The Corning Flood:
MUSEUM UNDER WATER

Aerial view of the Corning Museum of Glass surrounded by flood water, June 23, 1972.

The Corning Flood:
MUSEUM UNDER WATER

The Corning Museum of Glass
Corning Glass Center
Corning, New York 14830

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Cover: Islamic Pilgrim flask with dissolved plaster restoration.

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Preface

On June 23, 1972, The Coming Museum of Glass was flooded to a level of five feet four inches above the floor, possibly the greatest single catastrophe borne by an American museum. The Agnes Flood broke hundreds of objects, saturated over half the Library (and all the rare books), ruined equipment, and covered galleries, cases, offices, furniture, and files with a thick layer of slime.

Thirty-nine days later, on August first, the Museum was reopened to the public, and four years later, in June of 1976, the Museum completed the task of restoring the glass collection and the Library. This book describes the restoration process and offers suggestions for disaster planning gleaned from experience. The scientific research which lay behind the restoration of the Library, in particular the research which led to the successful rehabilitation of books printed on coated papers through vacuum drying techniques, will be available in a separate publication.

The extent of the devastation suffered was matched by the help received. Among the first and most substantial help was that from the insurance broker, Mr. Huntington Block. His understanding attitude and faith in our professional abilities permitted us to get the restoration process underway. The claim, painstakingly prepared under Dr. Robert Brill's direction, was paid in full and has subsequently supported the Museum through restoration and much replacement of objects from the collections. Grants from the National Endowment of the Arts and The National Museums Act have improved the quality of the research/restoration process and enabled us to publish the results—this book is an example of the Endowment's support.

Literally hundreds of individuals came to help. From local children to eminent specialists from all over the world, people arrived at the Museum to do whatever they could—lugging silt-covered debris, hosing down furniture, sifting mud for fragments, making lists, taking inventory, washing, testing, diagnosing, wrapping, readying, repairing—the work went on day after day. They are too many to list here, but the Appendix lists what was recorded and is recalled.

Needless to say, most of the burden was borne by the staff and they responded, without exception, magnificently. The incumbents as of flood time are listed in the Appendix. In addition to Robert Brill who became Director after the flood and who designed and administered the restoration program, I would credit three others for their extraordinary efforts. First, Paul N. Perrot, who was director and who returned from the American Association of Museums annual meeting in Mexico City as soon as word reached him. Already on his way to an Assistant Secretaryship at the Smithsonian, he faced the apparent ruin of twenty years of his own work in building the Museum. He pitched in and saw us through the emergency phase, past the August opening and well on the road to restoration. The second is John Fox, Director of the Corning Glass Center and, therefore, the Museum's landlord. Taken by helicopter from the roof as the flood waters rose, he started planning restoration of the building and all its systems before the flood receded. His continuous attention to the Museum's myriad needs made the August reopening possible. The third to whom special acknowledgement is due is Raymond Errett, staff photographer and restorer. He was the first to reach the Museum after the flood despite the total loss of his own home. He became and remained a major strength in all critical matters during the entire emergency period. His judgment, his knowledge, and his manner provided the kind of leadership the Agnes aftermath demanded.

Thomas S. Buechner, *Director*
The Corning Museum of Glass
December 1976

Introduction

Introduction

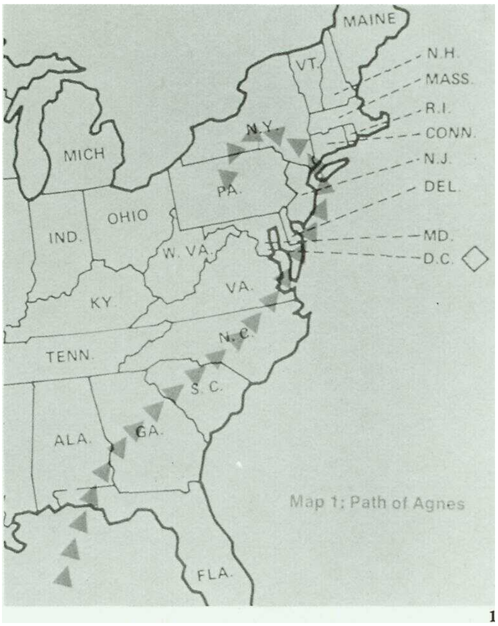
In June of 1972 The Corning Museum of Glass and its library were suddenly faced with catastrophe; without warning most of the priceless collection of approximately 13,000 objects and 13,000 books was submerged by flood waters, the aftereffects of a hurricane.

During the first part of that month, Hurricane Agnes had swept up the eastern seaboard but seemed scarcely a threat to a museum 275 miles from the Atlantic. At the beginning of the third week in June, Agnes (now designated a tropical storm) suddenly swerved inland and then paused for three days of continuous rainfall along the New York-Pennsylvania border in the western part of these states (Fig 1). One statistically-minded observer estimated that the amount of water which fell would have filled a container twenty-five miles long, one mile high, and one mile wide—more water than had ever fallen before in this inland area.

In the Coming-Painted Post area of western New York, three rivers join to form the Chemung River which bisects the city of Corning. On June 22nd the river, normally a placid one- to two-foot deep stream, stood about fifteen feet deep, well contained within its twenty-three and one-half foot dikes. Worried citizens who remained awake that night were assured by local officials on the radio at midnight that there was no danger.

At 5:00 a.m. on June 23rd, the river suddenly crested at twenty-seven to twenty-eight feet, topped the dikes, and poured into the town. (Fig. 2). The action of the current as it coursed over the dikes ate into the rear of the embankments (Fig. 3). Before long the dikes were badly breached in five places. The torrent which raged through the north side of town tore houses from their foundations, sweeping some downstream and scattering others in the valley. Water up to twenty feet deep raced over areas of the town. Without warning the city was split in half (Fig. 4). When flood waters also cut the approaches, Corning was effectively isolated from the rest of the world (Fig. 5).

The isolation was complete—suddenly the community was without electricity, natural gas, telephones, gasoline, drinking water, sewage disposal, or main highway access. On transistor radios townspeople could hear about the flood in Elmira, eighteen miles downstream, but it was impossible to learn of anything occurring in an area only a few blocks away. The next morning, miraculously, the river was back in its banks, but it was almost three weeks before all utilities were restored to most of the city.



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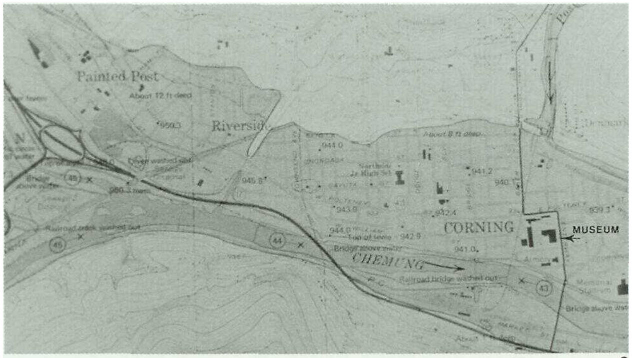

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Fig. 1. Path of Tropical Storm Agnes, June 1972.

Fig. 2. Area covered by floodwaters, June 23, 1972. Note location of The Corning Museum of Glass.

Fig. 3. Floodwaters from Post Creek and the Chemung River topping the dikes.

Unfortunately for the Corning collections, the Museum was situated in the middle of the disaster area (Fig. 6); water had surged fifteen to twenty feet above lower level on the west side of the Glass Center. Five hundred and twenty-eight of the approximately 13,000 objects in the glass collection sustained damage. Chapter I covers restoration of the glass collection; Chapter II is devoted to the devastation wreaked upon the library's holdings. Sixty-five hundred of the Library's 13,000 volumes and all of the rare books were underwater.

On that morning following the flood crest, there was no question as to how high the flood waters had risen: from outside the Museum the mud line on the east side was distinctly visible ten feet above the ground level on the once-white curtains. Within the building, the water line was clearly marked on the walls and exhibit cases, 5'4" above the floor (Fig. 7). A two-inch layer of slippery mud covered the floor and made walking hazardous; rugs were twisted in muddy heaps at random. So much mud obscured the cover glasses of the exhibit cases that it was impossible to see into the lower part of the cases to determine the extent of damage without a close examination of each case. Without electricity, many areas were concealed by gloom; leaden skies offered little hope of more light. Athwart the main gallery lay an eighteen foot long case, fallen from its upright position, lying face down in the mud. Within it had been seventeen delicate and extremely rare objects, made between the tenth and twelfth centuries in Iran, specially exhibited to commemorate the founding of the Persian Empire 2,500 years ago. There was no way to evaluate the damage done. The cover glass had obviously fallen out as the case tipped, for shards of the once-clear glass were found broken.

Groping through the darkened galleries a staff member found that one case containing an eighteenth-century crystal candelabrum from Ireland (Ace. No. 50. 2.23AB) was missing; it was later located sixty feet away in the Glass Center's Hall of Science where the case had floated, the candelabrum shattered from surging back and forth within it. An exhibit case from the pressed glass collection partially blocked the entrance to the contemporary glass gallery.


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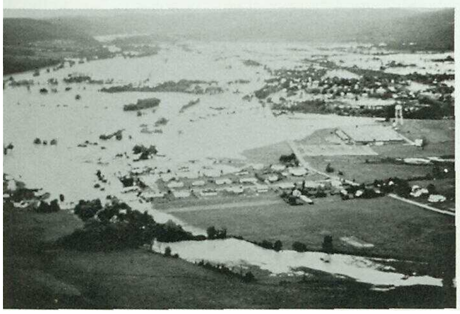
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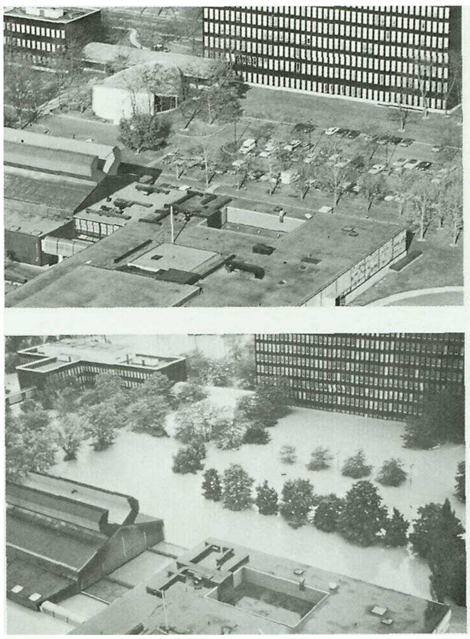
Fig. 4. Coming's Northside and Southside separated from one another at flood height.

Fig. 5. Eastern approach to the city closed by high water, isolating Corning and surrounding areas; Big Flats, New York, partially underwater in foreground.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6B

Fig. 6. Aerial view of The Corning Museum of Glass and Glass Center, (a) Normal conditions, (b) Inundated by floodwaters.

Introduction

The Museum offices were in chaos. Furniture had floated freely and come to rest on top of other furniture. Books and papers had been washed about the six offices and lay in mud-covered piles (Fig. 8). The swirling waters had pulled books and periodicals from their shelves, tossed them among glass objects, toppled a card catalogue, covered the files, and veneered everything below the 5'4" level with oleaginous mud.

The offices opened off the Museum's library, and the library itself was in total disarray. The card catalogue had been completely submerged; it eventually became so damaged by mold that it had to be discarded. The rare book case had tipped over, cascading six hundred volumes of ancient vellum and paper into the slime. Books with coated paper had expanded as they absorbed water, and the pressure had burst their cases, adding those volumes to the floor. Other books had expanded and locked themselves into place; their shelves had fallen but the books remained wedged in place. It would take crowbars to remove them. The Museum photographic collection, some 22,000 prints, and 22,000 negatives had been totally submerged; sixty percent of the 50,000 color slide collection had been under water.

Raymond Errett, the Museum restorer, and Thomas Buechner, the Museum's President, were the first on the scene that next morning; groping his way to the storeroom to obtain tools needed to open the cases, Mr. Errett encountered a large wooden storage cupboard that had fallen across the room; it had to be climbed to reach the keys to the cases and suction cups to remove cover glasses. Glass objects were scattered across the mud-laden floors, inviting further damage and making walking a difficult task, but the salvaging of the collection could begin.


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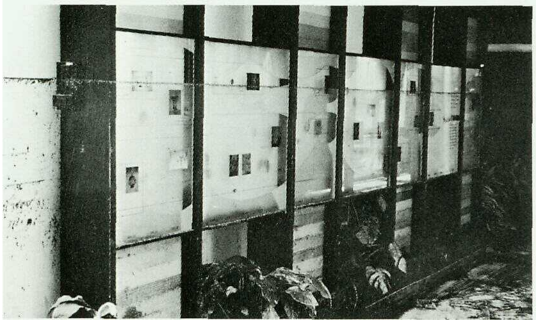
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Fig. 7. Flood level, building interior, (a) Mud line on curtains. (b) Line visible on wall.

Fig. 8. Museum offices, contents mud-covered.

Chapter I

The Restoration of the Glass Collection

Chapter I

The large case containing a temporary "Tribute to Persia" exhibition was obviously the first unit to be salvaged. It lay face down across a portion of the main gallery (Fig. 9), its front cover shattered; the pieces of glass in the mud around it could be part of either the cover glass to the case or of the seventeen ancient Islamic objects which had fallen with the case. Tools obtained with difficulty from the workroom were used to open the back of the case. Surprisingly, not all of the objects had broken; the buoyancy of the air in the case may have caused it to sink gradually while some of the objects were floating inside. Other pieces had been smashed and small fragments were picked up by the handful. Two objects were crushed between the front of the case and the floor (Fig. 10). All the mud from the case and the surrounding floor area was sieved with a tea strainer to recover all the shards necessary for the eventual restoration. (Strangely enough, months later, while one of the library books was being thawed before restoration, a missing piece of glass from an Islamic beaker (Ace. No. 63.1.10) was discovered within the book).

Some of the damaged objects in the Persian case may have been broken by small wooden pedestals on which the objects had stood and which had floated around within the case, moved by the currents of the flood water, eventually descending onto the objects as the water receded. Pieces under the case may have been further damaged when it was moved.

With the Persian case out of the way, and its fragments and objects stored in boxes for later sorting and restoration (pieces were kept with their objects; the inevitable box of "unidentified fragments" came into being later), attention was turned to the forty-foot long, six-foot high, and three-foot deep "Germanic Tradition" glass case. In contrast to the Persian case where pedestals had not been secured, the Germanic case consisted of a series of back lit shelf units with curved, translucent, plastic supports on which the objects had once rested and which could be hooked to any part of the back wall (Fig. 11). Since the boxes were hollow and light, they had risen with the water and their objects had slid off and floated down to the floor of the case. As the water receded, the boxes had either come to rest on top of the objects or had pinned them against the back walls or the front cover glass—a cover which had to be removed if the objects were to be rescued. In one case, the problem arose of trying to remove two pieces of glass pressing in two different directions; one piece was successfully removed, but its companion piece broke under the stresses upon it.

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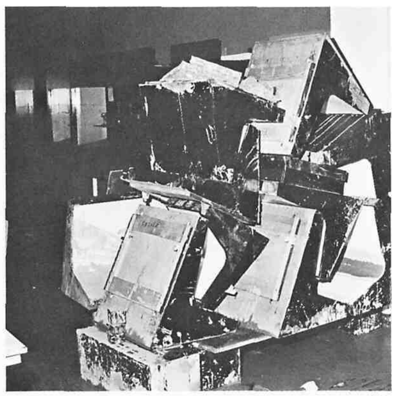
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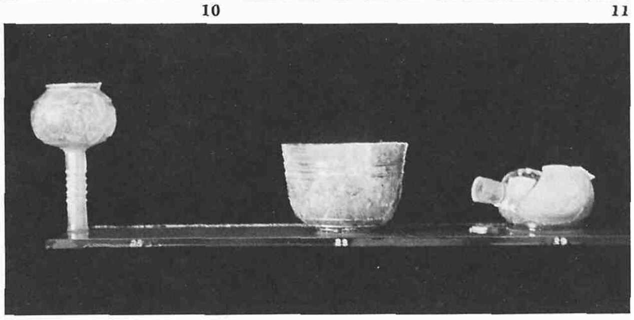
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Fig. 9. "Tribute to Persia" exhibit case, face down in mud.

Fig. 10. Fragments of two objects crushed between the front of the Persian case and the floor.

Fig. 11. Flooded curved translucent plastic supports after removal from Germanic Tradition case.

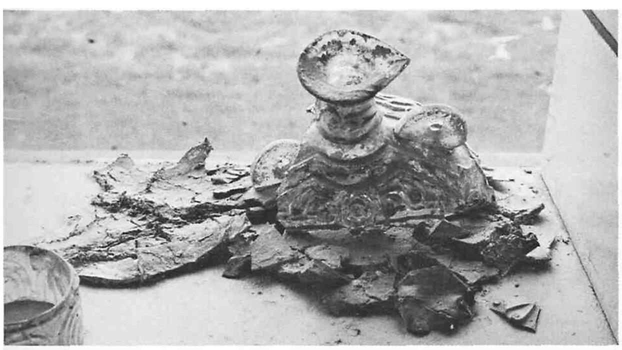
Fig. 12. Narrow-necked flask standing upside down, still full of water.

Damage in this case totaled approximately 30%, eleven out of thirty-six objects. The first obvious loss was a reverse painting on glass from which a section of paint had come loose. Double-walled and painted glasses were especially vulnerable to their watery exposure because they were held together by water-soluble substances. The lighter pieces had sustained much less damage than the heavier engraved pieces, perhaps because the lighter objects had floated on top of the water or had sunk more slowly.

Once empty, the massive Germanic exhibition case was used as a storage area to protect other damaged objects as they were found. All undamaged pieces were left in their original cases after they had been righted or emptied of standing water.

Cases of ancient glass in the East Gallery were opened next. The interiors resembled scrambled glass jigsaw puzzles. Some pieces were piled one on top of another; flasks or vases with large bodies and small necks were found standing upside down, still full of water (Fig. 12). Objects previously repaired before purchase with plaster of Paris or water soluble glues lay in heaps on the shelves or the floor of the cases (Fig. 13).

In the South and West Galleries (Fig. 14), the Venetian and American cases contained clear plastic shelves, secured to plastic backs. Although the doors were tightly fitted, the cases were not watertight (Fig. 15). Since the water had risen and receded slowly, damage was not extensive. Some objects were on the bottoms of the cases; others hung by a lip or were suspended, as if by a casual juggler, *between* the shelves. Many of the covered objects contained water beyond the rim, well up into the lids. It seemed impossible to open some of the cases without causing further damage, but careful handling prevailed. Fortunately, not a single object in the Museum is known to have been broken during the clean-up process or the months of restoration which followed.



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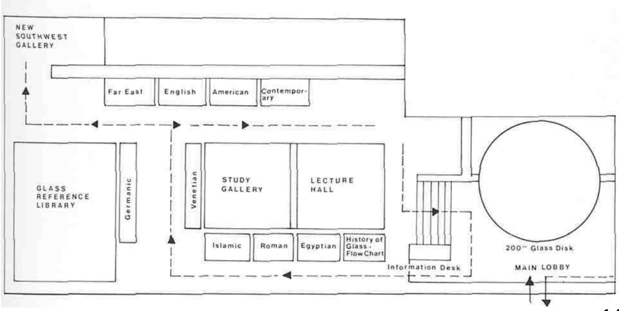

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Fig. 13. Islamic Pilgrim flask with dissolved plaster restoration.
Fig. 14. Floor plan, The Corning Museum of Glass, June 1972.
Fig. 15. Venetian case with plastic shelves.

Chapter I

As noted, there had been two large cases at the entrance of the West Gallery containing a pair of particularly fine late 18th-century Irish crystal candelabra (Acc. No. 50.2.23AB). Because of the darkness, no one had noticed at first that one of the cases was missing, having been floated or propelled the entire length of the gallery (sixty feet), and that the other case still on its original site appeared to be empty! A closer look revealed the ironic vagaries of the flood waters. The candelabrum had originally rested on a *3/4"* plywood false bottom base. The base had floated, dropped the candelabrum to the bottom, and, as the water level went down, the base returned to its original position—but now on top of the candelabrum (Fig. 16). The "disappearance" was complete; the damage to the hidden candelabrum was extensive.

