tension and avoids the risk of distortion which might result from adhering a continuous frame to it. The length of the strap varies according to the size of the skin, but 100-150 mm accommodates most material. At the corners, L-shaped straps can be used, which avoids having two thicknesses of Japanese paper at these points. The tissue straps are secured to the verso of the skin with a stiff wheat starch paste, attaching no more than 5-10 mm of the strap to the skin. The other end is secured to the back of the mount with PVA. The length of the straps is intended to allow some lateral movement

as the skin expands and contracts, and the tissue paper itself is able to stretch (though not recover) to compensate for a certain amount of shrinkage.

Should the skin shrink too much, the straps will either pull apart or tear along the edge of the support board, thus releasing the skin from further tension and preventing damage. If the skin does not cockle too much when this happens, it is possible to repair the mounting merely by replacing the torn straps.

Attaching the skin to the mount

This work should ideally be done at the same humidity level as the place where the mounted item is to be hung or exhibited. If this environment cannot be achieved within the workspace, then it is best that the item should be mounted in the location where it is to be kept.

It is important, having found the best position for the skin on the support board, to make sure that it is not shifted in the course of attaching it. This is most easily accomplished by placing the support board recto upwards on a block sufficiently high to give easy access to the underside around the edges. With the skin in the correct position, and held from moving by weights, stiff PVA is applied to the underside of the straps in the center of each side. These are then carefully molded around the edge of the support board and stuck to the underside, taking care to smooth them across the board before sticking down the glued ends. The corner straps can then be similarly glued down. Once the corners and centers of each side are secured, the mount, with the attached skin, can be carefully turned over onto clean paper or blotters and the rest of the straps can be glued in place. The straps at the corners need to be 'woven' over and under each other so that no strap is glued on to another. This can be achieved by gluing them down in the right order .

Framing the mounted skin

Once the assembly is complete, steps must be taken to protect the straps around the edge of the mount or they will be damaged by handling. If the assembly is to be framed, then the frame can be used to give this protection by allowing a small gap between the edge of the mount and the inside of the frame.

The mount itself can be attached to the backing board of the frame via strips of Velcro to give an easily dismounted assembly, or, more simply, via blocks of single wall corrugated board, glued with PVA to both the back of the mount and the backing board of the frame. Should the mount ever need to be removed, the corrugated board can easily be split apart. It is important that the Velcro or the corrugated board are attached without overlapping any of the mounting straps, and that the straps themselves are not in contact with the backing board. The Velcro and the corrugated board will both ensure this.

So as to avoid the risk of the skin expanding and touching the glazing or to prevent loose or friable pigments from being dislodged by the static pull of the glazing material, a space of 10 mm to 20 mm should be left between the

surface of the object and the frames glazing. If a glazed frame is not required, a shallow tray, the edge just deeper than the combined thickness of the mounted skin and the Velcro or corrugated board attachment can be used instead. It can be provided with a lid for secure, dust-free storage if required.

Mounting irregularly shaped skins

Square or rectangular support boards, cut slightly larger than the maximum width and height of the skin, work well with most material, which if it is not exactly square, is usually not far off, and the straps, if similar in color to the paper used to line the support board, need not be visually intrusive. A gilt fillet inside the frame under the glass or Plexiglas will mask the edge a little if required. However, material which is not at all square will need to be mounted on boards cut approximately to the shape of the skin to be mounted. This need not follow every exact contour of a highly irregular edge, and the straps can be masked with a more accurately shaped window mat if necessary. Alternatively, a special support board, made up of three or more layers of museum mounting board, glued together with PVA with the grain of each layer at right angles to the previous one, can be cut to the exact shape of the skin, bevelled on the underside, so that the mount will be all but invisible under the mounted skin. It is attached to the backing board or tray in the same way, and the same strapping arrangement is used, only here the straps are attached at right angles to the edge of that part of the skin to which they are pasted, and not in the neat parallel arrangement which is used for square and rectangular skins.

Conclusion

This method of mounting larger pieces of vellum or parchment for display or storage is not intended to be a perfect solution to the problem of securing such a highly hygroscopic material as parchment. Parchment's capacity for movement in response to changes in humidity levels is greater than the straps can possibly cope with, but provided that the mounted skins are not exposed to excessively dry conditions, the straps will secure the skin without exposing it to too much tension, and should the humidity levels rise, the skin will still be held around its edges, even though the tension of the mounting will be released. When the humidity levels return to normal, the skin will once more pull itself flat between the straps. Should it be necessary, the skin can be removed from the mount simply by peeling the straps away from the skin, dampening them lightly from the back if necessary. (NP)

4. Paper/False Margins

   a. Method used at the J. Paul Getty Museum: First suggested by Keiko Keyes for mounting double-sided, Old Master drawings, this method has been successfully used for mounting small manuscript fragments on parchment, particularly in cases where the design layer extends to the cut edge on the recto or if there is text or design on the verso.

      The paper selected for use in the mount should be of the same thickness as the parchment cutting or fragment being mounted (use a paper thickness

gauge), usually a medium-heavy weight Western handmade paper. The inner edge of the paper margin is cut approximately 1 mm beyond the edges of the object, so that there is a slight gap between the parchment edge and the paper margin; the width of the margin is discretionary (2"-4" in width as required.)

Thin strips (4-5 mm in width) of fine, long-fibered Japanese tissue (such as Kizukishi) are torn in separate lengths to correspond to each edge dimension of the fragment. The torn-edge strip of Japanese tissue is then pasted with rice starch paste and adhered to the verso edge of the cutting and the inside cut profile of the paper margin, bridging the 1 mm gap. The Japanese tissue need adhere only 1-2 mm or so onto the verso edge of the object, keeping the amount of paste to a minimum. A sufficiently strong attachment is made if only the fibrous edge of the tissue is pasted onto the object. The pasted edges are weighted between blotter and hollytex to dry. Once dried, the pasted, fibrous edges of the tissue become virtually transparent.

Once the attachment to the paper margin is complete, the whole can be mounted in either a single or a double-window mat, hinged, or mounted in place with photo corners. This mount allows the fragment to be float matted with a 1/4" margin so all edges are visible, and over-matting can thus be avoided (this is particularly important if the design layer extends to the edge of the support or if the support is badly cockled). Moreover, the window of the mat, when closed, puts pressure on the paper margin, not on the leaf itself, holding the entirety in plane.

If the object experiences RH change, the mount will react with the piece and not against it. By leaving the gap between the paper margin and the object, the object still has room to move. Moreover, since the paper margin is not a heavy card but a paper of comparable thickness and flexibility to the parchment, the mount will not act as a rigid constraint, as in the traditional drum mount technique. Therefore, any stress or strain will be acted upon the Japanese paper strips that bridge the gap between the object and the paper mount, not on the weakest area within the object itself.

The addition of paper margins to a manuscript fragment (a) prevents readers from handling the leaf directly, (b) keeps the fragment in plane and prevents the parchment support from curling, particularly if the cutting has been removed from a backing and may have residual adhesive on the verso or if the paint layer on the recto surface is thickly applied, and (c) can be easily replaced if soiled or damaged.(NT)

b. This mounting system uses false margins of japanese paper within a window mat. It was developed by Library of Congress staff as an alternative to string mounting (which is one of the primary methods of housing parchment at LC).

The principles behind string mounting (ie. movement with the object and detatchment of the string if the tension becomes too great) defined the approach when developing this mounting method. The string mounting system works best when held in rigid housing such as plexiglass

sandwiches or frames. For materials that will not be kept in ideal environmental conditions or for those that are in a mat that cannot provide a rigid support, the false paper margin mounting method is designed to avoid the need to re-enter the housing when a string pops off.

The principles of tensioning all around to emulate the manufacturing process and the use of an attachment material which will expand and contract as well as give-way first can be accomplished by using a modification of the Japanese scroll mounting technique (designed for drying objects on a drying board). This technique adheres false margins all around the edge of the object. For parchment objects, the paper margins are then slit at regular intervals. Without the slits, the paper margins cannot move and respond along with the parchment.

Select a Japanese paper which is aesthetically compatible with the object, but lighter in weight. Make the margin strips by tearing the grain long Japanese paper about four or five inches longer than the length of each side of the object and approximately one and a half to two inches wide. The margins may require shaping to the contour of the parchment. To attach the margins to the object, adhere the feathered edges to the perimeter of the verso, centering the object on the margin so that the extra lengths of paper extend equally. Working one half inch away from (and parallel to) the edge of the object cut inch long slits, every other inch, in the paper margin. Move one inch away from the object (half an inch from the cuts) and create an alternating pattern by making a second row of slits (parallel to the first row).

The paper margins are then adhered to the back mat board only along their outer half inch. Gelatin tends to make the tissue feathers transparent and is likely to expand and contract at a rate similar to the parchment document. Swab away any excess adhesive. This technique works well on a skin with a closed surface. As with any hinging method, open, pumiced surfaces could possibly go transparent or turn grey depending upon the characteristics of each individual skin. (JM)

5. Object Secured with Linen Threads

   a. Standard thread mat: For a good description, see Clarkson, 1987, pp. 201-209.

   b. Reverse thread mat: The reverse thread mat requires a mat cut to more than twice the width and height of the piece of parchment to be mounted, as the combined lengths of any two threads placed opposite each other around the edge of the object should be approximately equal in length to the width or height of the object between those two threads. This becomes a problem when miniatures or other drawings and paintings on parchment need to be remounted but still have to fit into existing frames or exhibition spaces.