The cases of English and French glass had to be opened from the top to retrieve objects resting on bases slanted toward the cover glass. Objects had either hit one another or had struck the cover glass, but damage was amazingly slight. On the other hand, a special exhibition of pressed glass was a victim of indiscriminate destruction. One of the cases was watertight, but had not been fastened to the floor. It had been pushed, or bobbed like a cork, down the gallery; its cover glass had broken and it had then fallen over, resulting in damage to every one of its objects.

The Study Gallery, an area forty by forty feet with shelves eleven feet high and containing seventy percent of the Museum collection, sustained remarkably little damage, considering the number of glass objects it housed, approximately 7,000 objects. The narrow shelves, six inches wide and three feet long, left little space for free-floating glass. Two shelves had collapsed after the water receded due to the weight of the water still standing in large objects. Because of the displacement of air by water, objects were sometimes piled three high and were leaning against the cover glass, making it difficult to reach the pieces since the cover glass had to be removed to get at the objects impinging upon it. Wire hooks were used to separate the components of such piles as the glass covers were carefully inched open (Fig. 17).

Two reverse paintings on glass (Acc. No. 53.3.32 and 66.6.1) which were damaged were sent to the noted Conservation of Historic and Artistic Works Center, Cooperstown Graduate Center in Cooperstown, New York. At that time the state of the art was not such that the paintings could be repaired. One whole painted surface of one of the reverse paintings (Acc. No. 53.3.32) had come loose and was in danger of crumbling as the paint had rolled back and could not be made to lie flat. In time, it was flattened and stored with acid-free cardboard holding it in place. Recent technical advances give hope that the paint can be re-adhered to its glass pane.

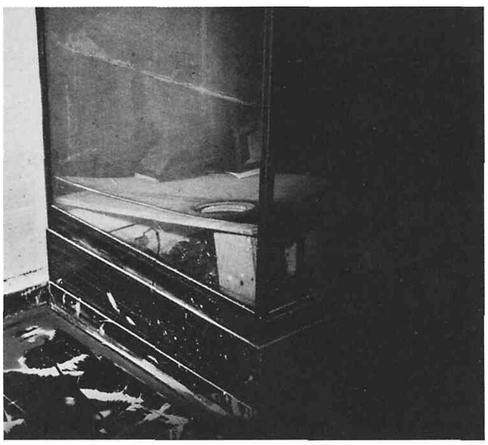

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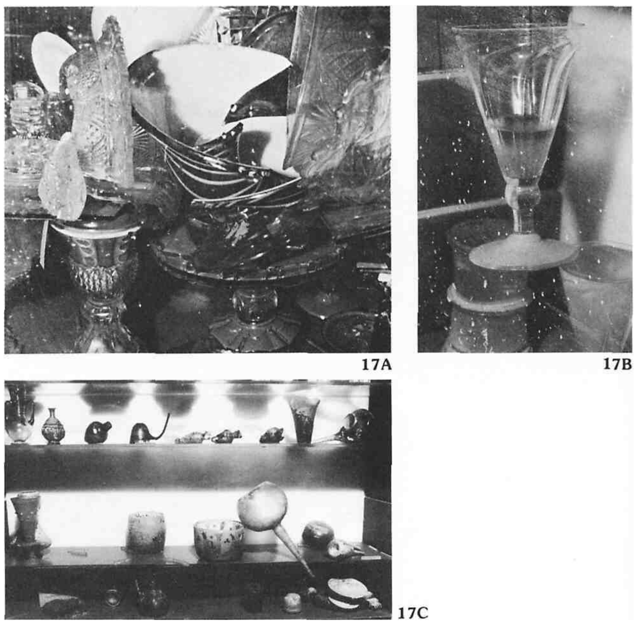
Fig. 16. Damaged Irish candelabrum beneath its false bottom.



17A 17B 17C

Fig. 17. Damage in the Study Gallery, (a) Collapsed shelf (b) Glass still filled with water, balanced on two other glasses. Objects leaning against the cover glass (c) (d)
(e) Filled German drinking vessels balanced against one another.

Once the cases in the galleries had been opened, the workroom and glass storage areas were the next concern. The open shelving in the storage area had permitted glass to move freely and consequently the damage was heavy. A large collection of American flasks had been spread on tables for study; the flasks were everywhere, and several were broken, unfortunately. Careful sifting, sorting, and examination of the mud for fragments as well as whole objects were essential.

As the cases were opened, an inventory was made. All cases were numbered, their contents listed; all were photographed. Within two weeks the inventory was complete. The problems of glass restoration accumulated and they were overwhelming. Lending urgency to restoration efforts was the decision to reopen The Corning Museum of Glass to the public on August 1, thirty-nine days after the disaster. Those surrounded by flood damage were not at all sure it could be done, only that it *would* be done.

Glass Statistics in June 1972

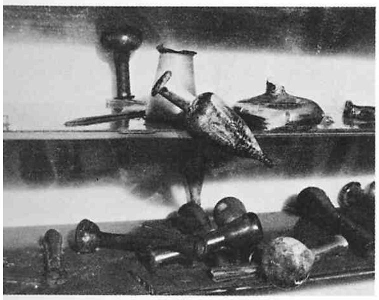
Total number of objects in the collection	13,000
Total number of damaged objects in the collection	(4%) 528
Objects requiring restoration	481
Objects not to be restored	38*
Objects to be restored eventually if suitable methods can be found	9

**Either more economical to replace than restore or damage too extensive to permit restoration.*

Distribution of losses according to categories:

Ancient	34%
English	12%
European	36%
American	15%
Other	3%

Help came from many areas. Volunteers were eager to do anything asked of them (Fig. 18); a contingent arrived from Rochester: Holman J. Swinney, Director, Strong Museum, Rochester, and volunteers Deborah Bacon. Peter Briggs, Jean Farnham, Peter Hotra, Lynda McCurdy, Robin and Sandra Stone; W. Stephen Thomas, Director of Development and Public Affairs, Rochester Museum and Science Center, and volunteers Karen Bennett, Lilita Berg, George Hamell, Robert Martin to wash with care all the objects still intact in the Study Gallery. Others came from Toledo: Michael Moss, Assistant Curator, The Toledo Museum, Toledo, Ohio, and Karen Smith; Drew Oliver from the Brooklyn Museum, New York; from Ontario, Barbara Snider of Upper Canada Village; and Newark: Susan and Ron Auth, Curator and Archaeologist at the Newark Museum, to help. A temporary repair shop was established in one corner of a former supermarket directly across the street from the Museum. Dubbed "the Acme Building" in honor of its former tenants, the restoration area became the center of the painstaking, deliberate program to reopen the Museum by August 1, 1972, with as many of its prized objects on exhibit as possible. Repair of the Venetian dragon-



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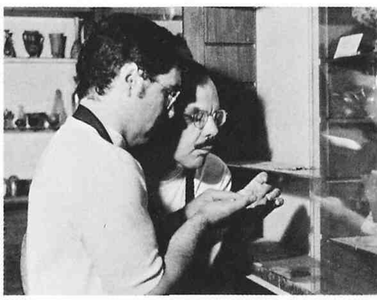

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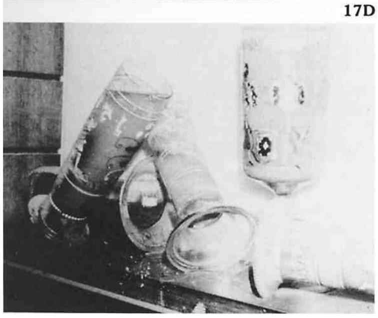


18C

Fig. 18. Volunteers (a) In the Study Gallery (b) Washing flooded objects (c) Younger volunteers pause before the next task.

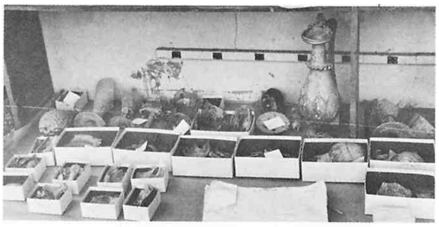
stem goblet (Acc. No. 51.3.115) was first on the priority list; it had long been a symbol of the Museum's collection, and was to become the symbol of its recovery. The first goal, an August opening, was met, and by the autumn of 1976, all of the glass restoration was complete.

As with all specialists, a glass conservator must possess a very special feeling for the material with which he or she works. It was, therefore, even more heartbreaking to survey what had to be done. Five hundred and twenty-eight objects were damaged, and four hundred and eighty-one were listed for repair or restoration. It was estimated that three years would be needed to complete the task, including time for photography, report writing, and general laboratory support activities. The initial step was for the restorer to handle each piece and attempt to determine how much bench time would be needed to repair or restore it. All of the fragments of each individual object were placed in a box marked with its accession number (Fig. 19). The extent of the damage to each piece could then be analyzed.

A professional restorer, Rolf Wihr, came from the Rheinisches Landesmuseum in Trier, Germany, for a month to repair specific pieces requiring his particular expertise. His wife Dorothea accompanied him and helped in many ways (Fig. 20). The former Master Restorer at the Metropolitan Museum of Art, W E. Rowe, was called from retirement for a year to utilize his vast knowledge in restoring sixty-one of Coming's flood-damaged objects.

Albert Fehrenbacher, a German model maker, refurbished a hand-carved model of a nineteenth-century glass factory, and then began the seemingly impossible task of transforming glass bits and pieces to their former appearance as altarpieces or other intricate compositions of the lampworker's art. Several students worked for periods varying from three months to six months: Lynda Aussenberg, New York University Conservation Center of the Institute of Fine Arts, New York, New York, Summer 1973; William Warmus, University of Chicago, Summer 1972, 1973, 1974; Steven Weintraub, New York University Conservation Center of the Institute of Fine Arts, New York, New York, six months, 1974. Each had some special skill to contribute. Two apprentices, Jeffrey Gaines, December 1973-July 1974, and Kristin Amy-Ion, June 1974-June 1975, also helped reach the goal of complete flood restoration by the end of 1976.

It was the Museum's curators with their intimate knowledge of the collection who decided what could be replaced and what had to be restored. A blue Sasanian ewer had been smashed into innumerable fragments (Acc. No. 65.1.23), but it was irreplaceable and important. It was the task of the conservator to restore what could not be replaced. The result has been a methodical program of repairing flood damage as well as improving past restoration practices. Many older adhesives had simply dissolved during their watery contacts; pieces repaired with plaster of Paris before purchase by the Museum had fallen apart. The first list of single objects to be repaired was quickly revised,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21A


21B

Fig. 19. Fragments classified for damage appraisal.

Fig. 20. Dorothea Wihr assisting the glass conservator.

Fig. 21. Cleaning broken glass surfaces with ammonia, (a) (b)

since it was found to be more useful to restore all the pieces in one exhibit case before those in the next case were begun. An object was photographed, cleaned, and assembled temporarily with tape; if it lacked a fragment, it was set aside until the missing pieces of the puzzle reappeared.

The enormity of the task was obvious, but the work which began after the flood followed the patterns established by glass conservators, disaster or not. The only special and unfamiliar problems posed by the flood-damaged objects were those of cleaning. Flood or no flood, glass repair and restoration involve problems of simple breaks, complex breaks, and objects with missing pieces. A survey of traditional techniques may be helpful before a review of specific flood-related problems is made.

Careful evaluation is required before any work is begun. The nature of the damage, the inherent strength or fragility of the glass and its decoration, the historical value of the object, and the desired final effect all must be considered. Repairs, too, range, from the simple to the complex.

To repair a break with two or three detached pieces, the broken surfaces are first swabbed with ammonia (Fig. 21), followed by acetone to remove all foreign matter. An even dispersal of ammonia is a good indication that the adhesive will disperse uniformly. Educated and sensitive fingertips are necessary to insure a proper fit. One can "feel" when the glass pieces are correctly seated before the pieces are taped together. With a fine spatula, an epoxy resin is applied to both surfaces in extremely thin layers to achieve a close joint. Excess resin is removed before it begins to harden.

The proper adhesive must be chosen. To add strength, a permanent epoxy resin is usually used at Corning instead of less permanent adhesives. A less permanent adhesive may eventually loosen, and an object may fall apart on its shelf or in someone's hands, causing further damage to the object or to any nearby object. Araldite AY103 has been used successfully in Europe for years and at The Corning Museum of Glass since 1965. It has the same refractive index as most glasses when applied in thin layers.

For objects with complex breaks, it is even more necessary to assemble the entire piece with tape. Scotch Magic Tape is flexible and adheres well. It is usually applied to the side without any decoration or design, always on one side only. Again with a fine spatula, a low-viscosity adhesive is then run into the cracks on the untaped side. The fluid resin seeps into the cracks and fills each void. Excess resin is carefully removed, for even a slight shift could introduce air bubbles, weaken the joint, and distort original shape. As the adhesive sets, whether the objects have either simple or complex breaks, they are either self-supporting or are supported by the tape, a sand table, or various laboratory stands.

Cone-shaped or narrow-necked objects present special problems. If both sides are not readily accessible, the object can be cut apart at a convenient spot to facilitate inside access and put back together with tape to assure proper seating before the adhesive begins to set. After the adhesive has set, the two halves can still be separated for cleaning and further restoration.

The Corning Museum of Glass restoration policy is to return an object as much as possible to a semblance of the original so it can be appreciated for what it was. Integrity of form, color, and decorative effect are important factors. Restoration is based on the unequivocal evidence which remains and the anticipated degree of stability.

There is no attempt to duplicate engraving, enameling or any other conjectural stylistic feature. Restoration is never carried to a stage where it would be deceptive or misleading. Restored features should not detract from the overall appearance of the object, but should become visible to the careful observer. Detailed restoration sheets are kept and filed eventually in object folders along with other information concerning the object.

If a small area of glass is to be restored, impressions from another part of the object are used to make a mold from dental wax coated with polyvinyl alcohol (to prevent resin from sticking to the wax and absorbing any of its color) and then transferred to the section to be restored. A small opening is left as a pouring spout. Plastogen G is frequently used at Corning; it is a colorless transparent polyester resin which cures at room temperature in approximately twenty minutes. If the impression is accurate and properly filled with the appropriate resin, the wax can be removed easily and the replica is complete after removal of the spout. Acetone is never used for surface cleaning of Plastogen G because of its tendency to attack the restored area. Technovit 4004a is another useful resin because of its low shrinkage, apparent mechanical and color stability, and rapid setting time. Color can be imparted in both of these resins by adding textile dyes before casting. Both transparent and opaque colors are possible.

Restoration of an object with many missing pieces may be much more complicated. All fragments must be assembled; the exact shape and size of the original object must be established. The existing curves of a bowl, for example, may be used to extrapolate the broken curves. A template can sometimes be made to turn the desired shape on a wheel. With the pieces in their proper position, restoration can begin.

A clay model of the exterior of the missing part is covered with a thin coat of silicone rubber thickened with Cab-O-Sil to the consistency of cake frosting. The silicone is then covered with a layer of plaster to give strength and to help retain the shape. The clay silicone-rubber procedure is repeated when the object is turned over for work on the inside, with the clay the same thickness as the glass. Before the silicone rubber is applied inside the bowl, a clay pouring spout is attached and possible air traps are eliminated by adding clay sprues to release the air. Sprues must be very small in diameter in case they have to be removed. Plaster is added to the inside, sometimes with a handle for easy removal; the handle may be made of wire or may be a large wooden screw embedded in the plaster.

After the plaster and silicone in the inside are removed, the clay is carefully detached and the mold cleaned, leaving the glass in place. Pouring spout and sprues are cleaned before the silicone and plaster mold is carefully sealed in place with a small amount of uncured silicone rubber to prevent leakage. The mold is then filled with resin, preferably in the morning in case of a leak. All resins used must be compatible with the silicone. Once the resin has cured, the plaster and silicone may be removed and restoration is complete.

The Corning Museum of Glass flood restoration has covered what must surely be the full range of glass restoration and utilization of every conceivable technique. Specific examples are described and listed in Appendix IV.

Any discussion of glass restoration techniques should include the inevitable list of miscellaneous advice based on years of experience and the practices of a particular museum. The Corning Museum of Glass is no exception. Its brief list follows;

- Handle every object as though it were broken and would fall apart in the hand. It may have been cracked or repaired previously, leaving it in an unstable condition.
- Always glue in the morning so that an object may be watched all day in case it slips, slides, shifts, moves.
- Make certain that the adhesive does not remove any part of the design. Gilt, for example, must be handled with special care; it detaches very easily.
- Do not allow resins or adhesives to come in contact with any objects with crizzled surfaces because the surfaces will absorb adhesives and resins, removal will be impossible, and the composition of the surface will be permanently altered.
- Be as consistent as possible in mixing resins. Both object and adhesive should be warmed to approximately 100° F. and temperature maintained until cured.
- Do not attempt to hide restoration, although it should not be overwhelming. Paint changes color in different lights; dyes are difficult to eradicate. No attempt is made to eliminate weathering at Corning Museum of Glass.

Today's Corning Museum of Glass visitor will find no obvious effects of the flood or its damage. All of the objects incomparable for their historical importance or for their beauty have been returned to their assigned places in the galleries. Meticulous repair and restoration have not only preserved the collection, but in many instances corrected earlier restoration practices.

Those who ask what would happen if *another* disaster occurred receive a ready answer. Everyone at the Museum now has a handbook listing detailed emergency procedures in case of fire, flood, tornado, smoke, power failure, or vandalism. No glass would be removed from the building. Those pieces most likely to be damaged by water would be placed in boxes and moved to an office on the highest level of the building. Test evacuations are held periodically. Greatest flood damage was caused by floating plywood pedestals and boxes; all are now anchored.

No magic wand will solve problems precipitated by a disaster. People determined to do what must be done are the most important resource. There is no substitute for the glass conservator who surveys the violation of years of glass history and of his own efforts to preserve that history, and begins immediately to put everything back together again.

Chapter II

The Restoration of the Library

Chapter II

Few visitors to The Corning Museum of Glass realize that for the past quarter of a century the Museum has been developing the library of record on the art, archaelogy, and history of glass. With the exception of information on the current scientific, technical, and manufacturing aspects, the Museum library acquires all published books and periodicals issued about glass and allied areas. The collection also includes original source material such as trade catalogues, archives, documents, pamphlets, prints, photographs, slides, as well as supporting material—movie films and printed ephemera. In addition, the Museum exhanges printed matter with countries world-wide and publishes its own books and catalogues.

Such diversity compounded the range of the restoration problems confronted after the flood; these can best be understood by a listing of the collection and its post-flood condition:

Pre-Flood *Collection*	*Number of Flood Damaged Items*
13,000 catalogued volumes	6,500 volumes
600 rare books	600 rare books
3,750 periodicals	3,111 periodicals
50,300 slides	36,400 slides
22,270 photographs	22,035 photographs
2,252 prints	2,032 prints
20,000 negatives	20,000 negatives
100 films	65 films
3 drawers documents	3 drawers documents
4 drawers vertical file	4 drawers vertical file
80 linear feet archives	72 linear feet archives
office files	office files

The devastation which the flood waters had wreaked upon this collection was perhaps even greater than that suffered by the glass collection. On the morning of June 23, 1972, muddy water had swirled through the offices and library to a depth of five feet, four inches. As noted previously, wet books had expanded and bent the sides of the stacks so that they bulged into a "V" shape (Fig. 22). These books were so tightly wedged into the bookcases that crowbars had to be used to dislodge them. Other shelves, suddenly sprung free from the sides of the misshapen stacks, had dumped their volumes into the mud and water (Fig. 23). The rare book and manuscript collection, shelved separately, had fallen into the slime as bookcases overturned.