   One answer to this problem is the reverse thread mat, in which the linen threads are taken around the edge of a specially prepared support board and held at the center of the reverse of this support board instead of

around the margins of a larger mat. The system does not allow for double-sided viewing, which the thread mat allows without difficulty, so any writing or image on the verso of material mounted this way must be photographed beforehand.

The support board

A piece of 4-ply acid-free mounting board is cut to the required size, normally larger by a margin of 1-2 mm on each side than the piece of parchment to be mounted. This is then set into a hardwood frame with a waxed and polished half-round edge, into the center of which are set small brass or stainless steel nails equal in number to the number of threads to be used to secure the piece of parchment. These pegs locate the threads as they pass around the edge of the support board and prevent them sliding towards the center of each edge; the polished edge allows the threads to expand and contract without difficulty. The back of the support board is filled in with mounting-board.

Attaching the threads

The cut lengths of bookbinders' linen thread, washed in water with a little soap, are secured to the parchment with wheat starch paste, as described by Clarkson. The object is placed face down on a sheet of clean paper on which are drawn guides to enable the support board to be placed exactly in the right position on top of it. The center thread from each side is then twisted between finger and thumb until the thread, held under light tension, begins to kink; it is then untwisted until the kink disappears, and the loose end of the thread is secured to the center of the back of the support with stiff PVA. The extra twisting increases the change in length of the thread in fluctuating humidity levels. As soon as these four threads are secure, the remaining threads can be attached in the same way, making sure that they are hooked over the correct brass peg. Care must be taken not to rotate the parchment during this process by pulling more firmly on some threads than others. Where miniatures cut from manuscripts with very uneven edges are being mounted, it will often be necessary to vary the angle of the thread attachment to suit the shape of the fragment.

An alternative approach is to twist the linen thread until it kinks a lot and then stretch it out, set the frayed end down with the PVA and weight it. This creates sufficient tension on the parchment, which is evidenced by one one particular piece which held its planarity for 17 years after having traveled for three years on exhibit. (JFM)

Attaching the support board to a frame

The support board must be held away from the board to which is it attached, and this is done by securing it with brass or stainless steel screws passing through the board, through spacing washers and into the wooden frame of the support board. The whole assembly can then be framed, making sure that there is at least a 5 mm gap between a small (100 mm x 100 mm) piece of parchment and the glass, the gap increasing as larger pieces of parchment are framed. If Plexiglas is used to glaze the

frame, a wider gap may be necessary to avoid the risk of friable pigment being detached from the surface of a painting by static pull.(NP)

D. Problems of Housing Multi-Sheet Documents

1. Research/reference materials
2. Display/exhibit materials: It is very impractical to exhibit sheets other than the top one in a multi-sheet document. It may be possible to roll back the upper sheet/sheets and restrain them with polyester straps joined with double-sided tape or with very wide cotton twill tape ties to display a lower sheet.

E. Problems of Housing Artifacts with Seals and Ribbons (see Szczepanowska 1992 and Burns and Bignell 1994)

Seals are either applied directly on the document or are hung from lengths of cord, parchment, or ribbon. Documents can be sealed with one or more seals, made out of wax, resin, paper or metal. Some seals are protected by metal or wooden skippets, and some are without protection. Every seal and its method of attachment are integral elements of the document, and must be taken into account when devising appropriate housings for their storage and display. Many require solutions that are very individually suited to the needs of a particular artifact.

The thickness of seals and ribbons must be accommodated in a window mat or in a sunken backboard/mount. A container for a seal can be attached to the surface of the mat (with a spacer placed on the mat), or between the window and the backboard. They can also be housed in a sunken compartment in a built-up thick backboard. Depending on their shape and placement on the document both seals and ribbons may require awkwardly-shaped windows. Heavy seals are also best supported by tailor-made compartments within the storage container even if they are not mounted for display. Surviving original containers for important documents are constructed with such compartments.

One housing system used for a large detached pendant seal at the National Archives consisted of a three-dimensional construction of archival corrugated board crimped with the direction of the corrugation to form a circular receptacle slightly larger than the seal. The corrugated board was two layers thick, lined on the inside with Nalgene 1/8" "clean sheet" expanded polyethylene. The composite was then covered with Japanese paper applied with wheat starch paste. The construction was slightly deeper than the thickness of the seal. A gap could have been left for any ribbons present. This construction can be used for long-term storage or for exhibit (with proper build-up of the window mat to the height of the construct) and can be attached to a rigid support or back mat with an appropriate adhesive. The outer covering of Japanese paper makes an unobtrusive presentation, and is usually close in color to mat board. (EO'L)

When an artifact with attachments or seals is encapsulated, the polyester should be welded close to and along the bottom edge of the artifact, up to the strap from which the seal hangs. This weld is important for helping to support the edge from which the seal hangs, so it is less likely to stress or deform that area. Additional welds or spot welds below and beside the seal will also help support the weight of the seal.

A housing system used for pendant seals and other large attachments can be created with plexiglas "skippets" mounted on the encapsulated assembly. Prior to encapsulation the parchment documents with seals are flattened. The document is then laid out on a large sheet of five mil mylar and a smaller second sheet (approxi-mately 25mm larger than the parchment on all four sides) is used as a top sheet. Using an ultrasonic welder the document is encapsulated on all four sides except where the ribbon, strap or thread extends to which the pendant seal is attached. A plexiglass skippet is fabricated from plexiglass tubes which are available from plastic suppliers. As they come in varying diameters, select one which is slightly larger than the seal. Creat a disk by cutting a section off of the tube that is taller than the seal is thick. To accomodate the ribbon or strap cut a notch out of the disk then finish and polish the edges. For a back plate cut a piece of 1/16" plexiglass sheeting that is slightly larger than the disk, bevel and polish the edges. Using a small drill bit that matches the size of brass escutcheon pins, drill holes every couple of inches through the back plate and into the bottom edge of the disk (the plexiglass tubes come in various wall thicknesses, the thicker the better to accomodate the pins). The large bottom sheet of mylar which supports both the document and the weight of the seal will be sandwiched between the back plate and the disk. The seal is placed into the plexiglass skippet and the back plate is pinned into place on the underside of the mylar, the pins can be adhered in if they are a little too small. The seal is then cushioned around the sides with strips of felt to prevent the seal from moving around in the skippet. This method of housing allows a document and seal to be safely and easily viewed from both sides, and is light weight and not bulky. (JFM)

18.4.14 Storage and Display (see also 18.6.3, 5, 9)

A. Environmental Guidelines

The establishment of temperature and humidity guidelines for the storage and display of parchment must take into consideration many factors including the age and condition of the artifact, its previous storage environment, the format of its present housing, and the way in which it is expected to be used by curators, scholars and others.

Humidity standards for the storage and display of parchment have traditionally been set at around 55% RH, with an allowable variation of 5%. These environmental standards widely cited for parchment have generally been based on the high RH typical of Great Britain and Ireland (eg. 55-60% RH) (see Cains, Stolow and Thompson). However, more recent research by Eric Hansen and other scientists at the Getty Conservation Institute has determined that parchment is more susceptible to gelatin and biological attack at relative humidities of 40% and above. Therefore it has been recommended by these particular authors that if preservation of collagen is the primary consideration then parchment should be stored and displayed in an environment of 30% RH +/- 5%. In their published paper, however, the authors include the following caveats:

1. The lower RH of 30% may be harmful to composite parchment documents which have illuminations or poorly bound ink due to the different reactions to changes in RH of the various materials.
2. Parchment may buckle or curl at the lower humidities.

An additional area of concern is if the parchment is brittle at lower humidities, such as medieval and modern vellum (from Hansen's studies), damage may occur if the parchment is subject to manipulation (such as items stored in mylar or unframed mats, or the leaves of a book).(JM)

Careful consideration should be given to the application of rigid standards to old collections stored for centuries in the same environment which, although not perfect, seem to be working well for the artifacts. Therefore, before making storage recommendations first examine the existing storage conditions, if possible, determine how long the parchments were stored in those conditions, assess any problems and establish if, in fact, the environment caused the problems. (HS)

B. Sealed Transport and/or Display Packages

1. Framed Objects

This system is applicable for string mats or any framed/glazed parchment housing. If the mounted parchment will travel or will be subjected to flucuations in RH, it can be placed in a sealed package to reduce those flucuations. A material like Art-sorb can be placed within the package to provide additional protection. A sealed package consists of glazing (glass or Plexiglas) on the front, the mounted/matted object and any supporting materials (Fome-core, mat or corrugated board, etc.), then polyester film on the back. The edges are sealed by wrapping a strip of pressure sensitive tape (J-Lar - a polypropylene tape with an acrylic adhesive that has good aging properties) from the edge of the glazing (just overlapping the front) and around the edge to the polyester film sheet on the back. The edges of the mount, etc. can be protected from the tape by covering them wiwth strips of 10 pt. folder stock as the tape is wrapped around the edge. Sealed packages of this design have been placed in humidity chambers of 80-90% RH for a week and have maintained an internal humidity of 50% RH. (LP)

Another alternative backing and packaging material in use today is Marvel Seal 360. This foil barrier sheet is made by the Ludlow Corporation and sold through University Products. Note: the manufacturer's name is printed on the foil in a red ink that is soluble, for conservation use Marvel Seal 360 should be ordered without the red printing. (HP)

For more information on the success of these systems and materials see the poster session by Hugh Phibbs of the National Gallery of Art presented at the annual AIC Meeting in Nashville, Tennesee, June 1994.