During the first attempts at salvage, librarians Norma Jenkins and Jinny Wright remembered hearing a lecture by noted conservator Carolyn Horton who recommended freezing water-damaged books. She had written an article for the Wilson *Library Journal* on the restoration of flood-damaged volumes after the Florence flood, and that article, fortunately, was not flooded. It was decided to follow her suggestion to freeze the books. However, all utilities were knocked out, and without electricity there were no working freezers. Transportation and supplies were non-existent, not to mention the lack of running water for cleaning mud from books. Through the assistance of the Corning Glass Works, community volunteers, and local merchants, supplies were obtained to begin the

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24A

24B

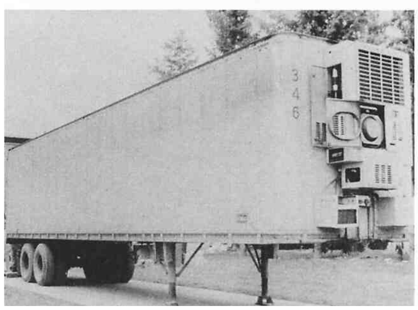

Fig. 22. Shelves expanded to V-shape.

Fig. 23. Books, periodicals on the floor.

Fig. 24. Flooded Special Collection removed from the mud for storage in the freezer, (a) (b)

Fig. 25. (a) Freezer truck parked at Museum side door.

job of saving the Museum library. Bill Warmus, a summer intern, found an empty home freezer in Hornby, outside the flooded area; another was located in Big Flats. Glass Works emergency radio transmitters were used to find a truck trailer which could freeze materials as they were loaded into it.

Although it was cool for June, it was still raining, and mold would soon develop on the books. Rescue efforts were thus concentrated at first on the valuable Special Collections which consist of medieval manuscripts, incunabula, and rare materials. These damaged volumes were picked out of the mud (Fig. 24), and wrapped in paper towels for ease of handling (because of their slimy covers), to absorb moisture, and to separate volumes from one another when they were finally frozen. Had the books been wrapped in plastic, which unfortunately was unavailable, they would have been easier to separate later—and the books would have been removed in a state of damp equilibrium. (It was discovered later that books with coated paper—i.e., paper finished by applying gelatin, starch, casein or some other substance to produce a glossy surface—which had partially dried had suffered irreparable damage.) Within a matter of days these books were boxed, packed in dry ice, and flown by private jet to Carolyn Norton's laboratory for evaluation and eventual restoration. The rest of the collection was loaded onto the freezer truck parked outside the Museum doors (Fig. 25). At first, packing was done in an orderly fashion, but the urgency to freeze material before mold developed eventually led to packing the volumes without labels or organization. Five days were spent boxing the damaged collection of approximately 10,000 books, along with pamphlets, research files, catalogues, and Museum office files. By the time the last volumes were placed in boxes, the first mold had begun to appear on some of the books.

Items which were beyond repair or those which were of current or ephemeral nature were discarded. This included part of the periodical collection—in the misguided expectation that it would be relatively easy to replace. The librarians later realized that *everything* should have been frozen so that decisions to save or discard could have been made more rationally at a less urgent time.

The card catalogue was abandoned, for example. It was muddy and tightly wedged into a warped and broken wooden case. Its loss was a great deterrent to the effective use of the rehabilitated library; had it been frozen, it could have been dried and cleaned by the conservation staff. The shelf list, which was equally muddy, was dried in a staff member's garage (Fig. 26). Photocopies made of the cockled cards became the basis for restoration efforts and for insurance claims which required months to assemble. The accession notebooks were also salvaged, which made it possible to ascertain purchase prices of most of the flooded materials.

25B

25C

Fig. 25. (b) Collecting material to be boxed for truck, (c) Sealing boxes of books to be frozen.

26A

26B

26C

Fig. 26. Shelf List retrieval, (a) (b) (c)

Chapter II

With the books frozen, the library staff turned to non-book holdings. Corning Community College, located on a hill above the flood plain, cleared the main and an auxiliary reading room of its library to provide a place to work, a place to begin the restoration process, and a space to store the 6,500 undamaged books in the collection (Fig. 27). A temporary library office was organized in one corner of this restoration area (Fig. 28).

The saturated art print collection (Fig. 29) and the original document collection (Fig. 30) had not been frozen and were taken to the college library. Working with meticulous care, volunteers separated the frail papers, opened picture frames to remove the prints, and blotted the excess water. Carolyn Horton and her assistant, Madeline Braun, traveled to Corning with a station wagon full of blank newsprint and canteens of fresh water; both were used to save these unique study resources.

The slide and photographic collections (over 72,000 items) were considered next. The photographic negatives were frozen as they were freed from their flood-swollen files. The mounted prints (approximately 11,000 items), which had begun to form a solid mass by the time they were extricated from the Museum, were immersed in a private swimming pool where it was possible to separate them and remove most of the mud (Fig. 31). Unfortunately, the chemicals in the pool adversely affected the emulsion and they had to be destroyed. Following professional advice, volunteers worked on the color slide collection (36,400 damaged items) at the college library. Seven thousand slides were removed from their aluminium and glass mounts, individually washed in rain water which had been collected (there was no water service for three weeks) (Fig. 32), and hung on lines to dry. Paper clips were used to keep the film, the mount, and its label together for future identification (Fig. 33). Despite this effort, it was decided later that the photographic images had become so degraded by the water and mud that the flooded slide collection had to be discarded. Rephotographing to return the collection to its 1972 status may cover a ten-year period.

Of the approximately 11,000 unmounted glossy photographs which were frozen after the flood, about 6,500 prints were cleaned successfully, while 4,000 photographs, not frozen until four days after the flood, were too damaged by mold. Some frozen 4" x 5" and 8" x 10" color transparencies and color negatives were also successfully restored. The worst damage sustained by these photographic resources, however, was not due to mud and mold but was caused by the wet glassine envelopes in which they were stored. The cockling of these envelopes combined with the water-softened surfaces of the film to produce a rippling texture on the picture surface. Those photographs filed in Kraft paper envelopes escaped such damage. The photographic collection is now stored in acid-free paper envelopes which do not cockle.

Once the holdings within the Museum were in process of restoration, attention was turned to material in storage warehouses. The wisdom of freezing the

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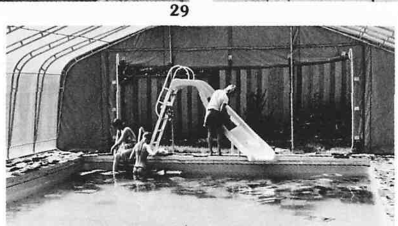

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Fig. 27. Improvised shelving for relocated volumes in the college Library,
Fig. 28. Librarians at work in temporary office,

Fig. 29. Print collection spread on floor to dry.
Fig. 30. Part of the document collection.
Fig.30. Separation of prints from mounts in a swimming pool, the only available source of water.

wetted paper immediately became evident, since the damaged back issues of periodicals in storage were ruined beyond repair. As the stored back issues of Museum publications could not be saved either, the frozen library copies gained greater importance.

On August 1, 1972, thirty-nine days after the disaster, the Museum reopened its doors and welcomed the public. In late August when the college needed its library for student use, the Museum library moved into a former supermarket across the street from the Museum (Fig. 34). The frozen collections were brought together in a rented freezer-trailer outside the building. That autumn was spent in further reorganization and in preparing the insurance claim. This latter task became an eighteen-month project. More time had been involved in the initial steps to conserve the collections and to re-organize than had been anticipated.

It was not until February, seven months after the flood, that work could begin on book restoration. The supermarket was divided into work areas for Museum storage, glass restoration, the undamaged library collections, staff work space, and a paper (book) conservation area. Sinks, drain boards, tables, a fume hood, and a refrigerator-freezer were acquired. Two special pieces of equipment were added: a dielectric dryer was borrowed from the Corning Glass Works Research Laboratory, and a fumigation chamber (later modified to sterilize as well) was purchased. It was now possible to set up a restoration assembly line.

Financial problems as well as problems of restoration had to be solved concurrently. Until there was an insurance settlement, it would be necessary to borrow against the regular operating budget to support the restoration project. Clearly this could endanger the regular operation of the Museum. But until the restoration project began, it would be impossible to estimate either the time such restoration would take or its eventual cost. Without such figures there could be no settlement with the insurance company to obtain the money needed to undertake restoration. The decision was made to spend beyond the budget, and book restoration proceeded concurrently with learning how to estimate the cost of restoration for the insurance claim.

Carolyn Horton was asked to restore one hundred of the finest rare books which had already been shipped to her in a frozen state. While those books were receiving out-of-house professional care, it was decided to restore the rest of the special collection in-house. An experienced paper conservator and a physical scientist were hired, the latter funded by a grant from the National Museum Act. Together they developed techniques for safe restoration of the collection. A staff of local adults was employed for the actual restoration work using traditional conservation methods. The scientist was commissioned not only to assist the paper conservator but to develop, apply, and test new or unorthodox techniques to help reduce restoration time and to bring about as complete a restoration of the collections as possible.


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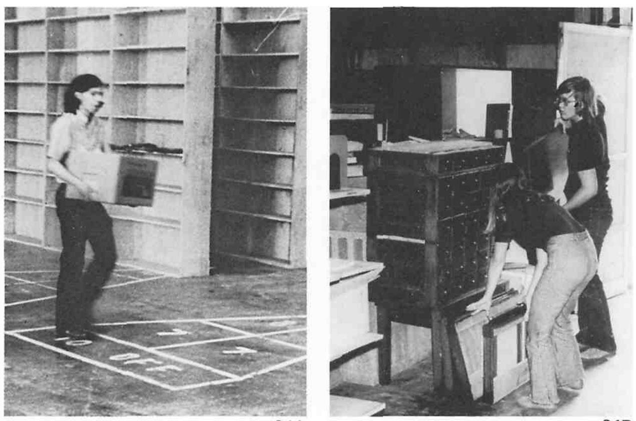
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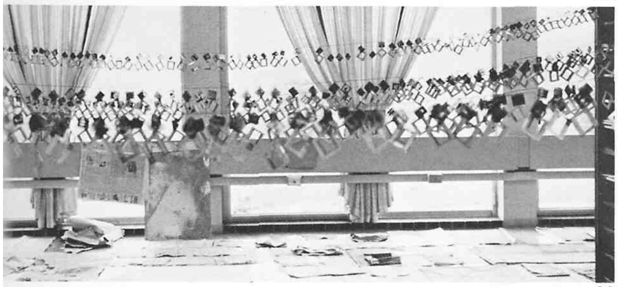
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Fig. 32. Careful removal of slides from mounts and hand washing.

Fig. 33. Drying 35mm slides.

Fig. 34. Conversion of supermarket and former recreation area to library/conservation/restoration center. (a) (b)

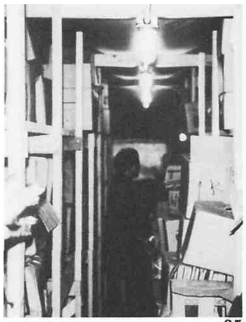
Chapter II

The freezer truck-trailer was a continuing problem. It was overcrowded and disorganized, an obstacle to any assembly line (Fig. 35); its refrigeration unit was unreliable. During one brief failure, the temperature within the truck rose to 30° F. Mold could have developed and damaged the books if the problem had not been resolved quickly (Fig. 36). Two large walk-in freezers were therefore purchased and erected within the restoration building. These cost no more than two years' rent for the truck, and at the end of the project, resale returned half of the original cost. The new freezers had a row of shelves against the outside walls and a third double range of shelves in the center, so a logical organization and more efficient handling of materials was now possible.

Individual treatment of every book would have been a task of five years or more. There was not the time, money, or staff for a job of such magnitude, so a goal of Christmas 1975 was set for completion of the project. Accordingly, a number of decisions were reached.

It was agreed that all volumes from the regular collection which could be purchased for less than fifty dollars per volume would automatically be discarded, a proposal endorsed by the insurance companies. The underwriters concurred that it would cost at least as much—and probably more—to restore the individual volumes. It was also decided to discard the periodical collection if replacement copies were readily available. Either these could be replaced through purchase (second-hand), or a reprint could be purchased in microform. (The Kraus Company, a reprint and second-hand magazine firm in New York, was most generous in helping in this area, and they deserve credit for their assistance. Swetsand Zeitlinger, Periodical Agents at Berwyn, Pennsylvania, were equally generous in offering to evaluate the periodical collection without fee so that a settlement could be reached with the insurance companies.) If journals could not be purchased, the librarians planned to obtain permission to microfilm journals in other libraries.

The accessions librarian began soliciting catalogues from book dealers throughout the world so that out-of-print volumes could be ordered as they appeared. Two staff members went to New York City to buy in the second-hand market. Foreign language book dealers were also commissioned to assist in the search, since forty-seven percent of the collection is in languages other than English.



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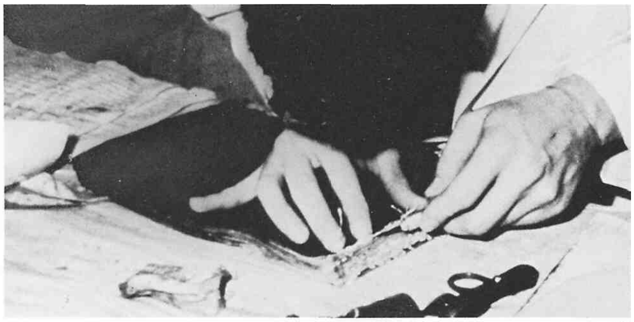

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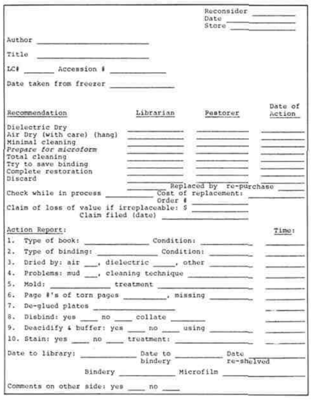

Reconsider ________
Date ________
Store ________

Author ________

Title ________

LC# ____ Accession # ________

Date taken from freezer ________

Recommendation	Librarian	Restorer	Date of Action
Dielectric Dry	____	____	____
Air Dry (with care) (hang)	____	____	____
Minimal cleaning	____	____	____
Prepare for microform	____	____	____
Total cleaning	____	____	____
Try to save binding	____	____	____
Complete restoration	____	____	____
Discard	____	____	____

Replaced by re-purchase ____

Check while in process ________ Cost of replacement: ________

Order # ________

Claim of loss of value if irreplaceable: $ ________

Claim filed (date) ________

Action Report: Time:

1. Type of book: ________ Condition: ________ ____
2. Type of binding: ________ Condition: ________ ____
3. Dried by: air ___, dielectric ____, other ________ ____
4. Problems: mud ___, cleaning technique ________ ____
5. Mold: ________ treatment ________ ____
6. Page #'s of torn pages ________, missing ________ ____
7. De-glued plates ________ ____
8. Disbind: yes ____ no ____ collate ________ ____
9. Deacidify & buffer: yes ____ no ____ using ________ ____
10. Stain: yes ____ no ____ treatment: ________ ____

Date to library: ________ Date to bindery ________ Date re-shelved ________

Bindery ________ Microfilm ________

Comments on other side: yes ____ no ____

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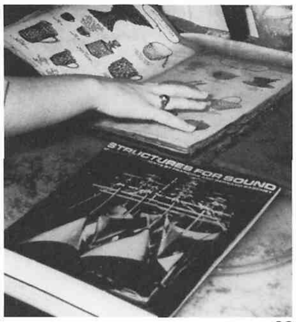

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Fig. 35. Congested freezer truck-trailer interior.
Fig. 36. Checking for signs of mold.
Fig. 37. Sample worksheet.
Fig. 38. Thawing a frozen book.
Fig. 39. Cutting threads on book binding.

It soon became obvious that no more than fifteen to twenty percent of the collection could be purchased in the market since the items were so specialized; thus up to eighty-five percent would have to be restored.

In sorting and preparing to move books into the walk-in freezers, every volume had been examined. The condition and value to the collection were recorded on a worksheet in multiple copies (Fig. 37), one for the librarians, one for the conservator, and one to remain with the book. As a book came out of the freezer, the conservator checked the sheet for the librarian's considered judgement: simply to "clean and dry," or whether to restore and by what method. He had a choice of traditional methods and, eventually, new methods. Some books were held for future decision, as it was hoped they could eventually be found on the open market. If their replacements were not found before the restoration process neared its end, they would be restored as well.

The use of the two types of restoration—by methods traditional or innovative—represented a major policy decision in order to complete the task within the allotted time. As a result, the collection was divided into two parts, with the more rare books being treated in accordance with established procedure, and other volumes—those of more informational than intrinsic value—receiving innovative handling. Three approaches were used:

1. *Traditional Techniques.* Volumes of intrinsic value in their original condition were thawed (Fig. 38), removed from their bindings (Fig. 39), separated into signatures and then into pages. These pages were supported on sheets of non-woven polyester and washed in water (Fig. 40). Running tap water baths removed most of the tenacious mud, water sprays removed still more, while physical agitation with a camel hair brush removed almost all the rest (Fig. 41) but left a stain where the mud had been. Bleaching could significantly reduce staining, but it weakened fibers and thus was not used. The pages were then deacidified and buffered by a thirty-minute immersion in a magnesium carbonate solution, a simple, inexpensive, and effective treatment. They were then air-dried on tables or on nylon fishline drying racks (Fig. 42).

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40B

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Fig. 40. Separated pages on support sheets, (a) (b)

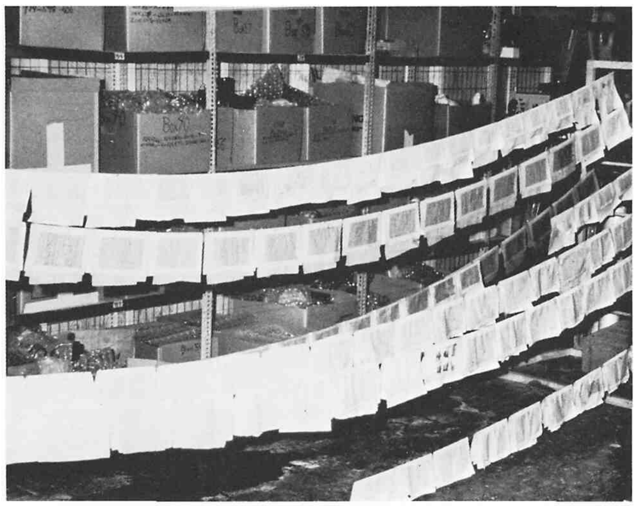

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Fig. 41. Use of camel hair brush to remove mud.

Fig. 42. Deacidified, buffered pages on support sheets drying on nylon fishline racks.

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Pages were collated, sterilized in the vacuum-chamber fumigator with a mixture of 12% ethylene oxide and 88% freon, and wrapped in permalife paper with acid-free board for storage until they could be microfilmed (Fig. 43). If necessary, distorted books were pressed between weights to return them to near-original shape. Each packaged book had its work-sheet with the complete history of its restoration attached to the paper wrapping.

2. *Dielectric Drying.* A dielectric dryer was obtained from the Corning Glass Works. This device is about as large as a refrigerator with a chamber approximately eight inches by twenty inches (Fig. 44). Inside are two electrode plates between which a frozen volume can be placed. A burst of electrical energy is sent through the frozen book to begin thawing it. It was soon discovered that the covers should be removed from all books being treated, for they contained much water (Fig. 45); it was also found that unremoved staples or paper clips caused arcing between the electrodes, charring or burning the books.

By trial and error, the duration and the number of electrical bursts necessary to dry the varous kinds and sizes of books were determined, and like items were grouped to simplify the task.

Valuable books were only thawed, not dried, by the dielectric method and made ready for traditional handling. It was not known if permanent damage was being done to the paper with the electrical burst (e.g., permaturely aging it). In addition, all dried papers and books were sterilized in a vacuum fumigation chamber in order to prevent further spore growth, a continuing problem, as all flooded material is likely to harbor mold spores.

3. *Freeze-thaw Vacuum Drying.* Much thought was given to freeze-thaw vacuum drying, but it was decided that the technique was not then practical. To begin with, there were no vacuum chambers nearby, and most units were too small to handle materials in the amount on hand. It was feared that books with coated paper might "block" into a solid mass in the drying process. Many books with plates were printed on coated paper, paper which tends to become a solid mass after wetting and exposure to air.

Last, and of considerable concern, was the realization that vacuum drying might break down paper structure and would not remove the mud or stains on the papers. It would probably be necessary to rewash all such dried volumes, and it might be impossible to eradicate all the flood stains. Nonetheless, some medieval parchment manuscripts were sent to the Library of Congress for experimental freeze-drying, since their vellum leaves presented other problems which might respond to that treatment.