Anecdotal information from Portland, OR picture framers who used gray conservation corrugated on my recommendation. On large framed pieces, the cardboard would bow out, pushing the art work away from the wall. (JT)

2. Plexiglas Sandwich

A "Plexiglas sandwich" is a housing for a matted object. It is made by sandwiching the matted object between two sheets of acrylic that are then taped together, around all four edges, with polypropylene tape (J-Lar). This sealed package system provides both a rigid structure and a relatively constant microenvironment. Parchment or paper artifacts are often placed

in Plexiglas sandwiches particularly during transport and exhibition. However, in many cases, especially for moisture sensitive parchment, these temporary housings are often retained for permanent storage.

To construct a Plexiglas sandwich place the matted object between two sheets of 1/8-1/4 inch acrylic, which are cut to the same outer dimensions as the mat. Place the assembly face up on a clean table allowing one edge to extend beyond the table top in order to tape the sides of the sandwich unit together. It is helpful to place a weight on top to keep the stack properly aligned.

Using 1-inch wide clear polypropylene tape, start at the corner (allowing some overlap around the corner) align the tape along the edge so that there will be a 1/8 inch of tape over-lapping the top acrylic sheet. The remainder of the tape wraps around the side edges overlapping onto the bottom acrylic sheet. Rotate the unit until all edges are sealed. Repeat this step for the added protection of a second layer of tape. Finish by burnishing the tape to obtain the most effective adhesion possible.

When weight, cost or additional protection from moisture is a concern corrugated polypropylene (Coroplast) has proven an effective substitute for the acrylic back panel. The polypropylene material is lighter in weight and costs less than acrylic sheeting. Furthermore, a simple experiment at the Library of Congress revealed that the corrugated polypropylene panel was actually a more effective moisture barrier.

To gain a better understanding of the moisture barring qualities, as well as, to compare the effectiveness of various sandwich materials the following experiment was conducted in the Paper Section of the LC Conservation Lab. Three 11" x 12" sandwich units were assembled according to the instructions above the only variation being the back panel material. Each unit had a different back panel of either 1/8 inch thick acrylic; five mil polyester film (Mylar), or five cm corrugated polypropylene. A humidity indicator strip, mounted in place of an artifact in each window mat was used to monitor the internal humidity which was approximately 35% RH. All three of the units were placed in a 100% humidity chamber for 19 days. Within four days the Mylar backed unit registered a 5% RH increase and ultimately registered 50-55% RH.

After 15 days, all of the acrylic sheets became warped from their one sided exposure to the humidity. The two acrylic sheets in the one unit bowed away from each other causing the tape seal to break and allowing humidity to enter the package. The Mylar and Coroplast backed units remained intact as they moved with the warping acrylic.

After 19 days the corrugated polypropylene unit registered an internal RH of 40-45% and a small area of the tape had begun to loosen. In summary, of the three backing materials the Mylar allowed the most moisture to pass through. The corrugated polypropylene panel provided an equally effective moisture barrier as the acrylic sheet backing and in contrast was also able to accomodate the warp of the acrylic top sheet preserving the tape seal. (HW)

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18.6 Special Considerations

18.6.1. Distinguishing True Parchment from Modern Parchment and Vellum Papers (Dianne van der Reyden)

Parchment and vellum papers are generic names for two of four types of tracing papers. Tracing papers are made by either 1) processing the paper fibers by overbeating the fiber raw stock pulp slurry, which breaks down fiber structure and reduces porosity, thereby eliminating light scattering air/fiber interfaces (as with natural tracing papers), and/or 2)processing the formed paper sheet to fill voids, pores, and interfaces with material having a refractive index similar to paper fibers, by either immersion of the paper sheet in acid (used for genuine parchment paper), calendaring of the sheet (used for imitation parchment paper) and/or applying a transparentizer (coating and/or impregnating agents) to the sheet (used for vellum or prepared tracing paper).

Natural tracing paper is usually made from highly overbeaten chemical wood pulp that results in relatively flat and easily fibrillated fibers having good conformation. The fibers are processed by overbeating in a large volume of water (c.6% fiber content) at a high temperature (c.80 degrees centigrade) in order to soften the fibers and increase fibrillation and bonding. This fiber processing, compounded by machine calendaring, results in the near total collapse of interfiber voids, making the paper highly translucent, with a relatively matte surface.

Parchment paper, also called vegetable parchment, is a generic term used for either genuine parchment paper or imitation parchment paper, which are made in totally different ways. **Genuine parchment paper**, usually made of slightly beaten chemical wood pulp, is transparentized by momentary immersion of the paper sheet in baths of diminishing strengths of acid (such as sulfuric acid for thin paper or zinc chloride for thicker paper), which swell and partially disperse wood fibers, leaching out short chain beta-cellulose and gamma cellulose, forming an amyloid gel. Translucency is achieved when washing and neutralization reconstitutes, solidifies, and reprecipitates the cellulose and gel, so that during drying, the dispersed short chain polysaccharides form membranes which are deposited on and around the remaining fiber structure, effectively dispelling air within the interfiber voids. This process bonds the fibers into a grease and solvent resistant paper having high initial wet strength, often used for off-set lithography and silk-screen printing.

Imitation parchment paper, such as glassine, is made of chemical wood pulp that undergoes prolonged beating (20-30% fiber content in water) to fibrillate and partially "gelatinize" the fibers. Translucency is enhanced when the sheet, dampened to 10-30% moisture content, is supercalendared under high pressure (ca. 2000-3000 lbs/linear inch) and heat (surface roll temperature of 180-200 degrees C), generating steam that dries the paper to a 5-7% moisture content and expels air, causing further collapse of the paper structure. Supercalendaring imitation parchment paper causes the top side to become highly glazed as fines and fillers are molded smooth, while fibers on the underside of the sheet become flattened.

Vellum papers, prepared tracing and recently developed "self-healing" tracing papers are usually made from slightly beaten cotton fibers. The low fibrillation potential of cotton fibers, combined with their twisted structure, prevents close conformation of the

fibers, resulting in the scatter of light at the fiber/air interface around voids or pores. To achieve translucency, voids must be filled by impregnation and/or coating with transparentizing agents having a refractive index similar to cellulose. Resins are added either to the fiber pulp slurry (wet-end additives) to improve wet and dry strength (by preventing water from penetrating and breaking hydrogen bonds) and stiffness (by increasing adhesion between fibers), or to the surface of the formed paper sheet to improve water and scuff resistance. Transparentizers used in the past also include oils and waxes.

Tracing papers may react differently than parchment skin to aqueous treatments, which may cause expansion and opacity of the papers as compared with shrinkage and translucency in parchment skin. Solvents may cause an increase in opacity if they affect the coating of vellum papers. Translucent papers can not be flattened by tensioning as can skin (which would cause paper to split), but rather they should be dried under some form of contact pressure. Humidity pack humidification systems should be avoided as they may cause softening and distortion of coatings on papers.

The above information has been extracted from: van der Reyden, D., C. Hofmann, and M. Baker, "Effects of Aging and Solvent Treatments on Some Properties of Contemporary Tracing Papers," JAIC, 33, 1993, 177-207 and van der Reyden and M.Baker, Genuine Vegetable Parchment Paper: Effects of Accellerated Aging on Some Physical and Chemical Properties, to be published in the proceedings from the Materials Research Group Symposium, Cancun, May 1994.

18.6.2. Fumigation (Walter Newman)

Any fumigation technique suspected of having deleterious effects on paper should be suspected of also being unsafe for parchment. The increased sensitivity of parchment to heat may make it even less suitable than paper for exposure to processes where heat is involved, such as thymol chambers and microwave radiation. Since the growth of most fungi is favored by an acidic environment, parchment, which is naturally alkaline, is less subject to fungal attack than paper (see Szczepanowska 1992). As with paper, there is no substitute for good housekeeping in combating fungi, insects, bacteria and other forms of biological attack. Every fumigation procedure is only a temporary measure at best, and in fact may render an artifact vulnerable to even more vigorous biological attack when it is returned to an inhospitable environment. Since parchment responds so readily to humidity fluctuations, and since all infestations are promoted by high humidity levels, there is added incentive for controlling relative humidity levels where parchment is stored.