Microwave drying was also tried, but it was not satisfactory. Since only domestic microwave ovens were available, the experiment was dropped as being non-conclusive. Experiments in the use of ultrasonic cleaning and drying (a technique successfully used in cleaning pieces of glass in the collection) were tried


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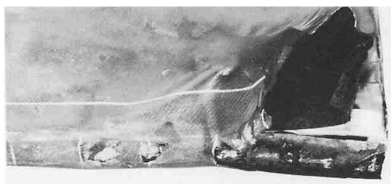
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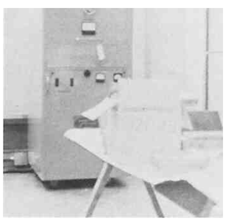

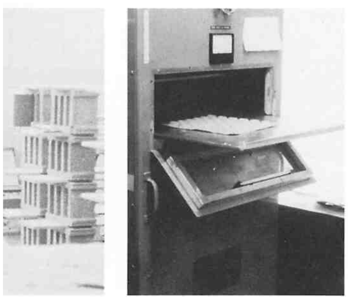
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46A

Fig. 43. Restored books being wrapped for storage.

Fig. 44. (a) Dielectric dryer (left), (b) Dielectric chamber.

Fig. 45. Charred book cover after first Dielectric burst.

Fig. 46. (a) Truck unloading frozen Corning Museum of Glass library books at Valley Forge.

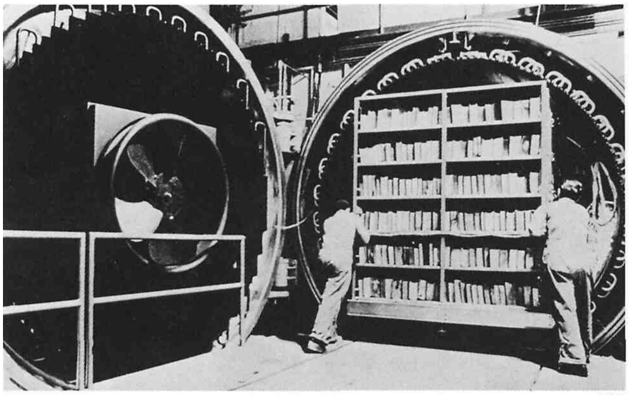
also. Other experiments of a limited nature were also made with solvent extraction techniques but were only a qualified success.

Within the first year, 3,000 books and thirty boxes of files had been dried, cleaned, and readied for microfilming by traditional methods. By this time, the scientist had established the behavior of coated paper (see Chapter V) discovering how and why it turned into a solid mass after wetting and then drying. Based on his experiments, approximately 3,500 frozen volumes (primarily of coated paper) were taken by refrigerator truck to Valley Forge, Pennsylvania, to the General Electric "space chamber" to be thawed and vacuum dried (Fig. 46).

After nine days of treatment, ninety-five percent of the coated stock (2,850 volumes) was saved. This was the first time, to the librarians' knowledge, that such a success rate has been achieved. The five percent loss may be attributed to books being partially dried before they were sent to the vacuum chamber; some may have blocked on the library shelves while waiting to be frozen; others may have lost water through sublimation in the freezer. In view of the freeze-drying problems of the Temple University Law Library, following its disastrous fire in July 1972, it is important to stress the need to monitor the freeze-drying process. If books are not completely dry when they come out of the freeze-dry chamber, they must be returned for further drying or else they must be air-dried. Some one hundred and twenty-five damp books were carefully hand-dried on their return to the Museum Library (Fig. 47). All the dried but still cockled and dirty books were cleaned during the next eight months by erasing the flood dirt with draftsmen's dry-cleaning pads and camel hair brush (Fig. 48). In December, 1974, the book restoration department closed, twelve months ahead of schedule. Almost 6,000 books were dry and clean, and thirty cartons of files were also dry. Most of the art prints, photographs, audio tapes, and sound films were restored to usefulness as well.

The last phase of restoration then began—the microfilming of the flooded library collection (Fig. 49). Duplicate copies of the film were turned into microfiche format. This was done for a number of reasons:

1) To preserve the information in the restored books in the event that they disintegrate prematurely.
2) To insure the collection against another catastrophe; one master copy was stored outside the valley, and a second copy was kept in microfiche form for use in the library.
3) To provide information to out-of-area researchers and to decrease physical handling in interlibrary loan of rare or one-of-a-kind volumes.



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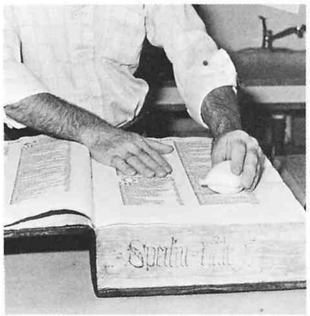

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Fig. 46. (b) Books being moved into General Electric space chamber.

Fig. 47. Air-drying damp books after return from vacuum drying.

Fig. 48. (a) Flood mud removed by dry cleaning pad.
(b) Removal of eraser crumbs with camel hair brush.

4) To make holdings of the library available to specific libraries in the United States and abroad in exchange for the privilege of microfilming unobtainable items in their collections. Due regard to copyright laws is observed in all cases.

The three-and-a-half year period after the flood was difficult for the library staff, which continued to support all the diverse Museum activities and at the same time to be involved in a monumental salvage and restoration undertaking. Museum personnel have taught conservation seminars so that others might learn about their techniques, and the Museum has published this book in the paradoxical hope that it will prove useful—but never have to be used.

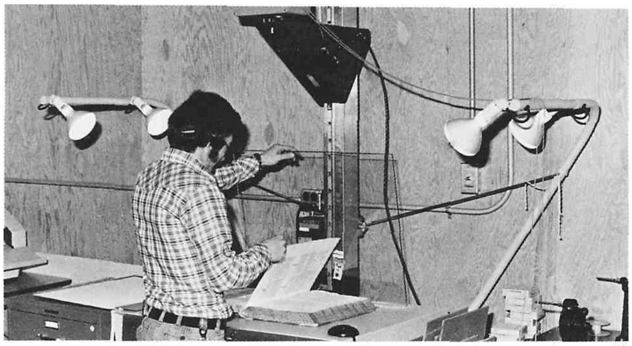

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Fig. 49. Microfilming a restored volume.

Chapter III

The Restoration of the Photographic and Audio Tape Collection

Chapter III

Perhaps the greatest single loss to the Museum collections occurred in the photographic department (see page 22 for the listing of this collection). Although massive efforts were made by staff members and volunteers in the week after the flood, much of the collection could not be restored to the professionally usable state required by the Museum.

As has been indicated previously, those films, negatives, photographs, and slides which were inadvertently sent to the freezer were in the long run salvaged with far less loss. Freezing halted any organic growth on the photographic materials and at the same time provided the needed suspension of time until these materials could be worked on and then dried by the vacuum drying techniques to be discussed elsewhere.

If the photographic materials had been wet by clean water and then frozen immediately, further restoration might not have been necessary after vacuum drying. When discoloration by dirt or other foreign matter occurred, these additional restoration steps followed:

1) Thawing only the number that could be handled in one day
2) Washing in clean water from the emulsion side with a soft sponge
3) Placing prints in a print flattening solution followed by a Photo Flo® solution and drying on a drum drier (Fig. 50)
4) Photographs with flaking, loosening emulsion

Placement in *Kodak Hardener F-5a for less than five minutes soak.*

600 cc	Water, about 50° C
75.0 grams	Sodium Sulfite, desiccated
235 cc	23% Acetic acid
37.5 grams	Boric Acid crystals
75.0 grams	Potassium Alum

Cold water added to make 1.0 liter

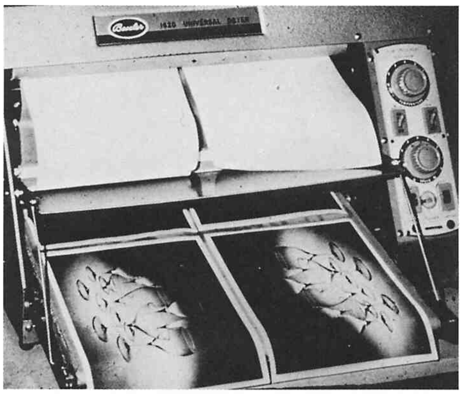
Kodak Special Hardener SH-1

500 cc	Water
10 cc	37% Formaldehyde by weight
6 grams	Sodium Carbonate, monohydrated

Water added to make 1 liter

15 to 30 minutes wash in running water
Placement in blotter roll or between blotters

If the damage to photographic materials is not extensive or if the damaged materials are few in number, they can be treated in-house in the following manner:



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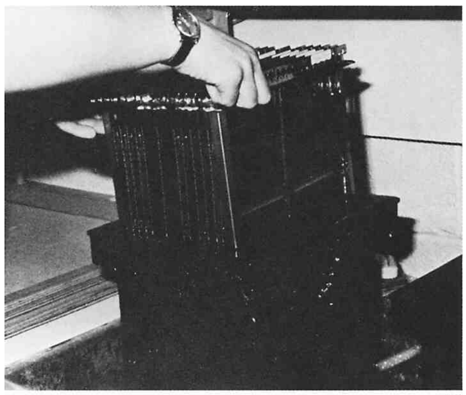

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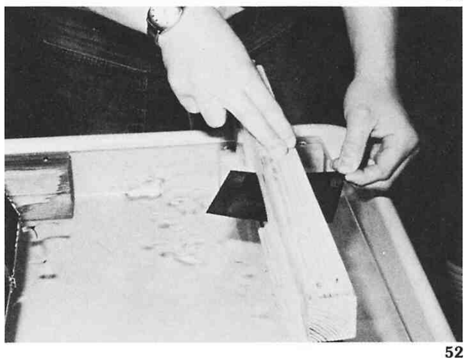

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Fig. 50. Restored photographic prints dried on a drum dryer.

Fig. 51. Transparencies being immersed in Photo Flo® solution.

Fig. 52. Transparency pulled gently through sponge rollers.

Preservation of Slides

1) Remove slides from original containers, retaining as much identification as possible. Place them in solution "A"—10 grams magnesium sulfate, 10 mis of 37% formalin per liter.
2) Following storage in solution "A," disassemble mounts. Gently clean slides with camel hair brush using solution "B"—10 grams sodium carbonate, 10 mis of dequest 2006, and 10 mis of 37% formalin per liter.
3) Soak Ektachrome films in a regular Ektachrome stabilizer solution.
4) Rinse slides in solution "C"—standard final rinse in Photo Flo® solution.
5) Air dry slide, emulsion up, on a paper towel lined tray. Do not remove film from the mount.

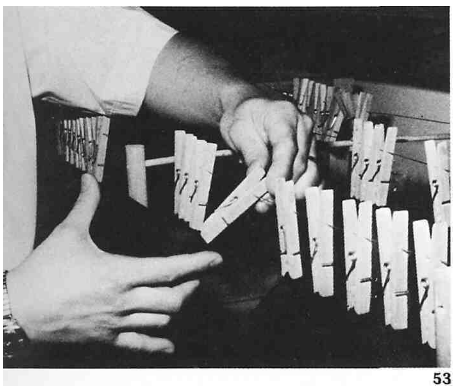
Glass Mounted Slides

1) Following storage in solution "A," separate film from glass if emulsion does not strip. Clean with camel hair brush in solution "B." Dip in solution "C" and air dry, emulsion up, on cloth lined trays, keeping mount and film together. If possible, save the glass in a separate container. Ektachrome films require a stabilizer soak.
2) If emulsion adheres to the glass, soak further in solution "B" before final cleaning and drying.

Color transparencies

1) Remove transparencies from their sleeves and place in stainless steel processing holders. Two 8 x 10 processing tanks are needed for water baths,—one tank for Photo Flo® solution, one tank for hardener solution.
2) Immerse transparencies in holders in the first water bath for approximately five minutes to remove all surface dirt.
3) Immerse transparencies in 2% Photo Flo® solution for five minutes (Fig. 51) with agitation to swell the gelatin and release residues. The gelatin is extremely soft during this step. Care should be exercised.*
4) Return transparencies to first water bath, this time with running water and wash for about five minutes.
5) Place in hardener solution tank (Kodak SH-I Special Hardener for about five minutes. Remove excess with soft sponge (Fig. 52). Line dry (Fig. 53). Fig. 54 shows two prints made from successfully restored transparencies.

"In extreme cases *only,* a 15% solution of sodium carbonate will swell the gelatin even more and remove all stubborn residues.



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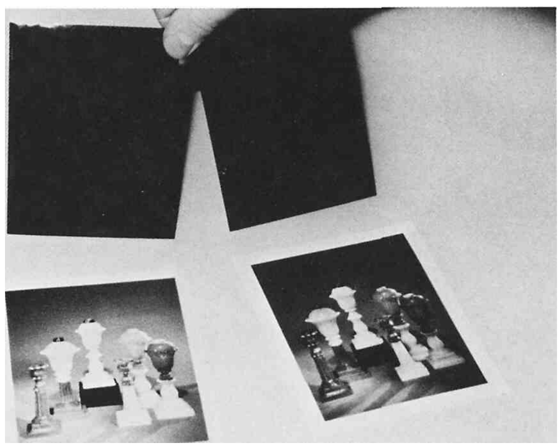


Fig. 53. Transparencies hung to dry.

Fig. 54. Results of successful restoration—color prints made from restored transparencies.

Movie Films

1) Remove film on reels from cans and store in Solution "A." Retain identification if possible.
2) Reprocess in white light.
   - Feed on rollers without emulsion contact.
   - Start the film in a prehardener solution followed by solution "B."
   - Run through a spray rack if possible.
   - Depending on trial experience, invert film and buff emulsion side.
   - Complete processing; take up dry film on cores.
   - Reassemble on reels.

Audio tapes which were damaged were more of a problem than photographic materials. Mud could be eliminated from the tape with ordinary tape cleaning, but the differential stretching of the tape's acetate base made playback extremely difficult. Most of the recordings were interviews of historical value to the Museum library. The material was transferred from reels to cassettes using a three head, four track reel-to-reel recorder.

By monitoring, it was found that applying slight manual pressure to the pads holding the tape against the heads would eliminate the periodic dropouts caused by tape warpage. Although this increased the background noise level, it did result in a very usable audible recording. The use of filters and dolby circuitry could reduce this problem.

ChapterIV

Fumigation and Sterilization of Flood-Contaminated Library, Office, Photographic, and Archival Materials

Chapter IV

As the flood waters receded on June 24, 1972, a layer of mud was deposited on the Museum's library collection, archives, slide and film collections, and office files. Because the mud contained microbial contaminants, as well as eggs from various insects, all of the flood-damaged materials except the glass objects were frozen to preserve them from attack by these biological species. This freezing action also permitted the Museum's staff to consider restoration plans specifically designed for each of the damaged items.

Even though some of the Museum holdings were not directly in contact with the flood waters, all became contaminated during subsequent removal from the Museum and transfer to temporary storage areas. Since the humidity and temperature were not controlled in these storage areas, there was serious concern about the possibility of biological growth in the materials. A random check of the storage area, books in the collection, and correspondence in the office files substantiated that this concern was real. Insect, fungal, and bacterial growth were found. Starch, casein, and cellulosic materials, constituents of paper formulation, are utilized by some of these species.

Approach to Fumigation and Sterilization of Contaminated Books

As restoration planning evolved, concern for the stored, non-frozen contaminated materials increased. The use of insecticides was considered initially; the suggestion was eliminated after discussions were held with several groups of paper conservators since they felt that such compounds might leave residual halogens in the paper. Such halogens ultimately contribute to an acidic environment which in turn accelerates aging of the paper.

The need to treat biological contamination necessitated the search for and purchase of appropriate equipment. To minimize capital expenditures, the need for a quick delivery, and the fact that only a small amount of space was available, a modified Vacudyne Document Fumigator (VDF) was selected. It was manufactured with an extra large vacuum pump and had heating elements installed in its side walls. The unit was purchased (Vacudyne, Altair, Chicago Heights, Illinois) to establish conditions for the kill of insects and mold, not necessarily as a sterilizer for the kill of bacteria. Since ethylene oxide could be used in its chamber, it was hoped to modify its normal operating sequence to develop a sterilizing treatment for the books. Ethylene oxide, when used under the proper conditions, is not only a fumigant but also an effective sterilizing agent. It is used extensively by the pharmaceutical industry to sterilize various plastics and bandages.

Fumigating for destruction of book worms, silverfish, moth, larvae, mold, and fungal contaminants proceeds under milder conditions than those required for killing the bacteriological contaminants. It was necessary to sterilize all of the Museum's books to eliminate subsequent damage due to biological growth or transfer of contaminants by users to other books as well as to the users themselves. The following experimental approach was developed: In order to obtain the maximum amount of information on the quality of sterilization with the least efforts, attention was focused primarily on identifying conditions for kill of what was believed to be one of the most resistant bacterial species. After being procured, this species was to be placed in the center of closed books, the location most difficult for gas penetration. If process conditions could be identified for kill at this location, it could be assumed that all other, less resistant forms of biological life would also be killed. Time and money could be saved by not conducting the latter experiments. A survey of the Museum's problems confirmed the fact that mold and bacterial growth were even more of a threat than insect growth.

Experimental Considerations

Fumigation

The initial effectiveness of the VDF was determined by conducting a series of experiments which varied the amount of air being evacuated before the ethylene oxide mixture was allowed to enter, the time of exposure, and the temperature of application to the books. The dimensions of the chamber in the fumigator were 1.2 by 0.92 by 0.46 meters. A normal library cart with three shelves could be moved in and out of the chamber. When these shelves were stacked with books, approximately two thirds of the volume inside the chamber was filled by the books and cart. After loading the chamber and closing the door, a pre-selected program-evacuation of air, injection of gas for treatment, evacuation of gas, and back-filling with air was begun.

Ethylene oxide at a composition of 12% by weight with UCON Refrigerant 12 (Oxyfume-12, Union Carbide Corporation) is non-flammable and can be used safely in a closed system. Effectiveness of this commercial mixture depends on the amount of ethylene oxide present, temperature of its application, time of exposure, and the relative humidity in the chamber.

Microbiological Tests and Controls

Because *Bacillus subtilis* is a rugged, resistant microbiological species, spore strips (Castle Company, Rochester, New York) of this bacteria were chosen for study. The investigation was supplemented by use of additional biological samples involving actual pages from badly damaged books; colonies of mold and bacteria had been allowed to mature intentionally for use in subsequent experimentation. Later in this report, these samples which were placed inside books are described as muddy-moldy pages. Cultures of *Escheria coli and Aspergillus sp. were* also included in the experiments.

Positioning of Biological Test Samples

Initially spore strips and sections of muddy-moldy pages were placed inside closed books. All samples were held at the center of the page with pressure sensitive tape. When kill was not observed, the samples were attached to a page in the book which was set on its bottom edge and partially opened during treatment.

During final experimentation, when better conditions for kill were identified, special attention was given to the positioning of biological samples. They were attached to pages in the center of books which were then placed between two 1.27 cm Plexiglas plates. Four C-clamps, one placed at each corner of the plates, were tightened with equivalent torque, 4.0 Kg cm, to insure the uniform application of pressure to each book. This amount of torque was chosen to duplicate the pressure exerted on books when they are tightly packed on a shelf. Five different locations on the cart (Fig. 1) were used for the books containing biological samples.

In petri dishes placed on top of books packed on the cart, Trypticase soy agar and Sabouraud's agar were streaked with *E. Coli and Aspergillus sp.* respectively and then exposed to ethylene oxide for four hours. These samples were used for a special part of the second series of experiments.

Microbiological Media

Trypticase soy broth (liquid), and trypticase soy agar for bacteria, and Sabouraud's agar for fungi were used as media. Although the agar media are indentical and nutritionally comparable to the liquid media, the agar was added as a solidifying agent for cultivation of bacteria or fungi on a semi-solid surface.