A report from the Center for Occupational Hazards in 1983 warned that "Routine fumigation should be avoided and fumigants should be used when all other control measures have failed." If it is decided to go ahead with fumigation, it should be remembered that parchment is an organic material, so any fumigant which affects organic materials may damage the parchment irreversibly. An example reported by Szczepanowska is ethylene oxide, which may result in loss of adhesion of gum arabic and animal glues and can cause a cross-linking reaction with proteins. Organic materials commonly found in parchment artifacts which could also be affected by fumigation include parchment sizes, fish glue, and gelatin. Metals for gilding, pigments, and binders could also be at risk. Fuchs reports severe damage to pigments, especially vegetable dyes, in experiments exposing colors produced according to

medieval recipes to formalin and ethylene oxide. Some colors shifted in hue, some changed completely (e.g. from red to green), and some sank into the parchment supports and penetrated to the reverse. (see Fuchs et al. 1988)

18.6.3. Relative Humidity Levels for the Display and Storage of Parchment: A Consideration of Levels Below 50% (Eric Hansen)

The most often encountered recommendations for the optimum relative humidity (RH) for the storage of parchment are usually around 50%. Investigations were carried out at the Getty Conservation Institute from 1988 to 1992 to determine the basis for this recommendation; and, what further information needed to be gathered to confirm or augment this recommendation (Hansen et al 1992). The effect of relative humidity on the biodeterioration of parchment was also studied (Valentin et al 1990). A further investigation was conducted specifically for the effect of relative humidity on the Dead Sea Scrolls (Schilling and Ginell 1993).

Conclusions based upon a survey of the previous conservation literature were: 1) 50 % RH was necessary to maintain a pliable or manipulable state of parchment; and 2) that a relative humidity below 70 % was necessary to inhibit noticeable fungal or microbial growth. One noticeable exception was the preservation conditions suggested by the National Bureau of Standards for the Charters of Freedom of the United States (the Constitution and Declaration of Independence), which are maintained in a helium atmosphere humidified to 25 % RH (NBS 1951).

An extensive review of the biochemical literature was conducted to determine the degradation rates and physical properties of collagen, which constitutes 95% of defatted, dehaired skin. It had been shown since the early 1940's that collagen requires a certain amount of water to maintain its molecular stability, which is present at relative humidities above 25% (Kozlov and Budygnia 1982). Thus a lower limit of relative humidity for the preservation conditions of objects containing intact collagen is 25%. This was the reasoning that was used by the NBS to set the conditions for the Charters of Freedom of the United States. Further data from the leather industry (Bowes and Kaistrick 1964, 1967) indicated that relative humidities above 40% increased the rate of the conversion of collagen to gelatin (the course of denaturation for the protein collagen).

Further testing (Hansen et al 1993) was done to determine the effects of maintaining different relative humidities on the mechanical properties of modern, intact parchment at different relative humidities. Standard samples of calfskin parchment were subjected to (1) tensile fracture, and (2) measurement of the force that developed when restrained samples were subjected to step decreases in relative humidity in the region between 60% and 11%. The results indicate that, although no particular level of relative humidity can be excluded in general from consideration as a storage or display condition on the basis of tensile fracture testing data alone, at 11% RH there is a decrease in both the ability to elongate and in the tensile strength. It was further demonstrated that below 25% RH large stresses could develop in restrained samples.

Valentin and her co-workers (1990) demonstrated that biodeterioration, for both aerobic and anerobic micro-organisms common to parchment deterioration, resulting from the growth of micro-organisms occurred beginning at 40% RH and increased with higher levels of relative humidity. Hansen and co-workers (1992), on

consideration of the physical chemistry and chemical reactivity of collagen, the effect of RH on physical properties, and the results of the biodeterioration study, suggested that a relative humidity below 40% and above 25% should be optimum for storage or display if preservation of the collagen was the primary consideration. 30% was suggested as an optimum level, permitting a cyclic variation of ± 5% with minimal effects of swelling and shrinkage.

These considerations have been the subject of some debate and concern among librarians and archivists. Of particular concern are: 1)when these conditions might be favored as opposed to higher relative humidities around 50%; 2)what problems might be encountered with parchment in varied states of age and deterioration; and 3)what problems might be encountered with the composite nature of documents and illuminated manuscripts, particularly in regard to inks and colorants. Burns (1993) summarized a discussion held at the "Conservation of Parchment" course and workshop (held at the Conservation Analytical Laboratory, Smithsonian Institution, February 1-5, 1992), which helps clarify these issues.

Burns (1993) stressed that the recommendations for lower relative humidities were not a blanket recommendation, but an attempt to define "the lowest amount of atmospheric moisture (above 25% RH) that will allow for mechanical requirements...other composite elements, and aesthetic requirements" (Hanens, et al., 1993). In the discussion, it was recognized that "rather than implementing changes based upon them, archivists might use the findings to reflect upon a situation that is not as straightforward as they perhaps had thought...Those charged with the care of collections may have other aims, such as handling and aesthetic considerations. Conservators must evaluate the specific context of individual collections - the type of parchment, historical and geographic origins, processing and finishing variables, subsequent use, storage history, present needs, media -- and assess the feasibility and practicality of the recommendations of Hansen and his co-workers."

It can be seen that much subsequent research and work needs to be done to determine adequate relative humidity conditions for the full range of types of parchment materials in archival collections. For example, Schilling and Ginell (1993) investigated the dimensional changes in Dead Sea Scroll samples and laboratory degraded parchment (partial conversion to gelatin), and confirmed the large changes associated with levels below 25% RH for historic samples. A suggested immediate concern for future research would be investigations of the effect of different relative humidities on the stability of inks on documents or paint in illuminated manuscripts.

18.6.4. Case History: Conservation of Early Koran Fragments (Ursula Dreibholz, edited by Walter Newman)

During the restoration of the west wall of the Great Mosque in Sanaa, in 1972, over 40,000 manuscript leaves and fragments from the first to the fifth Higri (700-1200 A.D.) were discovered between the outer roof and inner ceiling of the mosque. This was most likely a place to discard Korans which could not be used any more because they were damaged, but which could not be simply thrown away because of their sacred nature. As soon as the importance of the find was realized, the question of preservation arose. In 1980 an agreement was reached between Germany and Yemen to set up a special project, sponsored by the German Foreign Ministry, to catalog and conserve the artifacts.

Fragments from almost 1000 different volumes of the Koran have been distinguished but not one of these volumes is complete. Leaves range in size from 50 x 80mm to 400 x 450mm. They date as early as the seventh century A.D., and include printed texts as late as the 19th century. Most of the manuscript is in brown or black ink and color has been used for the dots of the vocalization marks and other pronunciation signs as well as occasional decorations such as verse stops and sura headings. The number of fragments written on parchment has been estimated at twelve to fifteen thousand. There is also a large but uncertain number of fragments written on paper. The parchment manuscripts have been given priority so far, as they include examples which are more significant to early Koranic paleography.

At the time of their discovery the condition of the objects varied from very good to almost totally destroyed. It was immediately obvious that the material had been a source of food for rodents and insects. However, much of this damage may have occurred prior to storage in the roof. Rain from the undetected leaking roof had mixed with centuries of dust to form encrustations upon a great many of the manuscripts, some of which resembled bricks. The water had caused inks to bleed or even disappear completely; there were severe cases of parchment shrinkage and in the worst examples the parchment skin had irreparably deteriorated. Still, despite localized damage from rain water, many of the parchment leaves were relatively well preserved, thanks to the dry climate of the area. Relative humidity averages between 25-35% most of the year, and only goes up to 50-60% during the two rainy seasons. Although the leaves are very dry, stiff, and brittle, they are preserved and can be successfully relaxed in the humidity chamber. Other damage took the form of heavy pleating and creasing, tears, and deliberate mutilation where areas of the leaves had been cut out.

The immediate aim of the initial conservation treatment was to consolidate the material so that it could be examined. This mainly involved gentle relaxation and cleaning of the items. Tears were only repaired when it was deemed that the item could not otherwise be safely handled. Extremely fragile leaves were placed in polyester film sleeves which were open on two sides to assure air flow and easy retrieval. Although the treatment applied to most of the items was simple, each item was individually assessed and treated according to its particular needs.

The previous conservator had reportedly used urea for treating the parchment. She did not use a humidification chamber at all, but applied urea solution liberally to the parchments and then pressed them while still wet. Consequently, some of the leaves have a shiny, translucent, and alien appearance.

Since a purpose-built conditioning chamber was not available, a much simpler but effective device was employed. This was constructed by placing a shallow tray of water at room temperature into a larger container. Nylon netting, with its edges glued between strips of strong plastic to give support to the parchment leaves, was suspended above the tray. The nets were in turn supported by frames cut out of sheets of foam rubber, which allowed sufficient space between the nets to accommodate the deformed parchment leaves. The uppermost net was then covered by a layer of moist blotting paper, while a wooden board with a thinner foam rubber glued inside it closed the chamber tight enough to create an appropriately humid atmospher. The humidity level could be varied by leaving the cover slightly open,or by not using moist blotting paper, or by leaving the pages in the chamber for longer or shorter periods of time.

After an overnight stay in the chamber the leaves were easily unfolded and unrolled, and pages stuck together were separated with care.

Dirt was then cleaned off with a cotton ball moistened with a solution of four parts ethanol and one part water. After several tests this was found to be the most efficient mixture for this purpose. When used carefully it removed dust and dirt effectively but did not affect the inks or pigments. It also softened fly spots and encrustations to the point where they could be removed easily with a scalpel. The alcohol seemed to help distribute the moisture evenly throughout the parchment, while at the same time preventing it from becoming too wet. The hair side was always dampened first because it does not absorb moisture as readily as the flesh side, and this helps prevent the edges from curling. During local dampening it could be observed that parchment which was exposed to excessive moisture or to water at an earlier time (which was clearly indicated by increased decomposition, shrinkage, or discoloration) was more hygroscopic and reactive to moisture even if it had been dry for a long time.

Next came what proved to be the most difficult operation, that of tensioning the fragments in order to ease out creases, stretch shrunken parts, and smooth out curled edges. The irregular shapes of the fragments, and their fragile nature, meant that conventional methods of "pinning out" could not be used. The following technique was employed instead. The humidified and relaxed item was placed between sheets of waxed paper or silicon paper, weights were gradually placed over the object section by section, and the parchment was allowed to dry slowly. Some sections had to be manually stretched or manipulated. Sometimes the procedure had to be repeated several times, although generally once was enough. As the item dried, the parchment was checked about every ten minutes, especially to make sure that no edges were folded over, which would cause permanent damage under pressure, and heavier weights were placed on the item. When almost dry, the parchment was lightly sprayed with the ethanol/water solution, placed between sheets of waxed or silicon paper, and placed in a press with very light pressure. After a day had gone by, when there was no longer a risk of paper fibers sticking to the damp ink or of the ink offsetting, the waxed paper was replaced with blotting paper. This process was monitored over a period of a week or even until the moisture content of the parchment was stable and there were no longer signs of the parchment tending to move, and then the fragments were left in the press between blotters for another three weeks or even longer. Following this treatment they had usually regained sufficient flexibility and stability to have their textual content examined.

The main concern over the last few years has been the permanent storage of the collection. The huge task of cataloging the material relies on quick retrieval, so the system has to be flexible enough to accommodate newly cataloged items which are to be reunited with other leaves from the same codex. As mentioned above, extremely fragile leaves are placed in polyester film sleeves open on two sides. All the leaves are placed in flat folders which are lined with thin acid-free board. A sheet of polyester film is attached to this lining and then folded back over the object. In this way when the upper part of the folder is lifted one can easily see the object, while it is still protected by the sheet of polyester film and cannot fall out or curl. For larger and thicker parts of volumes a sheet of polyester film is attached to the inside of a wrapper of acid-free board. The polyester film covers the top leaf and permits instant visibility when the board wrapper is opened. A window is also cut in the top board for

visibility.The two boards confine the leaves like the covers of a book. They are tied together with linen tape, and the unit is stored in a drop-spine box. The boxes are stored horizontally, in the tradition of the Islamic book, in specially fitted cabinets.There is a folder for every signature, and the labels for over-sized or bulky objects which are too big to fit into the regular folders are color-coded so that one sees at a glance if the item is kept in a box or in the cabinet for oversized volumes.

The fragments are too weak to be resewn, and since the volumes are incomplete there is always the possibility that other leaves will come to light from among the unrestored material. So all consideration of rebinding, as well as of mending tears and filling in lost areas, has been postponed until the stabilization of the collection is complete and a more comprehensive program of priorities has been established. The conservation and storage facilities are installed in the Dar al-Makhutat, the manuscript library, which is across from the Great Mosque in the old city of Sanaa, where the fragments were found.

(A version of this report appeared in Paper Conservation News, Vol. 10, No. 69, March 1994, written by Ursula Dreibholz and edited by Edward Simpson. This version was edited by Walter Newman, incorporating additional information provided by Dreibholz.)

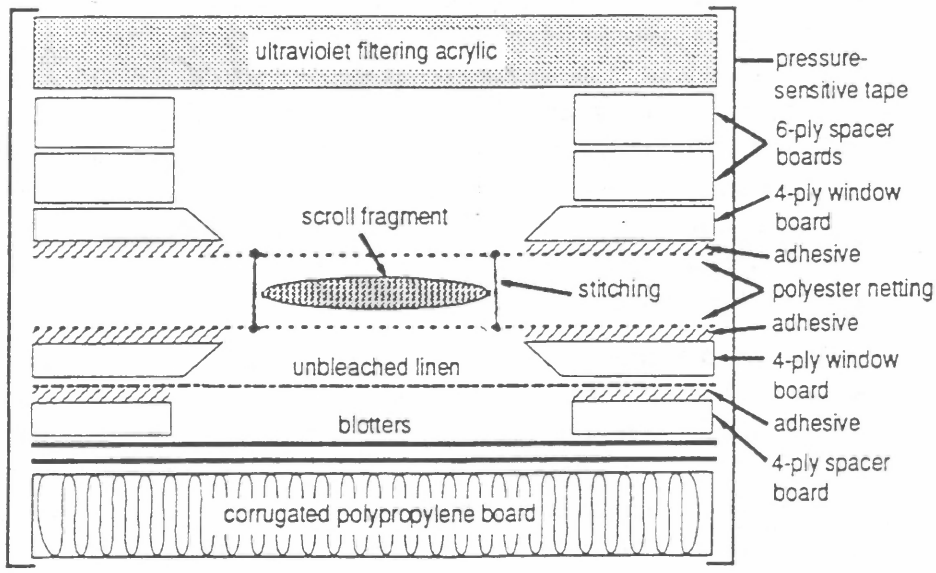
18.6.5. Housing of Dead Sea Scroll Fragments for Exhibition Tour in the United States (1993-1994) (Doris Hamburg)

The twelve Dead Sea Scroll fragments chosen for exhibition in the United States (1993-1994- three venues) are quite variable in terms of visual appearance and condition, though all are considered fragile. Some are very dark; others are quite light in color. In some cases there has been delamination on the top layer and tenting along cracks. Insect and/or mold is apparent on some. The thickness varies as well. Brittleness is a characteristic shared by most. Some scrolls were previously lined with lens tissue and a resin adhesive. All have breaks, losses, and staining. Many have undulations, and are not flat. In general the carbon ink appears well adhered to the support. The skin materials of the Dead Sea Scrolls are thought to come primarily from sheep and goats, and to have been partially tanned. The Scrolls date from the third century BCE to the first century CE, based on historical, paleographic and linguistic evidence, and confirmed by carbon-14 dating.

In considering options for the exhibit housing, it was clear that a modular system that would require no direct handling of the scrolls during the exhibit period was needed. Another focus was to create a system that would minimize changes in relative humidity and would avoid any flexing and movement of the fragments. The scrolls were being exhibited and stored between venues in institutions with good environmental conditions and monitoring; all scrolls would be hand carried between venues. It was considered preferable to avoid the use of adhesives. To facilitate packing issues, the outer dimensions for ten of the twelve fragments were standardized.

A layered system that formed a "package" was developed, as illustrated. The acrylic sheeting filters ultraviolet radiation and provides a physical barrier as well as rigidity to the package. A spacer below, made from alkaline buffered rag board, separates the scroll fragment from the the acrylic sheet. Two mats were cut to hold stretched pieces

of polyester netting (Tetex- aka Stabiltex). The openness of the net weave and the color allowed viewing of the scroll fragment. None of the scroll fragments showed evidence of the skin softening due to gelatinization, as has been reported in some fragments that were subjected to higher humidities. If this type of softening and gelatinization had been evident, and/or if the environment was not to be controlled, this system would not have been chosen. The polyester fiber is smooth and has long term stability. Silk has been used in other contexts for related housings; it has a scaled fiber morphology and has less long term stability. Polyvinyl acetate (pva) emulsion was applied to the inner side of each mat, allowed to dry and the polyester net was applied in position with a tacking iron. The weave orientation of the polyester net on the second mat was askew to the first to minimize the possibility of a moire effect when placed together. Double sided 3M 415 acrylic tape was applied to the inside of one of the mats. The scroll fragment was placed between the two net mat layers, held together by the tape. The fragment was held in position by sewing around the outside of the fragment (not touching) using thread from another piece of the polyester netting. The sewing was visible only in some lighting situations, and was generally note seen by the viewer. The next layer was a natural, unbleached, washed airplane linen attached with pva emulsion (heat activated) to a rag board window mat. The linen provided an aesthetically pleasing background layer for viewing the scroll fragment. Below this were two layers of acid free blotter as a cellulosic relative humidity buffer. A silica gel tile would provide even greater buffering capacity, however, loose silica gel should be avoided due to the risk of stray gel in the package. An activated charcoal tile might be a useful addition to adsorb any volatile materials. The edges of this layered package



Drawing by Elizabeth Miller

were held together by two layers of J-lar acrylic tape along all four edge sides. Removal of the fragment from the package is fully possible.