Culturing of Test and Control Samples

Both control and treated spore strip samples were cultured at 37° C in trypticase soy broth for forty-eight hours to determine kill. Swab samples, taken from sections of the surface of the muddy-moldy pages before and after exposure to ethylene oxide, were placed in one ml of 0.001 M phosphate buffered saline solution at pH 7.0, for plating on appropriate media. These samples were taken from a 6.45 square centimeter section.

To determine the effect of adding moisture to dried contaminated pages, one ml of phosphate buffered saline solution at pH 7.0 was added to a section of each of several muddy-moldy pages before treatment with ethylene oxide. Swabs were taken from these selected areas before and after the gaseous treatment. Duplicate plates were made of all samples.

Process Conditions for Ethylene Oxide

Exposure to ethylene oxide was 4, 6.5, and 15 hours duration. To keep the relative humidity at the necessary percent, water vapor was added to the chamber of the VDF.

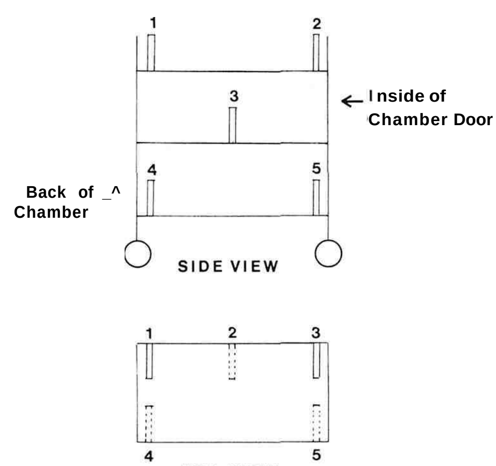


Fig. 1. Location of books containing biological samples on cart. Scale: 1 foot = % inch (9.5 mm).

Chapter IV

Exposure of the books to ethylene oxide occurred at either room temperature or at an elevated temperature. The maximum temperature in the chamber in the latter case was approximately 40° C. Figure 2 documents, during a 6.5 hour treatment, the temperature changes of the gas in the chamber after closing the chamber door. Thermocouples were placed at similar locations both inside and outside of books on the cart. A maximum difference of 11°C was recorded upon entry of the gas into the chamber between a pair of these thermocouples positioned on the bottom shelf (see Fig. 1, position 4). The difference was reduced to one degree after eight minutes of exposure.

A comparable discrepancy was observed for the extreme in the chamber's gas temperature after entry of ethylene oxide. The temperature measurements were made between the gas occupying the volume adjacent to the gas inlet, located at the bottom and rear of the chamber, and the volume in the center of the chamber. The disparity in temperature was reduced to almost four degrees after seven minutes of exposure.

The evacuation level and the volume of the books and cart in the chamber controlled the amount of ethylene oxide present in the chamber. The first series of tests was made when the air pressure in the chamber attained a value of 15 inches of Hg. At this pressure a selenoid valve was opened to release the ethylene oxide mixture. Gas continued to enter until a pressure of one inch of Hg was attained; then the valve was shut. When the second and third series of experiments were conducted, evacuation in excess of twenty-eight inches of Hg took place before the selenoid valve was opened for entry of the ethylene oxide to the chamber. After the desired exposure time had elapsed, the chamber was evacuated to this pressure again and then filled with air before it was opened.

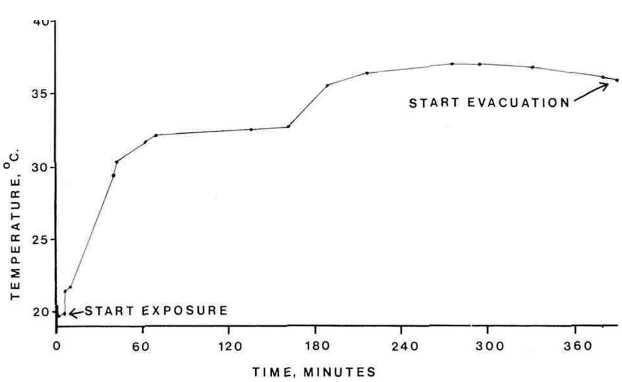


Fig. 2. Sterilization gas temperature during exposure; thermocouple in center of chamber.

Experimental Results and Discussion

Series I

The initial series of experiments was conducted with placement of the spore strips inside closed books at five different locations on the cart with exposure for four and fifteen hours at room temperature. The limit of the evacuation pressure was set at fifteen inches of Hg. Approximately fifty books were positioned on the cart, occupying about two thirds of the volume inside the chamber, None of the spores was killed by these treatments. Furthermore, when the chamber was opened, Oxyfume-12 could be detected. These two results suggested that (1) an increase in the total amount of ethylene oxide was required to facilitate kill and (2) a modification of the VDF program should be made so that gas left after the treatment of the books could be removed before the chamber door was opened. One change in the VDF program satisfied both needs. The level of evacuation was adjusted to a pressure of twenty-eight inches of Hg before ethylene oxide entered the chamber and before the chamber was back-filled with air.

Series II

In this series of experiments both spore strips and muddy-moldy pages were used, some placed in books which were partially opened and set on their bottom edges while they were being treated. Moisture was added to some sections of the completely dried contaminated pages.

The results listed in Table I show that spores of *B. subtilis* were not killed in the fifteen hours when located inside closed books. When a book was left partially open to permit ready access of ethylene oxide, kill of all spores was achieved.

The results described in Table II suggest that a necessary minimum of moisture encouraged kill of fungi and bacteria at short exposure times; kill was observed on the moistened muddy-moldy pages put in the petri dishes on top of the books within four hours. If the pages were dry, a fifteen hour exposure time was required for kill of these same species. The latter findings, involving exposure to muddy-moldy pages taped to pages in partially opened books, supported the data noted in Table I for similar exposure and kill of spores.

An additional experiment (see Table III) used streaks of moist vegetative cells of bacteria and moist fungal species placed on nutrients in petri dishes. Again only four hours of treatment at room temperature were required to kill these moist species. Similar dehydrated forms (see Table II), present on dry muddy-moldy pages, required fifteen hours of exposure. The necessary moisture content as well as its location were critical. The presence of water at a site other than biological could produce a reaction with ethylene oxide which would eliminate its chance to sterilize.

Series III

During these tests, conditions comparable to the second series were maintained except that the chamber was heated. It is obvious from a review of Table IV that 6.5 hours of exposure are sufficient to cause kill of spores in the most tightly packed books. There was a high percentage of kill of bacteria and fungi on the muddy-moldy pages (Table V) placed in the same books and treated at the same time, but the kill was not total. These facts imply that longer exposure times are required for complete kill when contamination is excessive, mud is present, and the surface of the page is dry. Complete kill was obtained when a fifteen hour (Table V) exposure was applied to muddy-moldy pages with populations of contamination comparable to those treated during the 6.5 hour exposure at the same elevated temperature.

During the Series II experiments, ATI Sterilization Indicator Tapes, #00180 (Aseptic-Thermo Indicator Company, North Hollywood, California), were mounted beside all spore strips and muddy-moldy pages placed in the books used for the 6.5 and 15 hour treatments. The color change from yellow to dark blue, indicating that sterilization conditions were met, was found in each case. These tapes provided a convenient approach to determine the general quality of the sterilization environment. They could not guarantee micro-environmental sterilization when excessive growth had left biological debris or when mud had been deposited. Such factors may control reactions with ethylene oxide or limit its diffusion to the active biological site.

Summary

Sterilization of spore strips and muddy-moldy pages in books treated at room temperature was accomplished in fifteen hours when the books were set on their edges and left partially open.

The importance of sufficient moisture is obvious from the results of treating the muddy-moldy page for four hours after being dampened, as well as the treatment of the active cultures of *Escherica coli* and *Aspergillus sp.* streaked on moist nutrient in petri dishes. A convenient practical way to insure the supply of the necessary amount of moisture to each biological site on each page still needs to be developed.

If library books which had not been exposed to muddy water or had not experienced excessive bacterial and fungal growth are involved, a 6.5 hour treatment under the conditions listed in Series III is sufficient to sterilize even tightly closed books.

Treatment of the most seriously contaminated books (muddy-moldy pages) required an excess of 6.5 and less than 15 hours of processing when the conditions outlined in the Series III investigations were met.

The use of the higher vacuum, allowing a greater amount of ethylene oxide to enter the chamber, facilitated kill of the biological species. After treatment and back-filling with air, traces of gas were not detected upon opening the chamber door at the end of the sterilization sequence.

The results from the above investigations with books have led to the successful application of this process for sterilizing the library holdings, archives, office files, and film and photographic prints of The Corning Museum of Glass.

TABLE I—TREATMENT OF SPORE STRIPS, ROOM TEMPERATURE

Treatment Time, Hours	*Number of Individual Samples**	*Location of Spore Strips*	*Results after incubation*	
			*unexposed strip***	*exposed strip*
4	5	Inside Closed Books	+	+
15	5	Inside Closed Books	+	+
15	5	Inserted Inside Partially Opened Books, Standing on Edge	+	–

* one at each position noted in Fig. 1
** + = Growth
  - = No Growth

TABLE II-TREATMENT OF MUDDY-MOLDY PAGES, ROOM TEMPERATURE

Treatment Time, Hours	*Number of Individual Samples*	*Location Of Sample*	*Counts of Bacteria & Fungi per 6.45 cm^2*			
			Bacteria		*Fungi*	
			Before	*After*	*Before*	*After*
4	5*	Inside Closed Book	TNTC***	TNTC	TNTC	TNTC
4	5*	Inside Partially Opened Book	TNTC	TNTC	TNTC	TNTC
4	2**	Placed In Open Petri Dish****	60	0	TNTC	0
15	5*	Inside Partially Opened Book	TNTC	0	TNTC	0

* One at each position, noted in Figure 1
** Located at position 1, 2 in Figure 1
*** TNTC = Too numerous to count
**** Sample moistened with 1 ml. phosphate butter

TABLE III—TREATMENT OF CULTURES STREAKED ON NUTRIENT, FOUR HOUR EXPOSURE

Species	*Nutrient*	*Number of Samples*	*Growth after Incubation*	
			Before	*After*
Escherichia coli	Trypticase Soy Agar	5	+	–
Aspergillus sp.	Sabouraud's Agar	5	+	–

* + Growth
—No Growth

TABLE IV—TREATMENT AND EVALUATION OF SPORE STRIPS, ELEVATED TEMPERATURE

Type of Book Storage	*Position on Cart*	*Evaluation of Growth After Different Exposure Times (Hrs.)* 4		6.5		15	
		*Controls**	*Exposed*	*Controls*	*Exposed*	*Controls*	*Exposed*
Partially Opened	1	+	–	+	–	+	–
Partially Opened	2	+	–	+	–	+	–
Partially Opened	3	+	–	+	–	+	–
Partially Opened	4	+	–	+	–	+	–
Partially Opened	5	+	–	+	–	+	–
Clamped Shut	1	+	–	+	–	+	–
Clamped Shut	4	+	+	+	–	+	–

* + = Growth
 - = No Growth

TABLE V—EVALUATION OF TREATED MUDDY-MOLDY PAGES, ELEVATED TEMPERATURES

Type of Book Storage	*Position on Cart*	*Exposure Time (Hours)*	*Counts of Bacteria and Fungi per 6.45 cm²* Bacteria *Before*	After	Fungi *Before*	After
Partially opened	1	4	TNTC	0	TNTC	0
	2	4	TNTC	0	TNTC	0
	3	4	TNTC	0	TNTC	0
	4	4	TNTC	0	TNTC	0
	5	4	TNTC	0	TNTC	0
Clamped Shut	1	4	TNTC	TNTC	TNTC	0
	4	4	TNTC	TNTC	TNTC	0
Closed, Laying on Side	2	4	TNTC	0	TNTC	0
	3	4	TNTC	50	TNTC	0
	5	4	TNTC	0	TNTC	0
Partially Opened	1	6.5	TNTC	0	TNTC	20
	2	6.5	TNTC	70	TNTC	10
	3	6.5	TNTC	0	TNTC	10
	4	6.5	TNTC	10	TNTC	30
	5	6.5	TNTC	50	TNTC	10
Clamped Shut	1	6.5	TNTC	80	TNTC	60
	4	6.5	TNTC	300	TNTC	0
Closed, Laying on Side	2	6.5	TNTC	50	TNTC	0
	3	6.5	TNTC	0	TNTC	10
	5	6.5	TNTC	180	TNTC	10
Clamped Shut	1	15	TNTC	0	TNTC	0
	4	15	TNTC	0	TNTC	0
Closed, Laying on Side	2	15	TNTC	0	TNTC	0
	3	15	TNTC	0	TNTC	0
	5	15	TNTC	0	TNTC	0

Chapter V

Vacuum Freeze Drying: A Report

Chapter V

Among the major restoration problems for the Museum library was the variety of materials which had been frozen. The Museum's library of record for glass included literature from countries throughout the world; the composition of the paper as well as the types of printing and binding varied considerably. Both water soluble and insoluble inks were used in the records and ledgers. There were archival materials: flat works of art, photographs, newspaper clippings, patents, correspondence, and photostats.

A search of relevant literature and conversations with scientists and conservators revealed that freeze drying and vacuum drying techniques had great potential as initial procedures for salvage and restoration. Scientific laboratory data on drying frozen books by these methods was too sparse to justify application to the Museum's valuable collection. The conservator therefore applied traditional air-drying techniques to the frozen damaged materials during the early stages of restoration. A scientific evaluation of freeze and other drying processes was begun with the hope that the remainder of the frozen flood-damaged materials could be dried in a single operation.

Many decisions could not be made until the agglomerates of frozen books were separated, the individual books thawed and opened, and the librarians had identified the books and established their value.

The following categories were established:

- Discard—material no longer of value, or replacement had been assured.
- *Replacement—severe* damage, but duplicates could be obtained immediately.
- *Recycle*—item returned to freezer; replacement not yet established; restoration postponed.
- *Microfilm*—minimal cleaning with drying required; discard after filming.
- *Totally Clean*—cleaned, de-acidified, sterilized, and packaged for subsequent binding.
- *Completely Restore*—same as Totally Clean, plus salvage of binding for future decision as to its use.

The conservator could then allocate necessary money and time for restoration of each item. Often each book presented its special set of problems. At this point the conservator and his assistants noted two extremes during their daily operation. On those days when the librarian identified thawed books to be discarded, many books were processed. However, when a thawed book required complete restoration, several days and in some cases weeks of effort were required before restoration was completed. When this happened the number of books processed per day was low. The periodicals which contained coated paper were returned to the freezer immediately whenever they were discovered, since the conservator had no practical options other than the time-consuming operation of interleaving the coated paper pages. It was anticipated that a new, more efficient technique would result from research. The normal restoration operation for the damaged books was sufficiently complex without adding the variety of problems caused by this assortment of special coated papers.

Approach to a Solution

The conservator specifically requested that priority be placed on finding an acceptable mass drying technique. All other conservation research projects were set aside and full attention was focused on this problem. To minimize cost and reduce the time required for obtaining results from a survey of possible drying techniques, the scientist and conservator agreed to buy books containing the two extremes in paper for experimentation. After preliminary tests, separate uncoated and coated paper books were selected. Experiments showed that normal drying of the uncoated paper books caused no problem; sticking was a major problem in drying the group of coated paper books.

Both sets of books underwent a standard simulated flood, drainage, and freezing sequence. Pairs of these standard flood-damaged samples were dried by different laboratory processes and evaluated. It was established that Freeze and Solvent Extraction Drying techniques could be applied with success to books containing coated paper. Furthermore, the general quality of the coated paper dried by these two processes was better than that resulting from the traditional air dry and interleave technique. Since these initial laboratory experiments were successful, a pair of flooded, drained, and frozen books was taken to the General Electric Company in Valley Forge, Pennsylvania, to be dried simultaneously in their large space chamber with a mass of wetted, basically uncoated paper books by a freeze dry method. After the successful drying of this pair of coated and uncoated frozen books, the scientist suggested that the conservator consider applying this technique to the remainder of the museum's frozen flood-damaged collection.

Freeze-Thaw Vacuum Drying Process

During initial restoration operations the temperature inside the thawed books was monitored by a flat head thermocouple to help determine the temperature above which sticking would occur unless the pages were interleaved. From measurements on a random selection of some seventy-five thawed books containing a variety of coated paper, it was observed that in the majority of the books sticking took place when the temperature exceeded 10° C. Sticking was not observed, however, when the temperature of the water in the book was below 4.4° C. This information reinforced the conclusion of earlier reports. It also indicated that in removing water from the book by evacuation, advantage could be taken of the greater vapor pressure of water in its liquid phase in contrast to the lower vapor pressure of ice or water at its melting point. Thus the concept of using a mass Freeze-Thaw Vacuum rather than a standard Freeze-Dry process developed.

Water has a vapor pressure of 6.3 mm at 4.4° C and 9.2 mm at 10° C. These values are greater than 4.6 mm at 0° C for the equilibrium vapor pressure of an ice-liquid water combination. The potential efficiency with which the water is removed at 4.4°C rather than 0° C is increased by at least thirty-seven percent. Specifications were developed so that the temperature of the liquid phase in the books during drying would be kept close to 4.4°C and would not exceed 10°C. This was extremely important during the early stages of drying when a large volume of water was present in each book. It was less important when smaller amounts of moisture were present.

Final Recommendation for Mass Drying the Museum's Collection

After considerable discussion and several supplementary experiments, both the scientist and the conservator recommended the application of this mass drying technique to the remainder of the frozen items. The recommendation was accepted by the Museum's administrative and library staff. There was still serious concern about the effect of this process on the adhesive quality of the mud since there had been no mud on the research books being dried during earlier experiments.

At this point, approximately one year of work on the Museum's collection had taken place. The majority of the uncoated paper books had been restored; books and periodicals primarily containing coated paper remained in the freezer. No attempt had been made to restore the frozen, flood-damaged periodical collection for several reasons: (1) the high content of coated paper made successful restoration improbable because this paper sticks while drying; (2) the application of the interleave drying technique was too expensive because of the labor-time requirement; (3) it had been assumed that periodicals would be replaced by acquisition. Replacement of both books and periodicals was not completely successful since many items were out-of-print and not available on the world market. Archival objects and photographs were still in the freezer and were to be included in the mass drying operation.

THE PLAN AND ITS IMPLEMENTATION

Packaging and Transportation to the Drying Site

Arrangements were made with a commercial truck agency for the rental of a freezer truck and for a driver to transport the frozen flood-damaged materials to General Electric's Space Center at Valley Forge, Pennsylvania. The control of the Museum freezer's temperature was lowered to -28.9° C one week before this trip to insure that the books would be frozen when loaded. The General Electric Company was asked to transfer these frozen materials to their space chamber for Freeze-Thaw Vacuum Drying immediately upon arrival.

The number of books in the truck was limited by its size and weight. Everything in the freezer which was to be dried could be transported in the available vehicle, plus a selection of discarded items representing variations in paper type and book bindings. The number of books (3,500) in the truck, it was estimated, would fill two-thirds of the General Electric Space Chamber.

Several unforseen problems had to be solved. When the freezer truck arrived at the Museum it was found that its refrigeration unit was defective. The compressor stopped when the truck reached a speed of sixty-four miles per hour; the compressor was found to work well if the truck was stationary. When the temperature of the refrigerated section of the stationary truck reached -12.2° C it was decided to load the materials described in Table I. They included 240 carry boxes (33 x 43 x 28 cm).

A pair of simulated flood-damaged, frozen, coated, and uncoated paper research books was loaded with these flood-damaged books. They were packed in dry ice for additional insurance against thawing; their primary mission was to provide quality control for the Freeze-Thaw Vacuum process itself, not to monitor the transportation storage conditions.

Before leaving for Valley Forge, the owners of the freezer truck gave assurances that the insulation in the truck walls would keep the books frozen for ten hours even if the compressor stopped. This was encouraging, but as a precaution it was requested that a mechanic be at Binghamton, New York, to repair the compressor before the longer part of the trip through the Pocono Mountains was begun.