The scrolls in their packages were displayed in exhibit cases buffered with silica gel, at an angle not exceeding 18 degrees. The shallow angle was intended to avoid potential pressure on brittle edge, by distributing the weight overall. The exhibit halls were all environmentally controlled and monitored. Lighting (max.3-4 footcandles) was viewer activated through infrared or button systems. The relative humidity was kept between 45-50%, with temperature 68-72 degrees F. Due to the package housing, the scrolls were quite easy to monitor during the course of the exhibit in terms of shifting, breakage, etc. Photographs and diagrams assisted in recalling details of staining, undulations, etc. This system or a variation thereof is being considered for long term storage.

Other possible options for mounting the fragments might have included the following, however were not considered appropriate in this context. Polyester encapsulation was not appropriate due to the delamination of some of the fragments, three-dimensionality of the support, aesthetic considerations and distracting glare. Hinging with Japanese tissue or a related material was not used to avoid any future need to remove the hinge in changing the housing. Straps or half moons did not seem aesthetically appropriate and in some cases would have been difficult to apply given the brittleness of some of the fragments.

18.6.6. Special Considerations for Nineteenth Century Fine Art Prints on Parchment (Jane Smith and Victoria Bunting)

History: The use of parchment as a substrate for fine art climaxed at the end of the nineteenth century in conjunction with the desire for *objet de luxe* reproductive prints in Europe and North America. In order to control the number of proofs per plate, regulating bodies, such as the Incorporated Printsellers' Association, were established in London. Prints produced under this Association's guidelines can be identified by the hand-written signatures of both the engraver and the painter below the image, and the absence of any engraved inscription except for the publication line. Artist's proofs always had the Printsellers' Association stamp in the lower left hand corner. (*An Alphabetical Listing of Engravings at the Office of the Printsellers' Association, London, from 1892-1911 Inclusive*, 1912).

Of the tens of thousands of prints pulled from a typical plate, 125 - 250 of these were apparently artists proofs on parchment (*An . . . Printsellers' Association . . .* 1912). A variety of subject matter was represented in parchment prints of the late nineteenth century. Landscape images were commonly reproduced as prints on parchment at this time, as were dramatic scenes after Pre-Raphaelite paintings by William Holman-Hunt, Sir Lawrence Alma Tadema and others. Nineteenth century *de luxe* edition reproductive prints are often on a split skin substrate and can measure from 45 - 55 cm by 65 - 80 cm.

Since the ink is never absorbed into the skin but rather, spreads under the pressure of the press, the print will have a gorgeous velvety texture, which may be easily disturbed during conservation treatment. Treatment options for these objects are limited because of the fragile surfaces of the ink, which are easily abraded and which may detach if the supports are flexed too much, and because of the inherent weakness of split skins.

The modest pressure used during printing may help to explain the faint or even absent platemark of many prints. Jenkins suggests that the platemark could be lost in the pressing after the printing. The platemark could also be lost in the mounting of the parchment to the backing board in preparation for framing.

Since these prints on parchment were deluxe versions of printed editions on paper, they also were expected to be relatively flat. These prints may be found glued down to a rigid support which is quite possibly their original mount. Catalogues of the period note that publishing companies such as the Fine Arts Society would do mounting of prints for the buyer (Sparrow, 1926; McIntosh Patrick, 1993). The original mount may be of poor quality materials which should be removed. The consequences of restraining skin, which has its own inclinations to move, accompanied with prolonged exposure to fluctuating relative humidity and temperatures, can be damaging to prints. Problems include cockling, splitting, tightening like a drum, and pulling away from the support.

Treatment: Removal of Adhered Matting and Mounting Boards

The brittle and broken backing board and window mat may be removed from the sheet of parchment mechanically, dry with spatulas and with Methyl cellulose (A4M high DP) poultices if the adhesive is water soluble. (See AIC/BPG/PCC 10. Spot Tests.) While this technique may remove some of the adhesive, there still may be residual adhesive in and on the skin. Although parchment is much more resistant to abrasion than is paper, it is still possible to abrade its surface, especially on the degraded edges.

Thin accretions of adhesive and mounting materials may be removed by swabbing with saliva and blotting the surface dry. If moisture in any form is applied, deformation where hot animal glue was applied originally in the mounting process may become more pronounced.

To provide access to the inside of folded edges, the crease of the fold may be swabbed with undiluted absolute ethanol to gradually relax it. One consequence of this process is that tidelines may result in discoloured skins. The tide lines may be reduced by feathering the hard edge with ethanol.

Surface Cleaning and Disinfecting Mold Covered Areas

Superficial surface grime and surface mould may be removed by swabbing with absolute ethanol in non -image areas only. Eraser cleaning as applied in paper conservation may be used for non-image areas. In image areas, loosely adhered accretions and mould may be picked up with a kneaded eraser with the aid of the stereo binocular microscope. Tenacious accretions such as dots of paint can be broken up with the point of a scalpel and the fragments dusted off by brush or air from a photography bulb/hurricane blower.

Review of current knowledge and treatment options, offer no acceptable method for minimizing the staining caused by mould and matting materials.

Retensioning

In retensioning parchments the surface characteristics of the ink and the image dimensions must be carefully maintained. The precise square shape of the image is important in keeping with the pristine surface and aesthetic qualities considered

desirable in prints from this period. Breaks and thinned areas already present in the skins must not be accentuated.

There are numerous ways to retension parchment. These prints on parchment, may withstand only minimal tensioning. One method to apply minimal tensioning is as follows. Construct a wooden strainer of dimensions two to three inches larger than the object. Hammer galvanized nails around perimeter on one side of strainer at one inch intervals, leaving heads protruding. Make a grid pattern using fishing line wrapped around the nail heads. This will be used to support the object in the humidity chamber. Elastics are used to attach bulldog clips to each nail. The clips should be padded with blotters, felts, Pellon, etc. to protect the parchment from indentations. These clips will be used to tension the parchment once it is humidified by adjusting the elastics around the nails. During humidification the parchment may be held with a few bulldog clips on each side to prevent curling or extreme distortions. After sufficient humidification, additional clips are applied and the tension is adjusted using the elastics. After a few hours, the parchment may be removed from the strainer and placed between blotters, felts and plate glass. If appropriate, more weight may be added. In most cases complete flatness may impossible to achieve without risk of damage to the image or distortion of dimensions. (Jane Smith and Victoria Bunting)

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Personal correspondence, 1993, Mr. Andrew MacIntosh-Patrick, Fine Arts Society Archives, 148 Bond Street, London W1Y 0JT, England

18.6.7. Case Study of U.S. Public Laws: Record Copies on Parchment (Catherine Nicholson)

Following practices established in England, the official record copies of U.S. public laws were engrossed, that is, hand-written in a formal calligraphic hand, on parchment supports. The initial words or lines of the text would be written with larger, thicker, thus "engrossed" letters, built up of multiple parallel pen lines with the space between parallel lines hatched or filled in solidly with ink. As early as 1802, the engrossed initial words were printed by letter press on the parchment, with the remainder of text handwritten in iron gall ink on a parchment support, generally unsplit.

Continuing into the first quarter of the nineteenth century the parchment supports were large, up to about 30 by 34 inches. While laws of shorter length were written on one side, generally the toothier flesh side of individual parchment leaves, longer laws were written front to back, with text running from top to bottom on the recto and then from bottom to top on the verso. For longer texts, faint pencil guidelines were made, sometimes between holes pricked in the side margins. The practice of writing from bottom to top on the verso indicates that initially the separate leaves were joined together along the top edge, a practice common in English public records. The U.S. Constitution similarly has a set of vertical slits in the top margin of each parchment

leaf, with faint blue coloration on the split edges apparently from ribbon used to hold the several pages together. (They are however only written on the recto.)

Until the late nineteenth century, the Constitution is known to have been rolled, and for some period of time the rolled parchment leaves were stored in a tin cylinder. All the large parchment public laws were probably originally stored rolled. The office entrusted with their custody during the nineteenth and early twentieth century was called the Bureau of Rolls at the State Department. Physical evidence of rolled storage remains in parallel horizontal ridges or creases, and in patterns of stains that repeat along the length of a parchment leaf. They may later have been bound into structures with leather-covered spines, possibly in the late nineteenth century, as small remnants of brown leather were found glued along the upper edge of one early public law. In 1926 the Government Printing Office bindery devised a postbound structure for the large early public laws, which continues in use today. The shorter individual leaves were stitched and glued with animal glue along their top edges to buckram tabs. These buckram tabs and the top edges of the longer parchment leaves were then sewn together onto a buckram tab into signatures of about ten leaves. Each signature had a reinforced buckram top edge with grommet holes held into a large locked post bound structure, measuring 33 x 40 inches closed. Several signatures of Public Laws are grouped in a post binding by session of Congress, arranged by date of approval and numbered sequentially.

In 1824, smaller parchment leaves ca. 15 x 22 inches began to be used for public laws. The parchment was split, making it thinner. Faint blue lining served as a guide in writing the manuscript text, below the engrossed initial lines printed by copperplate engraving. Text was generally written only on the recto. By the middle of the century the use of red and/or blue ink border lines in the margins around the text became common. The parchment leaves were sewn along the left edge into leather bindings arranged by session of Congress. In 1893, the size of the parchment leaves decreased even further to ca. 10 x 15, because the text was now printed on the recto only within a border line of double red lines. The leaves were bound along the left edge into volumes.

In 1920, the use of parchment for record copies of laws was discontinued, and a high quality heavy weight off-white wove paper was introduced. Text was printed within a red line border in the margins, with original pen and ink signatures on the final page.

The National Archives has had a practice of making "red line" copies of public laws upon request which can on first glance be confused with the originals, as the red line border paper used is the same used for printing public laws. The copies are produced on a xerographic copier and can be distinguished from originals on close examination.

Though they are not public laws, the ratification copies of the Constitution and Bill of Rights were also executed on parchment supports. Ratification copies, which were sent to each state for approval, are in addition to the official record copy retained by the U.S. government, so more than a dozen copies were originally created. Ratification copies typically show evidence of having been folded up for transport to the states, with an endorsement or address written on the exterior of the folded up document.

18.6.8. Case Study: The Declaration of Independence (Elissa O'Loughlin)

The Declaration of Independence, the Constitution (five pages) and the Bill of Rights were sealed in glass and bronze cases in 1951-52. The work was done by the National

Bureau of Standards under contract to the Library of Congress. The parchments are held by compression on several sheets of a high alpha-cellulose paper within the cases which contain humidified helium. Evelyn Erlich and George Stout treated the Declaration for the Library of Congress in 1942. The upper right corner had become detached in part due to the uncontrolled exhibition environment at the Library. A circular loss about 1/2" in diameter above the letter "m" in "America" was inserted with new parchment. Minor tears and small losses were mended with Japanese paper and wheat starch paste, and pulp fills were made with Japanese paper fibers toned with Winsor and Newton watercolors. For his work on the Declaration, George Stout was named "Honorary Consultant in Parchments" by Archibald MacLeish, then Librarian of Congress.

Verner Clapp asserted (Special Libraries, Dec., 1971) that the reason for the poor condition of the Declaration was that the parchment was "not even an excellent sheet of parchment to begin with; apparently it was a home-made (colonial-made) piece of parchment found fairly quickly in the markets of Philadelphia." Clapp's assertion has not been confirmed, and no source for the information is given in the article. However, there were parchment makers in Philadelphia and elsewhere in the colonies at the time of the Revolution. As early as 1748, David Hall (partne of Benjamin Franklin) advertised in the Philadelphia Gazette tht "very good" parchments were made locally by Joseph Wood were available for sale at the Post Office. Later, in the April 1779 edition of The New York Journal, Robert Wood advertised parchment made by himself for sale to stationers and large quantity users. Benjamin Franklin mentions a Robert Wood whose parchments were said to equal those of English import in quality. Other parchment makers were working in New York CIty and in Alexandria, Virginia in the latter part of the eighteenth century.

18.6.9. Storage and Display of Parchment: Case Studies (Dr. Nathan Stolow)

The recently published studies[1] of the mechanical and biological properties of parchment and the recommendations under certain circumstances for reducing the accepted R.H. norm to the level of 30 ± 5% (albeit for modern vellum) is cause for concern, especially so for archival conservators and custodians of parchment documents, manuscripts and ancient artifacts of similar proteinaceous composition. For many years it had been established that old parchment, from the Dead Sea Scrolls to the U.S. Bill of Rights, required an ambient level of 50-60% to maintain suppleness, ease in handling, and geometric stability in display situations. The goal in climate controlled cases was to achieve constancy in R.H. control over extended periods of time. Careful examination of the condition of parchment artifacts maintained in such cases showed that surface features were well preserved.

Thus, dimensional relationships and any distortions out-of-place remained fairly constant. Where documents were displayed flat, without appreciable restraints, it was determined that the parchment was sufficiently relaxed at the level of 50-60% R.H. to justify the light restraints to anchor the document in position. Likewise, rare manuscripts exhibited at fixed (or occasionally variable openings) were less likely to be physically stressed when displayed at the recommended humidity levels.

My experience with parchment documents and manuscripts goes back some twenty-five years, particularly in the specialized field of controlled climate cases and exhibitions technology. I was responsible thus for the environmental and conservation

standards for the display and travel of the Book of Kells and other manuscripts[2]; the Magna Carta (Brudenell/Perot); and more recently the Bill of Rights (Virginia)[3]. Summary descriptions of these projects with annotations relevant to ongoing study of the reactive properties of parchment are included here. In all instances the levels of R.H. in the 50-60% range were recommended by the institutions, archives, and consultant manuscript conservators themselves as conforming to past environmental history (display and storage) and desirable physical maintenance.

A. Kells and Other Irish Treasures.

The exhibition, "Treasures of Early Irish Art: 1500 B.C. to 1500 A.D.," included treasures from the Trinity College, Dublin; the Royal Irish Academy; and the National Museum of Ireland, and traveled from Dublin to the U.S.A. and to various U.S. major institutions from October 1977 to May 1979. Included in the exhibition were two volumes of the Book of Kells, the Book of Durrow and Dimma, Armagh, and Stowe manuscripts. This exhibition, in revised and reduced form, also traveled in Europe, 1980-83.

Required Environmental Standards: 60 ± 2% R.H.; 66-72°F.

Case Description: Externally back-lit acrylic cases with conditioned silica gel, and these display units (5) were housed in a large display structure with temperature control, moderate R.H. control, and various security alarms. Light levels were strictly controlled -- ultraviolet free at 5 foot-candles at document surfaces.

Condition Monitoring: Daily R.H. and temperature monitoring by resident curator, and by consultant during site visits at each exhibition venue. Environmental reports sent regularly to Dr. Stolow and Irish authorities, and instantly evaluated for any possible remedial action, if required.

Photographs were taken initially of selected details of the Books of Kells and other documents and these areas are restudied at different times to determine if any changes were taking place. Observations of cockling and other surface defects particularly noted.

Comments: The level of 55-60% R.H. was rigorously maintained for the 18 month display period, and also in transit. Condition studies showed that the exhibited manuscripts and documents remained supple and flexible, and all decorative elements were well preserved.

Specialists Concerned and Acknowledgements: Dr. N. Stolow, Conservation Consultant; Anthony Cains, Manuscript Conservator, Trinity College, Dublin; Stuart O'Seanoir, Keeper of Manuscripts, Trinity College, Dublin.

B. Magna Carta - Brudenell/Perot.

This version of the Magna Carta, dating to 1297, was purchased by Ross Perot of Dallas, Texas, in 1984 from the Brudenell Estate in Great Britain. The parchment document measures 14 1/2" wide by 17 3/4" long, is written in Latin, and has an attached seal. After conservation treatment by Don Etherington and assisted by James Stroud, it was prepared for travel in a specially designed climate controlled case and outer security container by Nathan Stolow. The overall exhibition design was executed by Staples and Charles of Washington, D.C. The itinerary covered the

period 1985-86, including showings in Washington, D.C.; Philadelphia, Pennsylvania; Dallas and Austin, Texas; and Boston, Massachusetts.

Required Environmental Standards: 52 ± 2% R.H., 68-74°F. 5 foot-candles illumination ultraviolet free, vibration and shock protection in transit; nitrogen environment; pollution control.

Case Description and Condition Monitoring: At the end of the tour the document was exhibited again in the Rotunda of the National Archives. In 1990, Dr. Stolow redesigned the climate controlled case, installing a permanent one fabricated in stainless steel and housing the document on a special platform with securing devices modified by Don Etherington. The R.H. control was achieved by preconditioned silica gel maintaining a consistent level of 52 ± 2% at ambient Rotunda temperatures. This climate and light controlled case was fitted with various probes, including that for R.H. and temperature (Vaisala Hygrometer) reading the internal conditions from the externally rear-mounted meters. At the time of setting up, and on an annual basis, the case was charged with 99% nitrogen gas (at 52% R.H.), the level of residual oxygen determined on-stream with a Beckman oxygen monitoring device. To the extent possible, all internal materials used in the climate controlled case were deemed to be pollution free. To limit any residues of pollutants building up within the case, a quantity of activated carbon pellets was placed in a dust-free porous container under the platform of the displayed document alongside the silica gel bed.

In accordance with conservation standards, the light level infringing on the document was limited to 5 foot-candles, ultraviolet free. Outside of visiting hours, the display front of the Magna Carta installation was covered over with an opaque panel to limit the cumulated light exposure on the document. The external display housing in marble and anodized aluminum was designed by Staples and Charles. The external viewing glazing (spaced away from the climate control module) was of 1 1/4" Lexan, a material resistant to heavy blows, mechanical shock, and even bullet proof! This permanent installation remains as redesigned in 1990, and functions extremely well. Some typical environmental data, R.H. and temperature levels inside the case are given in Table I, and for the corresponding ambient conditions in the Rotunda external to the case in Table II.