The mechanic repaired the compressor, which continued to function during travel on Interstate Highway #81, but as the truck encountered rougher highway—the Northeast Extension of the Pennsylvania Turnpike—the compressor stopped. The truck was halted and kept stationary until the compressor was started and the temperature was lowered to —6.7° C. Only then was travel resumed. Between such starts and stops, four times between Scranton and Valley Forge, the temperature of the air above the books oscillated between -6.7 and +10°C. The compressor was started upon arrival at Valley Forge and functioned well until the frozen books were unloaded at General Electric's Space Chamber.

Chapter V

Unloading the Truck and Loading the Drying Racks

Upon arrival at General Electric's Space Center the temperature inside the freezer truck was -12.2° C. The truck's temperature measurement was checked with a separate thermocouple system. The two were found to agree within 0.6° C. This confirmed the accuracy of the temperatures measured while traveling to Valley Forge.

The space chamber, a 7.32 meters long cylinder with a 3.7 meter diameter, had room for three book carts. Each cart consisted of a base on which were mounted two rows of 91 x 30 cm shelves, 213cm high and 213 cm deep. This gave each cart fourteen shelves measuring 213 x 91 with 30 cm between shelves, or a total flat surface area of 27.3 square meters. Each shelf had a strip heater attached to the underside. Each heater was connected to a variable transformer so that the input power could be varied. Approximately 30 thermocouples monitored the temperature. Half of the thermocouples were placed in books at random, and the other half were to monitor the strip heaters and the chamber functions. The chamber was mounted on concrete about 6.1 meters above ground level and was loaded by rolling a cart along a track and onto an elevator which lifted the cart up to the chamber. The cart was then rolled to the back of the chamber at which time the electrical and monitoring connections were made.

To diminish labor costs, the Museum's carry boxes were placed directly on the cart shelves; the books were not taken from the boxes, but the lids of the boxes were removed. Two-thirds of the boxes had been packed with the spines of the books on the bottom of the box. The books in the remainder of the boxes had been packed both horizontally and vertically. Several boxes had frozen agglomerates with the books in every position. The oversized volumes were placed horizontally on the shelves of the cart, primarily on the highest shelves. All the frozen material was loaded onto the racks of the carts and placed in the chamber one and one-half hours after arrival.

The location of eight boxes with solidly frozen books was noted especially. Each time the chamber was opened a check of these boxes was planned to determine the progress of the overall drying operation. The two frozen research books were also positioned so their progress in drying could be checked by quick removal and weighing. The amount of water absorbed and frozen in each had been determined precisely before the trip to Valley Forge.

Specifications for Treatment

Since the sticking of some types of coated paper is accelerated by high temperatures, the first phase of the drying process was to be run with the shelf temperature as low as possible. The temperature chosen was 21°C. The initial chamber pressure established by mechanical pumps was to be 10 Torr before freon cooled with liquid nitrogen was circulated through the condenser (13.94 square meters). This coil was positioned inside, not outside, the space chamber. The condenser was to be kept below -9.4°C and defrosted when necessary. Drying progress was to be checked every twenty-four hours unless both parties agreed to a modification of the schedule.

Observations and Action during Drying

The following observations led to successful drying of these materials.

Time *After Initial Evacuation*	*Date*	*Observation and Action Each Time the Chamber Door Was Opened*
26 hrs.	4/23/74	The refrigeration coil was defrosted. Forty gallons of water were removed. The uncoated control research book was checked and found to have lost 44.5% and the coated control book 24% of their original absorbed water. Some of the Museum's books were almost dry; others were still frozen. The door was closed, evacuation initiated, and drying started.
51.5 hrs.	4/24/74	The condenser's coil held only a small amount of ice; it was removed. The uncoated paper control book had lost 77%; the coated paper control book had lost 43.8% of the original absorbed water. More of the books were dry, although several remained frozen. Adjustments were made so that the heaters would increase the shelf temperature to 32.3° C. The door was closed and drying was begun.
94.0 hrs.	4/26/74	The small amount of ice on the condenser's coil was removed. The uncoated paper research book was completely dry; the coated paper book had lost 86.2% of its absorbed water. A complete evaluation of the books showed that 50% were dry. These were removed from the chamber. The remaining frozen items were removed from the carry boxes and individually placed spine down on the heated shelves. It was noted that the overall removal of water was slower than anticipated. Complete drying of the coated paper research book

		could be expected in another 24 hours of treatment, but General Electric's commitment to dry at least 95% of the books would not be satisfied at that time. The chamber door was closed and the drying started again.
126.5 hrs.	4/27/74	After the coil was defrosted, the coated paper research book was found to be dry. Many books were still frozen. The chamber door was closed and the pumps were set to pull a vacuum of 35 mm for the remainder of the weekend. The heaters were turned off during this period.
156.5 hrs.	4/29/74	Many books were still frozen. The position of these books on the shelf was changed to facilitate heat transfer for subsequent drying. The power for the heaters in the shelves was increased to give a maximum temperature of 48.9° C. The books dried and removed earlier (approximately 100 boxes) were placed in a truck (non-refrigerated) for storage until their return trip to Corning. Since their environmental temperature was about 32.2° C, there was concern microbiological growth might take place. A tank of Oxyfume-12 was released inside the closed truck to decontaminate the books after a controlled leak to the atmosphere was provided. Several blocks of dry ice were placed between the boxes of dried books as a precaution to maintain a low environmental temperature until a return to Corning was possible.
180.5 hrs.	4/30/74	After the chamber door-was opened, the carts were removed. An individual check of each item revealed that about 100 still held noticeable amounts of moisture; the remainder were dry. All books were packed. The boxes containing the moist books were marked so that they could be given immediate attention upon arrival in Corning. The boxes were loaded onto the truck; the trip to Corning began.

EVALUATION OF RESULTS AND DISCUSSION

Inspection of Each Item

The truck was unloaded in Corning, New York, approximately eighteen hours after it left Valley Forge. Three inspection stations, one each for books, periodicals, and archival items, were established. As each box was unloaded from the truck it was opened to identify its general content and then given to one of the groups at these stations. Each member of these groups had been previously trained to categorize each item by (1) the percentage of coated paper pages that were stuck, (2) the amount of wetness present, and (3) the degree of cockling that was apparent. The percentage of stuck pages was determined by making a minimum of ten specific observations at different locations in the sections of the book containing only coated paper pages. If sticking was observed, an estimate of the percentage of the total number of stuck coated pages was made. The inspectors' training also included study of a standard set of damaged samples chosen to represent three categories of water content (dry, moist, wet) and cockling (zero, some, very).

If a book was identified as being moist or wet, it was taken to the drying area. It was set on its bottom edge and partially opened to let dry air circulate around it to remove the remaining traces of water. Dampness was determined by touch. Each inspector sampled at least ten different sections of each book by running his or her fingers over the entire page. If any dampness was detected, the book was rated as moist. If the degree of dampness caused the uncoated paper pages to adhere slightly so that separation was not rapid, the book was rated as wet.

Cockling is defined as irregularity in the flatness of a paper's surface. In its worst form, a large number of localized irregularities are found per unit area. The drying of newly-made paper on high speed rolls leaves residual stresses. These localized stresses are released when the paper becomes wetted and dried without stress. Both the previous history of the paper as well as the application of the second drying operation play a vital role in the amount of cockling which results.

The evaluation of each individual item by these crews—six inspectors—took about sixteen hours. The results at each inspection station were marked on the original sheet of paper identifying the category of the book; if these sheets were misplaced, a new sheet was inserted in the book. These sheets were used by (1) the librarians to record the value of the book (2) the conservator to note the degree of restoration that his assistants should apply, and (3) by the scientist to tabulate results. A total of 1504 sheets (Table II) was collected, covering about 50% of the actual number of dried items. None of the sheets attached to stuck coated paper books was lost.

Chapter V

Results (% Wet, % Stuck, % Cockled)

Before reviewing the tabulation results, it is important to remember the biases which were inherent in the frozen materials sent to Valley Forge to be dried. These are summarized below to aid interpretation of the findings:

1) Of the frozen books more than 85% contained coated paper pages.
2) Essentially all of the frozen flood-damaged periodicals contained coated paper.
3) A group of oversized books, the largest being 80 cm x 65 cm x 5 cm, had been set aside for drying by this method.
4) A series of damaged frozen books, ledgers, and albums containing water soluble ink and dyes was sent for application of this drying technique.
5) All books designated "difficult to replace" during the preceding year were included to determine whether they could be salvaged at a cost lower than their most recent replacement price.
6) From the group of books marked "discard," as wide a variety of materials as possible, including pre-wetted coated paper books, was selected to determine how versatile this treatment could be.

The distribution of percentages identified with the stuck coated paper pages are listed in Table III. Only 7% of this sample of 1504 books had 91% to 100% of the coated paper pages stuck. This category of sticking does not mean that subsequent restoration was impossible; it does indicate that some segment of each page was stuck sufficiently so that force had to be applied to bring about possible separation. Fifty-six percent of the items did not give any evidence of the coated paper pages sticking. Ninety-one percent (Table IV) of the books which received the Freeze-Thaw Vacuum treatment were dry. The sheets from the books revealed that 119 were identified as moist and only ten as wet. The majority, 56% (Table V), had pages with obvious cockling. An appreciable fraction, 35%, was cockled badly. Only 9% of the books were completely free of cockling.

SPECIAL EXPERIMENTS

Original Drawings

It was evident that some water colors in the freezer had run before they were frozen. More than 1000 drawings were frozen in two large blocks of agglomerates in a print drawer; the Museum staff members were concerned that by the time the top prints thawed enough to be removed by traditional drying techniques the sides of the agglomerates would be defrosted, increasing the probability of the color washing off or running. In several books with water colored illustrations, the binding medium became humidified enough to adhere to the facing page as it dried. There was no additional running of the water colors due to the Freeze-Thaw Vacuum Drying.

Oversized Volumes

Because of their size, large frozen volumes had to be placed individually on the drying shelf in a horizontal position. When dried by this Freeze-Thaw Vacuum drying technique, they were distorted very little. The volumes had returned to almost their original size. This was an unexpected but positive result of applying this drying technique.

Damaged Coated Paper Books Rewetted and Frozen

Several volumes containing coated paper were found to be stuck as restoration began. Efforts to separate the pages resulted in removal of the coating from the substrate. These volumes were rewetted and frozen until a new drying technique could be applied. It was hoped that the slight layer of ice from fresh water between the pages of a frozen book would provide enough pressure to break the bond between the coatings. If this ice could then be thawed and the liquid phase evaporated at a low temperature, the pages might be separated in a dried state. Similar frozen books were to be paired with these books for the mass drying experiment. They, however, were not rewetted. Both sets of books were sent to Valley Forge. There was almost no adhesion in the books that had been rewetted; similar books that had not been rewetted stuck excessively.

Photographs

Two file drawers of photographs, with some correspondence interspersed, were sent to Valley Forge. Most of the material in the file drawers was relatively dry because it was the last material to be frozen during salvage after the flood. The majority of the photographs, unfortunately, adhered tenaciously to each other, either emulsion-to-emulsion or emulsion to the back of the adjacent print. These photographs could be separated by rewetting, swelling the emulsions, and applying gentle force. When emulsions had already been damaged by mold, salvage was laborious, expensive, and at times impossible.

After mass drying, those photographic prints which were known to have been frozen promptly after the flood, i.e., containing much water and no mold, showed no adhesion and only slight cockling. An inspection of the emulsion showed no sign of damage. No reduction of gloss could be identified.

Discussions and Conclusions

Mass drying the frozen flood-damaged books permitted an efficient review of their value and an assessment of the degree of restoration they should receive. The librarians found that this drying method enabled them to re-evaluate their original decisions and better estimate replacement versus restoration costs. Most books were to be restored. They also found that books previously designated as discards were now usable. After fumigation and sterilization, some books were returned to use. Using the librarians' value notation, the conservator could organize all those books requiring equivalent degrees of restoration, instruct his assistants on procedure, and set up a modified production line for their efficient treatment. Estimates of the time necessary for restoration could be predicted more accurately.

The period of time for the mass drying was greater than the four days anticipated after the previous studies on drying the pair of wetted and frozen research books. Since different types of coated paper were involved, the temperature control for the chamber's shelf heaters was set lower initially. Most of these coated paper books were much larger than the research books; water diffusion to the edges of the pages took longer. Many archival items were wrapped in several layers of paper, which made water removal difficult. Another factor which could not be predicted from the earlier experiments was the uneven distribution of heat transferred from the shelves to the boxes containing the books and then later to the individual books themselves. The cardboard carry boxes were believed to contribute a minimum barrier to heat transfer; it is now known that if the boxes are to be used, all books should be packed in a vertical position with the back edge of the books on the bottom of the box. Horizontal packing of the books does not permit effective heat transfer to the books in the top of the box.

The surface quality of the dried coated pages was excellent. This does not imply that further restoration could be eliminated, but that restoration could be pursued with a high probability of success if justified by the value of the book.

The quality of the dried, bound newspapers and journals was very satisfactory. There were, however, cockled pages and damage to the spines, but these problems were independent of the Freeze-Thaw Vacuum Drying Process.

There was some evidence that the soluble materials in the coating had migrated toward the edges of the pages before freezing. This migration did not interfere with the drying and separation of the coated paper pages by mass drying technique if the pages had been sufficiently wet before freezing. In several volumes, portions of the coating were completely separated from the paper substrate. This was attributed to the history of the book before freezing and not to the drying process.

In general, cockling of the coated paper was greater than that of the uncoated paper. The amount of cockling depended upon the extent of wetting both book and individual pages.

The inspection of these books was not designed to determine whether the mud adhered more or less tenaciously to the paper than after application of other drying techniques. However, a large sample of dried books containing both uncoated and coated paper pages was checked after the initial inspection was completed. Surprisingly, the dried mud could be displaced with ease. Instead of this drying process further imbedding the mud in the paper, the mud appeared to be lifted to the surface. Mud removal from the surface of the coated paper was less difficult than that from the uncoated paper. Although a systematic controlled approach was not established to measure ease of dried mud removal, both the scientist and the conservator, as well as their assistants, agreed that the mass Freeze-Thaw Vacuum process aids rather than hinders subsequent elimination of dried mud.

It is not known why some of the coated papers were stuck. It is highly probable that the blocking, i.e., sticking, occurred before the drying process was applied. After the flood the drainage time of the materials was sufficiently long that some of the books had completely or partially dried before freezing; in some cases the degree of drying was sufficient to cause blocking.

Another explanation for sticking of some pages may be that the uneven excessive heating of the drying rack shelves could cause formation of an appreciable volume of liquid phase. If this happens, significant amounts of starch and casein (adhesives for coated paper) are dissolved. The final evaporation of this water from the pages results in the previously dissolved constitutents solidifying between the pages and thereby causing sticking. A daily check during drying did not identify this as a primary cause for the sticking.

Even when water soluble inks were used, the designer's sketches and the watercolored illustrations dried with little or no evidence of feathering. Some color did transfer to the back of the adjacent sketch, but the quality of detail in the illustration was little affected. Several of the archival items were still moist when the truck returned to Corning because they had been packed in multi-layers of paper; water removal from the center of the package was difficult. After the wrappings were removed, these partially wet items dried with minimal evidence of damage.

The results of drying the frozen photographs were most acceptable if the photographs or prints had been frozen quickly after being flooded and if there was no evidence of biological growth.

Chapter V

In general, the Freeze-Thaw Vacuum Drying Process, with the specifications set by the scientist, can successfully mass dry frozen and wetted items. This process can be applied to uncoated paper materials with a high probability of success. The quality of the dried product, except for cockling, will be excellent. Uncoated paper books dried by this process are less affected by their previous history than coated paper books.

Knowledge of the previous history of coated paper books is necessary to predict the quality of the dried products resulting from this process. If coated paper books are wetted and allowed to dry in part, or remain in a drainage position under pressure before they are frozen, they will probably stick after this mass drying process. When the history of coated paper books is unknown, the books should be dipped or soaked in fresh water for a short period of time before being frozen if non-stuck pages are expected from this drying process.

Although this mass drying operation primarily involved coated paper, two previous Freeze-Thaw Vacuum Dry treatments on the uncoated paper research books produced pages similar to their original state. The few uncoated paper books that were sent with the coated paper books for the final mass drying in the General Electric chamber also dried successfully.

Further experimentation is desirable to measure the true value of this mass drying operation for a wide variety of materials. The results of drying both coated and uncoated paper materials from The Corning Museum of Glass Library suggest that those with similar materials and the misfortune of water damage should consider this mass drying method.

TABLE I—FROZEN FLOOD-DAMAGED ITEMS TAKEN TO THE GENERAL ELECTRIC COMPANY VALLEY FORGE SPACE CHAMBER

Approximate Number of Individual Items or Boxes	*Item Type*
1300	Recycle books stored in boxes*
1000-1500	Bound periodicals: Several sets of the complete series of published volumes
1000	Original drawings of various designers (water colors, pastels, pen and ink, etc.)
30	Extra large volumes containing colored and black-white plates
30	Discard books stored in boxes: * Damage was severe and all contained coated paper; retention was for experimentation.
15	Special damaged coated paper books, rewetted and frozen
7*	Seven boxes* of archival items: photographs (1000), patents, ledgers, books, correspondence, notebooks
2*	Two boxes* of approximately 1000 photographic prints

*Box size, 26 x 30 x 40 cm.

TABLE II—DRIED ITEMS CHECKED FOR STATISTICAL TABULATIONS

Number of Individual Items	*General Description*
554	Periodicals, identification sheets marked
51	Periodicals, sheets not marked
83	Periodicals without sheets
899	Books, identification sheets marked
96	Books without sheets

TABLE III—INSPECTION FOR STICKING OF THE COATED PAPER PAGES

		Distribution for Various %'s of Coated Pages Stuck										
Type *of Item*	*Number of Items*	0 %	*1 to 10%*	*11 to 20%*	*21 to 30%*	*31 to 40%*	*41 to 50%*	*51 to 60%*	*61 to 70%*	*71 to 80%*	*81 to 90%*	*91 to 100%*
Non-Periodicals	899											
Actual #		439	71	50	42	32	100	21	10	33	19	82
Percent		49	8	6	5	4	11	2	1	4	2	9
Periodicals	554											
Actual #		378	53	26	28	17	16	4	6	4	2	20
Percent		68	10	5	5	3	3	1	1	1	0	4
Totals	1453											
Actual #		817	124	76	70	49	116	28	17	37	21	102
Percent		56	9	5	5	3	8	2	1	3	1	7

TABLE IV—INSPECTION FOR DAMPNESS OF DRIED BOOKS

Type of Item	Number of Items	Distribution for Degree of Dampness in Books		
		Dry	Moist	Wet
Non-Periodicals	863			
Actual #		802	58	3
Percent		93	7	0
Periodicals	553			
Actual #		484	62	7
Percent		88	11	1
Totals	1416			
Actual #		1286	120	10
Percent		91	8	1

TABLE V—INSPECTION FOR COCKLING OF PAPER IN DRIED BOOKS

Type of Item	Number of Items	Distribution for Degree of Cockling		
		Zero	Some	Very
Non-Periodicals	904			
Actual #		**80**	**479**	**345**
Percent		**9**	**53**	**38**
Periodicals	553			
Actual #		48	341	164
Percent		9	62	30
Totals	1457			
Actual #		128	820	509
Percent		9	56	35

Chapter VI

Planning to Protect an Institution and Its Collections

Chapter VI

Few libraries, museums, or historical societies have the prescience to develop a plan for the handling of a disaster—a disaster which may never come and which the odds indicate will happen to someone else. Unfortunately, institutions do suffer damage from fire, water, or extremes of nature, and when no plan for handling such emergencies is available, the loss will be greater than necessary. The following considerations may help in drafting a plan for specific situations:

A. Insure

Be certain that insurance coverage is complete and covers the collection, equipment, and building—as well as office furniture, restoration of files, costs of temporary relocation, and the myriad expenses involved in returning to the *status quo* before the disaster.

The first step in planning is to locate an insurance agent who can help to provide the proper coverage for all aspects of the institution's activities and holdings. Advice can be sought from local insurance representatives or from the appropriate professional organizations such as The American Library Association, The American Association of Museums, The American Association of State and Local History, or other pertinent organizations.