Comments: The level of 52 ± 2% R.H. was very consistently maintained to date (6 years at least) at ambient conditions in the range of 68-74°F approximately. Periodic examinations at the "microdetail" level of selected areas and observations on the degree of suppleness of the document by Don Etherington confirmed that the display mode conditions were quite suitable for conservation purposes. An interesting proof of the stable surface configuration was obtained by taking periodic raking light macro-photos of selected readily repeatable areas under precisely controlled light angles. This was carried out by James Stroud and the author, and verified that the document was dimensionally stable and was in a suitable "equilibrium" state.

Specialists Concerned and Acknowledgements: Ross Perot, Bette Perot, Merv Stauffer, Dallas, Texas; Dr. Nathan Stolow, Conservation Consultant; Don Etherington, Manuscript Conservator; James Stroud, Manuscript Conservator; Linda Brown, Assistant Archivist, and Norvell Jones and her conservation staff

members of the National Archives; Staples and Charles, Exhibition Designers, Washington, D.C.

C. The U.S. Bill of Rights (Virginia Version).

This parchment document is the original Virginia copy of the Bill of Rights, and was on loan by the Virginia State Library and Archives, Richmond, for the purpose of a 50 state national tour starting in Barre, Vermont, October 10, 1990, and ending in Richmond, Virginia, on the 200th anniversary of the U.S. Bill of Rights, December 15, 1991. The document is approximately 34" wide by 32" high (maximum dimensions). The preparation phase for the tour and the tour expenses themselves were underwritten by the Philip Morris Corporation. As Conservation Consultant, I was responsible for the design and construction of a climate controlled case to maintain constant R.H. levels, light protection, and to design as well a transportation container to travel the environmental module from state to state. The overall exhibition concept was designed by Associates and Ferren of Long Island, N.Y., who worked closely with me to ensure that my controlled climate case meshed in with the "high tech" devices used for the display mode. A special mobile track system was used underneath the public waiting rooms (above) to bring the document and its case by an elevating device into view. There were two such elevator shafts for viewing in alternate stations. The glazing at the viewing platforms was of bullet-proof 1 1/4" thick Lexan.

As can be imagined, a 50 state tour with up-to-date visual devices, video screens, posters, etc., involved a veritable army of staff and personnel ranging from technical and conservation experts to security personnel, and all sorts of installers and movers.

Prior to each state's public opening, the document was checked, as was the environmental monitoring system. This consisted of a Vaisala Hygrometer (R.H. and temperature sensors) hooked up to computers in an equipment trailer nearby. Readouts of R.H. and temperature could be ascertained in a variety of formats at any time (during and outside of exhibition hours).

Case Description and Condition Monitoring: Silica gel conditioned to 50-54% R.H. was used for maintaining the R.H. levels to an achievable range of 51-55% R.H. throughout the tour. The stainless steel case with 1/2" thick acrylic glazing was periodically purged with nitrogen gas to reduce the oxygen level to 1% or less. Pollution control devices were also utilized as described earlier in the Magna Carta project. The ambient temperatures were maintained by a separate air conditioning system keeping the exhibition case to within the range of 68-72$ F.

Periodic inspections of the document by myself, Don Etherington, and Dr. Manarin (of the Virginia State Library and Archives) confirmed the efficacy of the R.H. levels in maintaining the Bill of Rights parchment in a supple and relaxed state throughout the tour.

Comments: The Bill of Rights was adequately conserved and protected at the R.H. level of 51-55% R.H. with light levels controlled to 5 foot-candles. The constancy in dimension and configuration of the Bill of Rights was attributed to the controlled case environment.

Specialists Concerned and Acknowledgements: Dr. Louis Manarin, State Archivist, Virginia State Library and Archives; Dr. Nathan Stolow, Conservation Consultant; Bran Ferren, Associates and Ferren, Designers and Staff Engineers; Don Etherington, Manuscript and Book Conservator.

Also work credited in the following press releases:

* October 6, 1990: "200th Anniversary of the Bill of Rights. Preservation on Tour: Two Conservators and a Design Wizard Share Preservation Techniques for the Bill of Rights." Philip Morris Companies, Inc., New York, N.Y., 6 pp.

* April 24, 1985: "1297 Magna Carta on Loan to National Archives." National Archives, Washington, D.C., 2 pp.

References and Notes.

1. Hansen, E. F., S. N. Lee and H. Sobel. "The effects of relative humidity on some physical properties of modern vellum; implications for the optimum relative humidity for the display and storage of parchment." Journal of the American Institute for Conservation 31, no. 3 (1992): 325-342.

2. Irish Treasures Exhibition and Kells Books, etc., described in Stolow, Nathan, Conservation and Exhibitions, London: Butterworths, 1987, pp. 68-69, 205, 210-211.

3. Descriptions of my consultancy work on the Magna Carta and Bill of Rights projects were included in a paper given to the Virginia Conservation Association meeting in Richmond, VA, September 26, 1991: "Microclimate Case Technology for the Virginia Bill of Rights and for the Magna Carta."

TABLE I

MONITORING OF R.H. AND TEMPERATURES OF MAGNA CARTA IN CASE DISPLAY AT THE NATIONAL ARCHIVES (ROTUNDA) 1992-1994 (various intervals)

Date	Time	RH* %	T_1* °F	T_2** °C
3-19-92	2:15 p.m.	53	72.2	23.0
4-1-92	2:30 p.m.	52	68.5	21.0
4-13-92	8:17 a.m.	52	67.7	20.0
4-24-92	3:00 p.m.	52	68.5	21.0
5-1-92	12:30 p.m.	52	67.4	20.0
5-22-92	9:30 a.m.	52	67.6	20.0
7-8-92	12:30 p.m.	52	67.5	20.0
7-31-92	10:00 a.m.	52	67.5	20.0
8-25-92	9:00 a.m.	52	67.5	20.0
10-28-92	10:00 a.m.	52	67.5	20.0
11-1-92	8:30 a.m.	53	68.2	20.0
11-11-92	8:30 a.m.	52	68.3	22.0
11-14-92	8:30 a.m.	53	69.2	22.0
12-23-92	9:30 a.m.	53	68.2	22.0
1-13-93	8:45 a.m.	53	70.1	22.0
1-19-93	2:00 p.m.	53	70.3	23.0
1-22-93	11:00 a.m.	53	71.0	22.0
2-16-93	10:00 a.m.	53	70.8	23.0
3-12-93	10:00 a.m.	53	70.2	23.0
3-22-93	9:00 a.m.	53	70.4	22.0
4-23-93	9:00 a.m.	53	66.3	20.0
5-7-93	10:00 a.m.	53	66.6	20.0
5-11-93	10:30 a.m.	53	66.9	20.0
5-25-93	8:30 a.m.	53	67.5	20.0
6-9-93	8:30 a.m.	53	63.8	18.0
6-18-93	9:30 a.m.	53	68.7	22.0
6-24-93	8:30 a.m.	53	68.5	22.0
6-28-93	9:45 a.m.	53	68.6	22.0
6-30-93	11:30 a.m.	53	68.6	22.0
7-2-93	9:00 a.m.	53	68.5	22.0
8-27-93	9:00 a.m.	53	68.5	22.0
9-17-93	12:00 p.m.	52	68.4	22.0
9-20-93	9:30 a.m.	53	68.5	22.0
10-21-93	9:30 a.m.	53	68.6	21.0
11-8-93	9:30 a.m.	53	70.1	22.0
3-9-94	10:00 a.m.	53	67.7	21.0
4-7-94	9:30 a.m.	53	67.0	20.0

Table I
Monitoring of Magna Carta
R.H. and Temperatures
Page 2

Notes:

* R.H. (%) and temperatures (T_1, ^{o}F) measured from an electronic high quality Vaisala Hygrometer probe positioned under the Magna Carta document holding platform. The readout is from the meter component at the exterior back end of the display case. The R.H. readings are accurate to $\pm$ 2% R.H. units for this high quality hygrometer. The meter readings are rounded off to the nearest whole number (decimal fractions are not significant).

** The temperatures are taken from a small thermometer mounted on top of the display platform, next to the document (left side). Measurements are in ^{o}C for this thermometer.

TABLE II

R.H. AND TEMPERATURE RECORDS OF AMBIENT CONDITIONS IN ROTUNDA FROM THERMOHYGROGRAPH CHARTS 1993-1994 (various intervals)*

Week of:	R.H. Range (%)	Temp. Range (°F)
January 4, 1993	39-52	66-70
February 1, 1993	35-44	67-72
March 1, 1993	34-51	69-72
April 5, 1993	40-56	66-70
May 4, 1993	50-58	66-69
June 1, 1993	50-66	63-70
July 12, 1993	50-63	67-70
August 2, 1993	48-60	66-70
August 9, 1993	48-60	67-70
November 29, 1993	40-55	66-70
January 10, 1994	28-55	62-72
February 7, 1994	34-48	68-72
March 28, 1994	44-56	65-69

Notes:

* A selection of thermohygrograph chart records for the period (covering the seasons) from which the minimum and maximum readings were read and shown here as R.H. and temperature ranges.

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5/31/94
9th Edition