Working with an insurance expert is essential, for few professionals in museum or library work know the intricacies of proper coverage. The kind of records needed to estimate damage or loss to prove a claim are most important if an adequate settlement is to be reached. The details on which claims might be based must be well documented: records of the date of acquisition, source, original cost, current replacement values, and so forth must be readily available, for there will be no time to develop such details after a disaster when the struggle to maintain services and to restore the collection must go on concurrently.

Insurance coverage should be considered not only in terms of replacement costs but in terms of restoration costs as well. A price can be set for replacing a standard dictionary, but what is the restoration cost or loss-of-value factor if a nineteenth-century pamphlet or unique Venetian goblet is damaged or destroyed? What is the value of staff time in replacing a damaged or destroyed catalogue of holdings or in reconstructing files and records?

B. Keep and Duplicate Appropriate Records

The accession records, shelf list, or catalogue of collections are among the most important holdings of an institution, sometimes more important after a disaster than the items they represent. No proper inventory, no adequate claim of loss can be carried out without adequate and *available* data when catastrophes occur.

Such data should include a complete description of the object, with size, condition, etc., date of acquisition, source, provenance (where applicable), or original cost, current replacement value (this can be of assistance as well in adjusting insurance coverage as values increase or if de-accessioning of duplicates is under consideration), number of pages (books), number of plates or illustrations (color, black and white), and other pertinent information.

Not only must documentation be complete and up-to-date, but it must be available—which implies duplicate copies. A complete catalogue is of little help if the only copy is destroyed in the disaster. All key records should be available on microfilm and copies should be stored far away from the institution's headquarters so that they will not be lost also. Storage in a bank vault is not good enough—if the bank is in the same disaster-prone area as the institution. Duplicate records may be kept in the general area, but a master microfilm should be stored, preferably in a commercial archival storage vault where proper humidity control is available. Such storage firms can usually produce duplicate copies of masters if such are needed. Information on such facilities can be obtained from the National Microfilm Association.

Once the records of all holdings have been microfilmed, an annual filming of new records should be undertaken to keep the records complete. Often this means keeping an additional accession card to be used for the filming at the end of the year. Periodically (every five or ten years) it would be well to re-microfilm the master records so as to provide one master duplicate file which can replace the original master microfilm and its five or ten supplements.

C. Formulate a Plan

A plan for handling a disaster should be developed in consultation with or review by the entire staff of the institution so that each person knows his area of responsibility and to whom he reports during the emergency (the emergency chain of command may differ from the normal system of reporting). It should be in writing, available to all staff, and should be reviewed annually for up-dating or change.

The plan's priorities should outline action to be taken during specific disasters. If flood, hurricane, or tornadoes threaten, there may be time to take preventive action. Fire or burst pipes necessitate different responses, naturally. Thus it is well to divide the plan into three parts:

Action to be taken prior to a disaster
Actions to be taken during a disaster
Actions to be taken after the disaster

These three aspects are covered in the following pages. Some of the types of disaster which should be anticipated include:

Bomb Threat	*Gas leak*	*Riot*
Earthquake	*Flood*	*Panic*
Explosion	*Water damage*	*Power failure*
Plane crash	*High wind*	*Accidents or illness on premises*
Fire	*Hurricane*	

Part 1

Actions to Be Taken Prior to a Disaster

A plan of action for safeguarding a collection must be organized well in advance of any threatened disaster. It should provide for:

1) An allocation of manpower and chain of command
2) A listing of individuals and telephone numbers
3) An identification of items to be saved by their importance or value to the institution, and a chart of their current location
4) A listing of needed supplies, materials, tools, and their location; information on procurement of vehicles
5) A listing of electrical switches
6) A place for re-location if needed
7) A set of procedures to be followed in securing the collections or in moving them to temporary safety
8) Cameras and film to record damage

1. Allocation of Manpower and Chain of Command

As indicated above, an emergency chain of command may differ from the normal roster of responsibility as task priorities shift and new jobs are assigned during the period of an emergency.

One person should be designated as the coordinator for all actions and should be free of all responsibility other than the supervision of emergency problems. If ongoing business is to be conducted, it should not involve the emergency coordinator. Specific individuals should be assigned responsibility for moving areas of the collection, maintaining contact with security, radio and newspaper personnel, supervision or transportation (if needed), and control of other space to which the institution may have to move. Adequate "work gangs" should be assigned to each of the supervisors according to the needs of each area. Understudies for key personnel should be named. Their names should be secured in advance, and they should understand the kind of work they may be asked to do. Where necessary and possible, additional help may be obtained from friends of the institution or from the community.

A secondary command post should be designated in advance, with a telephone number, should it be necessary to evacuate the institution. Instructions for the staff as to when to report to such a post should be specific.

2. Listing of Individuals and Telephone Numbers

An important informational document is an up-to-date list of the names, home addresses, and telephone numbers of staff so they can be reached in an emergency outside of working hours. The list should obviously include police, fire, ambulance, security, or other such agencies. In additon, the names, addresses, and telephone numbers for outside areas should be available: transportation (truck to be used in evacuation, etc.), plumbers, gas and electric company personnel or technicians, volunteers who will help in an emergency.

3. *Identification of Items to Be Saved*

Each institution must develop its own list of items to be saved and the priority of such protection. The following listing cannot, therefore, be considered to fit all situations.

a. Listing of Priorities
After the priorities have been determined, a list of the order in which items are to be moved should be compiled and distributed. Where possible, names of those responsible for the items should be appended.

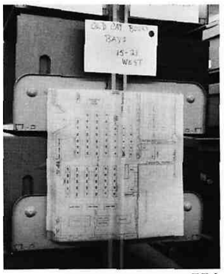
b. Location Chart (Fig. 55)
A chart which locates each of the items above should be posted. If certain responsible staff members are unable to be on hand during an emergency, it should be possible for other staff to locate holdings in order to carry out the emergency plans.

c. Holdings
The following list of categories of items to be saved is organized according to the priorities of The Corning Museum of Glass.

(1) Objects in the collection, listed by their degree of importance and priority of evacuation
(2) The catalog, shelf list, and/or accessions list.
(3) Library
  (a) Rare books, special collections items which are important because of their age, association value, one-of-a-kind factor, or limited editions.
  (b) Manuscripts, documents, archival materials—which may not fall into category (a)above.
  (c) General book collection. This may be subdivided into the more and the less valuable areas.
  (d) Periodicals. Same comment as (c) above.
  (e) Microfilm rolls and microfilm masters of filmed collection.
  (f) Circulation records.
(4) Photographic and audio visual
  (a) Films, slides, negatives, prints, transparencies
  (b) Video tapes, audio tapes, recordings
(5) Art works: Paintings, prints, posters and other two-dimensional items not considered under (2) above as objects in the collection.
(6) Office Records
  (a) Files and general records
  (b) Correspondence
  (c) Financial records and tax records
(7) Equipment and furniture
Generally speaking this is one of the least important since desks, files, etc. can be repurchased under an insurance claim. However, certain pieces of equipment may be given priority if time permits because of their expense, difficulty of replacement, or immediate need after the emergency.
This would include
  (1) Laboratory equipment
  (2) Photographic and projection equipment
  (3) Office equipment, i.e., electric typewriters
(8) Supplies—In general, office and library supplies are the most expendable since they are easy to replace. Consideration of saving these items should come only if a maximum of time and effort is available to save them.

4. *Emergency Supplies on Hand*

Power failure is one of the greatest handicaps in an emergency. Buildings should be equipped with enough permanently mounted auxiliary lights to provide illumination in an emergency. An adequate supply of fresh batteries for these lights should be maintained.



55A

55B

Fig. 55. (a) Location chart prominantly posted in the Library, (b) Card catalog with first-priority dots attached. (c) Carry boxes with appropriate category noted.

In addition, the following equipment or materials should be on hand:

(a) Electrical fuses
(b) Flashlights, additional batteries and bulbs
(c) Fire extinguishers. Periodic drills should be held to acquaint all staff with their location and proper use. Staff should have the opportunity to use an extinguisher out-of-doors to put out test fires.
(d) Crowbars and axes. These may be needed to disengage fallen shelving, panels, etc.
(e) Hammers, wrenches, pliers, screwdrivers, wood and metal hand saws, utility knife and blade, wire cutters.
(f) Brooms, buckets, mops, wringers, rags. Buckets are obviously essential for leaks. All these tools will be needed to handle water damage associated with fires.
(g) Plastic sheeting—to protect areas against water damage from leaks or runoff of water.
(h) Boxes for packing or carting. Record transfer boxes (12" x 16") with inset handles and with lids are the easiest to use, carry, and stack. They may be purchased flat and folded into shape as needed.
(i) Tissue paper, plastic "bubble-pack," and other materials to fill partially filled boxes or to protect delicate items.
(j) Battery operated radio.
(k) First Aid kit.

5. *Switches*

Staff should know the location of electricity, gas, steam, water, and sewer cutoffs so that these may be turned off as necessary. Specific individuals should be assigned these tasks and given hands-on training. Drainage outlets should also be designated to permit a rapid dispersal of unwanted water.

6. *Temporary Relocation Space*

Should it become necessary to evacuate the building, temporary relocation space should be designated and, when possible, designated in advance. Obviously, the most favorable locations are in public buildings, churches, schools, gymnasiums and similar structures away from the disaster area. Whenever possible, it is best to keep the institution's holdings together. Scattered locations will involve the splitting of staff, a need for additional security personnel, and will only add to the problems involved.

7. *Securing or Moving Holdings*

Depending on the nature of the disaster, plans will vary as to the securing or moving of holdings. Those objects on open shelves in the storage areas will be secured by nylon fishnet attached at the top of the shelf framing, ready to be unrolled and stapled as a safeguard to prevent object movement. It may be possible, in the case of a limited problem (loss of a portion of the roof in a storm) to move the affected collection to another portion of the building. In the case of threatened flood it may be necessary to evacuate part or all of the building. These contingent plans must be developed.

In the case of need for total evacuation, the following should be considered:

a. A plan for packing should be developed with an understanding as to who will be in charge of the packing, who will pack, who will carry. The use of carry boxes, as suggested in 4(g), permits loads light enough to be carried by amateur movers without undue strain and insures having standard sized boxes so that they may be stacked safely and compactly in a vehicle or building.
b. If shelves, cases, drawers, cabinets, etc., are numbered in advance, the appropriate number can be placed on the box to make retrieval possible if storage is for a long period or can make return to the appropriate shelf, etc., easier once the emergency has passed. Obviously a master chart of these numbers and their context should be made beforehand; this is particularly important if boxes have to be stored for a long time.
c. If the damage is imminent, i.e., flooding, boxed objects could be placed in a tractor trailer unit to be driven out of the danger area until conditions return to normal. The boxes could be left stored in the locked trailer, minus its cab, for as long as is necessary. Obviously, advance information as to the availabililty of vehicles, supplies, etc. must be ascertained.
d. If materials are to be relocated in another building, a plan for unloading and storage should be devised with assignments for specific individuals.
e. A plan for security should be created in advance so that temporary locations or trucks housing collections can be safeguarded. This may involve the hiring of security personnel or the use of staff on a rotating basis.
f. If water damage is involved, it is well to have a list in advance of freezer plants outside the threatened area and the conditions under which they will accept materials (i.e., will food lockers accept non-food items?).

Part 2

Procedures during the Disaster

Once an emergency has been declared, staff should be able to follow the procedures listed in the Disaster Plan book issued by the institution.

One important consideration that we kept in mind was that the safety of people comes first. Staff, supervisors, and management worked from this premise; in most cases objects can be restored if not obtained once more; life and health are not as easily repaired or replaced.

Outside assistance—police, fire, other public service units—can be of tremendous assistance. Unfortunately they can also do great damage inadvertently. Police can keep outsiders away from the problem area and so safeguard collections; they can also bar staff from the scene at a time when staff knowledge can be of major importance. Likewise, firemen may need information about the building and its collections so that their efforts do the least damage and the most good.

It is important, therefore, that firemen and police have an opportunity to review emergency plans with management and to get to know the affected buildings so that their efforts during emergencies do not become counter-productive. Key staff members should be known to them, and some system of identification or badges should be worked out so that staff are not barred from the scene at the time they can be helpful.

Security during the disaster can be a problem. Volunteer help can be invaluable, but staff or security personnel should plan to keep other unauthorized persons from the premises. Once the fire, flood, or other catastrophe is over, the building should be secured physically to keep out the curious (there are many).

Building materials can be obtained to erect barricades; temporary guards can be employed as needed, often with union help when unions are involved.

Part 3

Action to Be Taken after a Disaster

The reminders in an institution's "Disaster Plan" covering action prior to the disaster should give a good indication of the steps to be taken next.

It is essential that planning continue, since no advance plan can cover all emergencies. Objectives, both immediate and long range, need to be set and then constantly updated as required. Responsibility should have been divided among key staff in the original plan. This now may have to be modified by the situation or because of the inability of important staff to be present. Policy decisions made at this juncture may determine the institution's program for the next few years; thus it is essential to spend sufficient time in planning rather than arriving at hasty decisions.

Decide what can be handled by the staff, what may have to be turned over to the outside experts. Invite those outside experts to advise you at the very beginning (insurance will pay for this), and if restoration of a technical nature lies ahead, constitute a committee of such experts to review periodically and guide the restoration progress.

Above all, do not rush into an insurance settlement or the institution may settle for less than is warranted. It will take time to realize the full extent of the loss, and many unexpected expenses will occur in the period of restoration.

Volunteers will no doubt appear, and they should be welcomed—but with caution. Too many volunteers can create more problems than help; some volunteers are inept and can worsen the damage. Selectivity of volunteer help is imperative.

If water damage is involved, freeze all objects in a nearby freezer locker or rent a freezer-trailer (with a gasoline generator if there is no power available). Whole file drawers can be frozen; sorting can take place much later. Frozen collections cannot disintegrate, mold, or be a hindrance to staff members otherwise occupied in trying to recreate the institution. They can be worked on at a much later date as time or staffing permit. If individual objects are to be frozen, wrap them in polyethlene sheets or bags if available so they can be separated more easily later on.

It would be an ideal situation to know what can be repurchased—repurchasing is often far cheaper than restoration, be it furniture, books, or objects in the collection.

When outside experts are eventually hired to work with the institution's staff, be certain to reach agreement on seemingly ordinary terms—the word "restore" means one thing to a curator or a librarian; it can mean something quite different to a professional restorer.

Above all, provide enough time for restoration. Staff will be under strain, and the damage of a few hours may take years to repair. Patience and planning are essential.

Appendix I

MUSEUM STAFF •June 1972

Thomas S. Buechner, *President, Board of Trustees*
Paul N. Perrot, *Director*
Kenneth M. Wilson, *Assistant Director-Curator*
Jane S. Shadel, *Assistant Curator*
Robert H. Brill, *Administrator, Scientific Research*
Mary Catherine Dino, *Curator of Education*
Norma R H. Jenkins, *Associate Librarian*
Virginia L. Wright, *Library Cataloguer*
Jane M. Lanahan, *Registrar*
Adrian C. Baer, *Custodian*
Raymond F. Errett, *Conservator-Photographer*

Sherry Glosick, *Student Assistant, Library*
Doris Hares, *Assistant, Education Department*
Carol Hull, *Assistant for Slides and Photographs*
Frances, G. Kragle, *Secretary, Education Department*
Clifford Olmstead, *Storeroom Assistant*
Mildred Perry, *Receptionist and Library* Assistant
Priscilla B. Price, *Secretary to the Director*
Linda J. Randall, *Secretary to Administrator of Scientific Research*
Lynette C. Roe, *Secretary to Assistant Director*
William W. Warmus, *Student Assistant*

All staff members worked tirelessly to help reopen the Museum by August 1, 1972, thirty-nine days after the flood.

MUSEUM STAFF Restoration Period 1972-1973-1974

Robert H. Brill, *Director*
Dwight P. Lanmon, *Curator, European Glass*
Sidney M. Goldstein, *Associate Curator, Ancient Glass*
Jane Shadel Spillman, *Assistant Curator, American Glass*
J. Stewart Johnson, *Deputy Director Contemporary Glass (1974)*
Mary Catherine Dino, *Curator of Education (through 1972)*
John H. Martin, *Administrating Officer (1973 . . .)*
Nancy D. O'Bryan, *Business Manager (1973 . . .)*
Norma P. H. Jenkins, *Associate Librarian*
Virginia L. Wright, *Assistant Librarian*
Priscilla B. Price, *Registrar*
Adrian C. Baer, *Operations Manager*
Raymond E Errett, *Conservator-Photographer*

1972

Deborah Barker, *Student Assistant*
Sherry Glosick, *Student Assistant*
Mimi Cole, *Slides Assistant*
Doris M. Hares, *Assistant, Education Department*
Carol W. Hull, *Assistant for Slides and Photographs*
Dale B. Johnson, *Student Assistant*
Frances G. Kragle, *Secretary, Education Department*
Fatma Kassamali, *Periodicals Assistant*
Paul Killigrew, *Student Assistant*
Jane M. Lanahan, *Office Manager*
David I. Leveen, *Conservation Assistant*
Joseph J. Maio, Jr., *Storeroom Assistant*
Clifford A. Olmstead, *Gallery Assistant*
Mildred H. Perry, *Secretary, Curatorial Staff*
Linda J. Randall, *Secretary to the Director*
Lynette C. Roe, *Library, Serials Specialist*
Laverne Schnare, *Acquisitions Assistant*
William W. Warmus, *Student Assistant*

1973 Staff Additions

Kristin A. Amylon, *Conservation Assistant, Intern*
Margaret Belden, *Typist*
Paul A. Donahoe, *Student Assistant, Conservation*
Thomas W. Duncan, *Paper Conservator*
Charleen K. Edwards, *Conservation Assistant*
Douglas R. English, *Conservation Assistant*
Albert Fehrenbacher, *Model Maker*
David J. Fischer, *Physical Scientist*
Jeffrey Gaines, *Conservation Assistant, Intern*
H. Charles Herring, *Student Assistant, Conservation*
Jennifer B. Jones, *Student Assistant, Conservation*
Moira MacAvoy, *Student Assistant, Conservation*
Richard Michaiko, *Student Assistant, Conservation*
Mary O'Brian, *Conservation Assistant*
Merle A. Peck, *Conservation Assistant*
Katherine K. Poole, *Conservation Assistant*
Ellen P. Roche, *Student Assistant, Library*
Edward Rowe, *Glass Restorer*
Ann Southworth, *Conservation Assistant*
James E. Stein, *Conservation Assistant*
Pamela A. Thompson, *Student Assistant, Registrar*
Nicholas L. Williams, *Conservation Assistant*

1974 Staff Additions

Lois D. Hultzman, *Museum Assistant*
Bernadette Jacobus, *Secretary to the Business Manager*
Ralph Kragle, *Conservation Assistant*
Anne Maloney, *Conservation Assistant*
Betty B. Sabin, *Conservation Assistant*
Judy Seal, *Secretary to the Director*
Judy Stasch, *Conservation Assistant*
Tom Steen, *Conservation Assistant*
Bonnie W. Wojnowski, *Conservation Assistant*

MUSEUM STAFF • 1976

Thomas S. Buechner, *Director*
John H. Martin, *Deputy Director, Administration*
Dwight P. Lanmon, *Deputy Director, Collections*
Robert H. Brill, *Research Scientist*
Jane Shadel Spillman, *Associate Curator, American Glass*
Sidney M. Goldstein, *Associate Curator, Ancient Glass*
David R Donaldson, *Assistant Curator, Contemporary Glass*
Priscilla B. Price, *Registrar*
Charleen K. Edwards, *Assistant, Publications*
Norma R H. Jenkins, *Associate Librarian*
Virginia L. Wright, *Assistant Librarian*
Raymond E Errett, *Conservator-Photographer*
Adrian C. Baer, Operations *Manager*

Louise K. Bush, *Bibliographer*
Lois D. Hultzman, *Microfilm Assistant*
Ernestine W. Kyles, *Cataloger*
Jane M. Lanahan, *Secretary, Curatorial Staff*
Joseph J. Maio, Jr., *Microfilm Assistant*
Clifford A. Olmstead, *Gallery Assistant*
Gillian H. Paul, *Secretary to the Administratiue Officer*
Merle A. Peck, *Microfilm, Conservation Assistant*
Betty B. Sabin, *Microfilm Assistant*
Darlene Scouten, *Secretary, Curatorial Staff*
Judy Y. Seal, *Secretary to the Research Scientist*
Nicholas L. Williams, *Photographer*
Bonnie W Wojnowski, *Library, Serials Specialist*

Appendix II

Volunteers Who Helped Reopen the Museum

June Alexander
Ralph Alexander
David Alien
Olive Alien
Diane Alpert
Anne Ames
Mary Ellen Andrews
John Asiello
Lee Atherton
Ron Auth
Susan Auth
Deborah Bacon
Lee Baldwin
Dave Baldwin
Dick Baldwin
Lois Barber
Ray Barber
Debbie Barker
Peggy Belden
Katie Bennett
Lilita Bergs
Mary Ann Berta
Sue Black
Dorothy Blair
Anne Blizard
Henry Boyd
Madeline Braun
Peter Briggs
Elizabeth Brill
Peggy Brill
Donna Brown
April Brown
Tom Brydges
Karen Bublitz
Bonnie Buechner
Mary Buechner
Matthew Buechner
Tom Buechner III
Nancy Burgett
Lisa Burmeister
Louise Bush
Shirley Callahan
Sally Campbell
Tom Chase
Chris Chiodo
Jennifer Chiodo
Rex Cleveland
Mimi Cole
Patsy Cole
Rose Crain
Dwight Crandell
Ed Cummings
Sherman Curry
Herb Dann
Dick Darcangelo
Lindsay Davidson
David Doud
Barbara Egath
Sue Egath
Jim Eriacher
Peggy Errett
Jean Farnham
Biri Fay
Frank Fehlner
Dan Fox
Steve Frey
Edith Gaines
David Gaines
John Gates
Harvey Gerry
Rosalind Goldman
Dan Gray
Walt Griffin
Jeremy Guth
Polly Guth
Sabrina Guth
David Hamer
George Hamel
Bert Harris
Andrew Herczog
Madeline Herczog
Bill Herth
Clarey Hilton
Eddie Hood
Hal Hood
John Hood
Eric Hopkins
Mark Hopkins
Peter Hotra
Carolyn Horton
James Houghton
Laura Houghton
Robert Houghton
Ruth Houghton
Alexander Houghton
Tom Hull
Bob Ivers
Clint Janes
Greg Jarraleet
Chris Jenkins
Cody Jenkins
Wes Jenkins
Earl Jennings
Dale Johnson
Greg Johnson
Val Johnson
Leslie Kahl
Ivan Kellogg
Kenny Klane
Nancy Kohler
Mary Krampf
Bob Layton, Jr.
Carol Lanahan
Jack Lanahan
Dwight Lanmon
Mark Lanning
Floyd Lattin
Joan Leffel
Martha Leffel
Phil Leffel
Marge Lewis
Ann Ling
Laurie Liscomb
Gordon Lubold
Jean Lubold
Chris MacAvoy
Ellen MacAvoy
Phyllis MacDonnell
Bill Martin
Jack Martin
Phylllis Martin
Robert Martin
Scott Martin
Todd Martin
Lynda McCurdy
Peg McKale
Bev McKibben
Stan McKibben
Ed Mishrell
Gerald Millet
Michael Moss
Patty Neal
Tim Nealson
Bob Nikirk
Mary O'Brian
Mary Ellen Oakden
Andrew Oliver
Janet Orr
Sheila Osterhoudt
Kay Pepper
Chantal Perrot
Joanne Perrot
Nina Perrot
Robert Perrot
Dick Pope
Mary Ellen Quigley
Betty Raymond
Lou Rems
Ann Reynolds
Ellen Roche
Mary Kay Russell
Jef Saunders
Liz Saunders
Jan Schreurs
Clint Shay
Liz Shoemaker
Dave Smith
Lyn Smith
Barbara Snider
Amy Southworth
Ann Southworth
Annie Southworth
George Southworth
Mary Ann Sprague
Sandra Stone
Robin Stone
Jerry Swinney
Hank Taylor
Bob Taynton, Jr.
John Teachman
Ed Thomas
Steve Thomas
Linda Thomson
Ann Thompson
Billy Thompson
Kathy Thompson
Pam Thompson
Sue Tong
Emily Underhill
Florence Underhill
Alan Underhill
Anne Underhill
Chipper Underhill
Emmy Underhill
Alfred Valerio
Peggy Vine
Bernie Viger
Barbara Wakeman
Andrew Watson
Martin Watson
Bill Weber
Brent Wedding
Alan Werner
Helen Werner
Jan Wilde
Phil Wilde
Jean Wilson
Pat Wilson
Lori Wood
Ellen Woodbury
Jean Wosinski
Alison Wright
Jerry Wright
Kathryn Wright
Peter Wright
Nancy Yenawine
Dennie Younge

Appendix 111

Glass Center, Steuben, CGW Foundation and CGW Employees Who Helped Reopen the Museum

Dick Andrews
Stella Baer
Dick Bessey
Frank Burke
Larry dark
Ada Cope
John Fox
Dick Goltry
Larry Green
Raymond J. Hall
Leona Harris
Bertha Holmes
Shellie Holmes
Dick Johnson
Red Keck
VickyKing
Mary Knapp
Art Maio
Joe Maio, Jr.
Grace Maxwell
Tilly Mirglia
Marilyn Murphy
Peter Muth
Mike Negri
Donald Noyes
Bill Perry
Keith Price
Teresa Quails
Louise Resue
Ted Reyda
Joe Ross
Bob Share
Freeman Smith, III
Dave Tripp
Dave Wasson
Lyie Wasson
Peggy Wilson

Appendix IV

Examples of Glass Restoration Problems and Techniques

1) Dragon-stem goblet with broken finial on cover (No. 51.3.115). (Fig. 1 a, b, c)

As the symbol of the Museum, the Venetian dragon-stem goblet was the first piece restored. The goblet and cover were washed with water to remove mud; the surfaces to be glued were cleaned with ammonia and acetone. Because of the spiral finial, holding the fragments in proper alignment was very difficult. A temporary cement was used as a clamp around the outside of the joints. The cement was removed from each joint, one per day, and Araldite was run into the joints (Fig. 1b). In this way the object was properly sealed.

2) Enameled German footed beaker with couer (No. 51.3.215), body broken into nine pieces and finial broken off cover. (Fig. 2a, b, c)

The pieces were cleaned with water to remove the mud. The surfaces to be glued were cleaned with ammonia and acetone. The fragments were taped together. Since the outside had a painted design, the tape was applied to the inside, making certain that each joint was as tight and accurate as possible. When the object was completely assembled, Araldite was run into the joints from the outside with a pointed spatula. After all the joints were completely filled, the excess adhesive was cleaned off the surface. This was done with extreme care, for any movement of the fragments would weaken the joints by introducing air and possibly distorting the shape. The finial was attached with Araldite. (Since this type of repair is not readily visible, those who work with glass objects are reminded that an object should never be lifted by a finial or a handle.) When the adhesive had cured, the tape was removed from the inside and the object was complete (Fig. 2c).


1A


1B

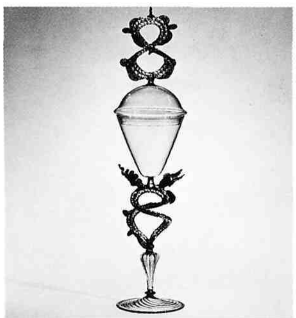
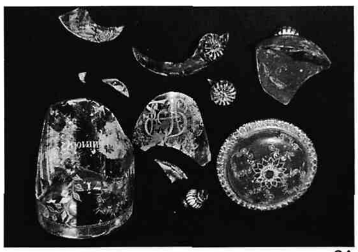

1C

Fig. 1. (a) Venetian goblet before restoration and cleaning. (b) Araldite being run into joints, (c) Dragon-stem goblet after repair.


2A


2B

Fig. 2. (a) German beaker before repair, (b) Adhesive applied with pointed spatula along each of the joints, (c) Beaker after restoration.

3) Venetian horse goblet (No. 54.3.236) with bowl broken from the horse's head and one ear broken and missing. (Fig. 3a, b)

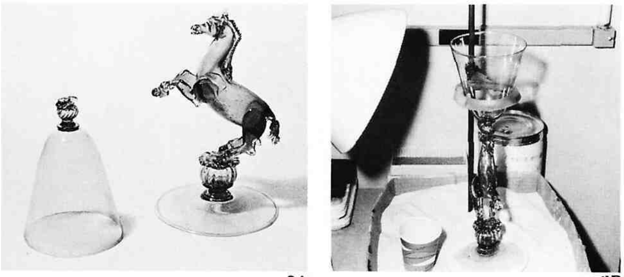
The body of the horse was full of mud. A previously repaired section of the mane was removed. The body was washed several times with water, mild detergent, and sodium pyrophosphate without much success. There were two very small holes to gain access to the inside, one on the missing ear and another where the mane was removed. Sodium pyrophosphate with 300 mesh silicone carbide abrasive grit finally removed the mud. In each case, the liquid was removed by placing a small, thin straw in one hole to allow air to enter and to force the water out through the other opening. The surfaces to be glued were cleaned with ammonia. The horse's head was protected, not supported, by a laboratory stand (whenever possible, it is best for an object to be self-supporting). The metal ring, covered with felt and closed in front with tape, was not touching the object.

4) Transparent bottle with applied red enamel decoration (No. 69.3.84), made by Maurice Marinot about 1914. (Fig. 4a, b)

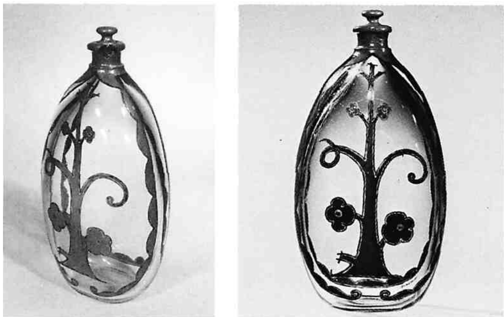
A chip had broken off the lip of the bottle and was not recovered. The broken portion was clear glass with an opaque fired red enamel. A replica of the missing part was made in Plastogen G, poured in place with wax backing to give it shape. After curing, the Plastogen was finished and polished with small burrs on a flexible shaft tool. The Plastogen was then removed and glued in place with Araldite. The finished filled area was colored with acrylic paint.

5) Blue Persian cut ewer (No. 65.1.23), part of the Persian exhibit toppled during the flood. (Fig. 5a, b, c, d)

The ewer was crushed beneath the case and smashed into aproximately one hundred small pieces plus twenty-four main fragments. The main fragments were taped together roughly to find where the one hundred pieces belonged. Because of the peculiar way in which the object was broken (in a zig-zag manner), the fragments locked themselves in place, but they had to be assembled in order. Sometimes several pieces were removed before one small piece could be fitted into place. The ewer was taken apart and put back together at least six times before it was ready for an adhesive. Araldite was then run into each joint. Except for some very small slivers, all the fragments were used. An area 4.0 cm in diameter was missing but was restored with Technovit 4004a, colored with dyes to match the ewer. Facets were then cut into the restored area with burrs on a flexible shaft.



3A 3B



4A 4B

5A 5B 5C 50

Fig. 3. (a) Horse goblet before cleaning and restoration, (b) Goblet standing in a box of sand, *protected,* not supported by a laboratory stand.

Fig. 4. (a) Marinot bottle before restoration, (b) Bottle after restoration.

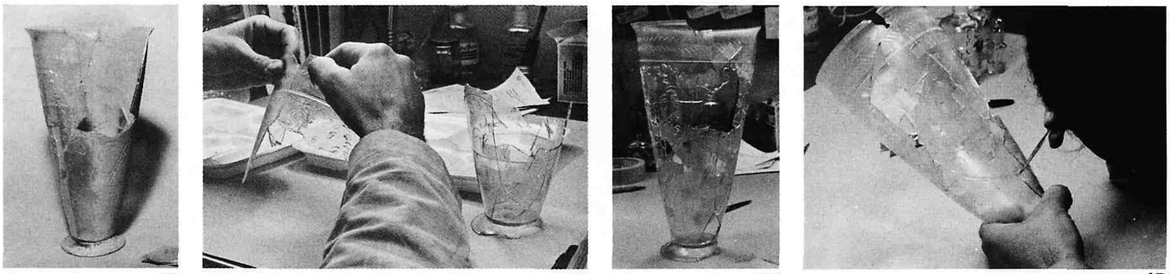
Fig. 5. (a) Facet-cut ewer before restoration, (b) Detail of fragments of ewer. (c) Rolf Wihr examining cut ewer during restoration. (d) Ewer after restoration.

Appendix IV

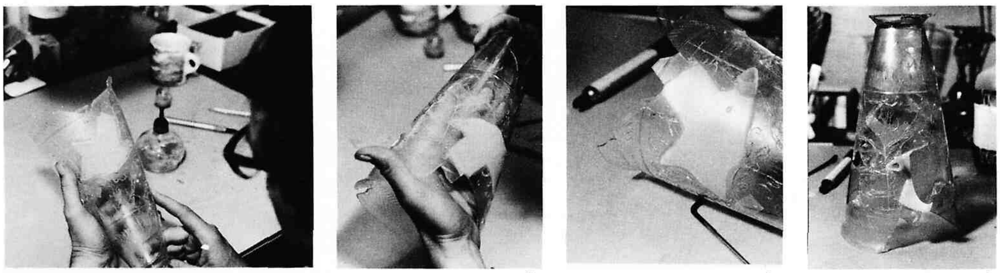
6) Engraved Roman beaker (No. 66.1.238). (Fig. 6a, b, c, d, e, f, g, h, i)

This previously repaired beaker had come apart during the flood. The object was taken apart and washed in water. Surfaces to be glued were carefully cleaned to be certain that the old adhesive was completely removed. Cleaning was checked by holding the fragments to the light so that the light reflected off the surface. The surfaces were then cleaned with ammonia and acetone before being taped together. Because of engraving on the exterior, the tape was applied to the smoother inside of the beaker. (Adhesive can sometimes seep through the joints and harden on the tape, making an object very difficult to clean on the rough engraved surface.) Araldite adhesive was run into the joints from the outside. When the joint was completely filled, the excess was removed immediately. After the adhesive had cured, the restoration of the missing area began. Dental wax was used for the mold. By warming it over a flame or hot air, an impression was taken from another part of the object on the inside. The contour was carefully molded to be the same as the missing area. Wax slightly larger than the area to be filled was then placed over the area to be restored and scored with a sharp instrument. This was done by holding the object against a light to permit light transmission through the wax. The shape was next cut with a hot knife to prevent the wax from breaking. The wax mold was coated with a polyvinyl alcohol to act as a separator between wax and resin and attached to the glass with a hot knife to make certain there were no openings for the resin to leak through. This procedure was then repeated on the outside, with one exception. An opening was left to fill the mold. The placement of the opening was chosen with care. To make sure that the mold filled properly, all undercuts faced the opening to prevent trapped air pockets. A wax spout was built over the opening to assure a steady flow of resin without forcing air into the mold and to act as a reserve tank for shrinkage.

Since the wax is translucent, the condition of the resin in the mold could be observed. If air became trapped, it could be released by making a small hole with a needle. After the air was released the hole could be sealed quickly with a hot knife. The resin used for this object was Plastogen G. The wax was then removed, the spout cut off, and the object was polished with a flexible shaft and cleaned. When restoration of a missing area was completed, Araldite was run between the resin and the glass to give a better seal to make the object more stable.



6A 6B 6C 6D



6E 6F 6G 6H

6I

Fig. 6. (a) Engraved Roman beaker before cleaning and restoration, (b) Object being fitted together, (c) Beaker taped together with other pieces not yet in place. (d) Araldite being run into joints, (e) Inside section of wax mold. (f) Outside section of wax mold being attached with a hot knife, (g) Completed mold with pouring spout. (h) Mold partly removed showing cured Plastogen restoration, (i) Restored beaker.

7) Sprinkler, Roman Empire, possibly Syria, 2nd-3rd. century A.D. (No. 59.1.148). (Fig. 7a, b, c, d, e, f)

The top of the object was detached; the foot was missing previously. The object was very carefully cleaned with water. A solution of sodium pyrophosphate was used to clean the mud from the cracks. Since there was no foot, it was decided to make one. The size and shape were based on a photograph of a similar object. The foot was turned freehand in clay on a potter's wheel and attached to the object for the final finishing (Fig. 7c). After curing, the rubber was removed; the clay was cleaned from the mold and the objects. The silicone mold was replaced on the object and sealed with a small amount of uncured silicone rubber. The mold could be filled from the top, using a straw as a pipeline to carry the resin into the mold from top to base without the resin touching any other areas of the object (Fig. 7d). Technovit 4004a was used; its natural color was similar to the object and it would not react with the silicone rubber. The mold was then cut away, revealing the molded foot (Fig. 7e). The top was attached with Araldite.

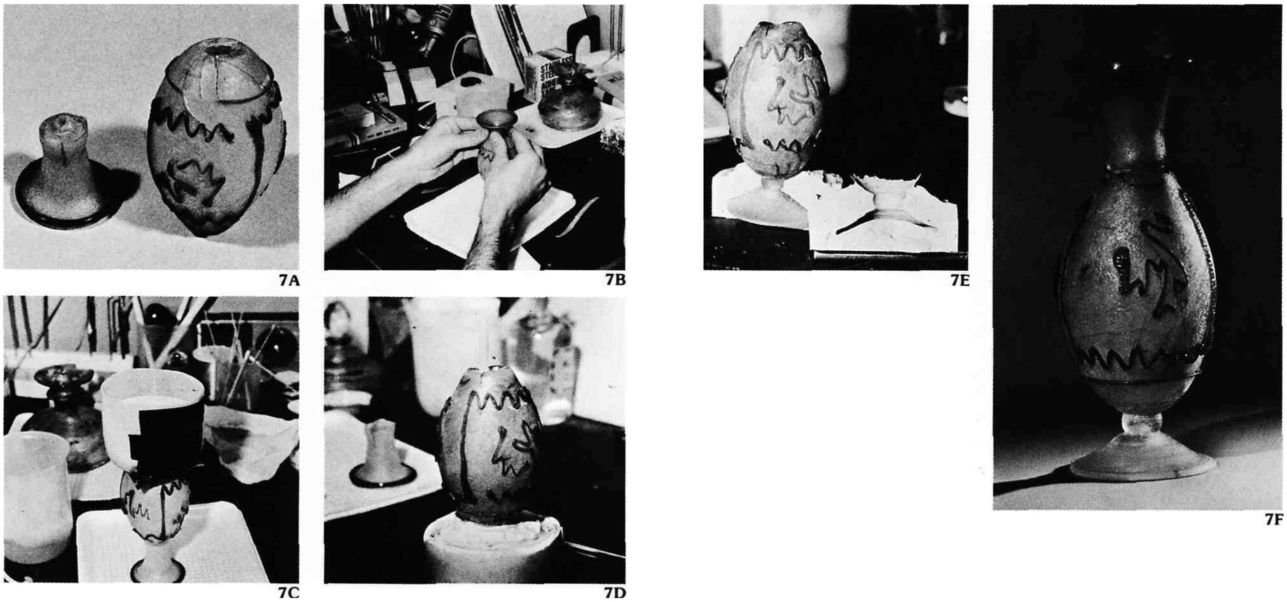


Fig. 7. (a) Sprinkler before restoration, (b) Foot being shaped in clay. (c) Pouring of rubber mold. (d) Mold in place with clay removed. Mold will be filled from the top with a straw as pouring spout, (e) Removal of plastic foot from rubber mold. (f) Completed sprinkler.

Appendix IV

8) Islamic beaker (No. 70.1.7). (Fig. 8a, b, c)

The beaker was broken into eighteen pieces. It had been restored with plaster, and Hakes of iridescence *not* part of the original had been glued to the surface (Fig. 8a). The object was very carefully cleaned to expose the original glass surface, taped together, and glued with Araldite (Fig. 8b). At this point the object was in a very unstable condition, with a number of small pieces missing on one side and about one half missing from the other side. All the small sections were restored first, by taking wax impressions of the outside portion of the beaker to match the areas to be restored. The wax was placed over the missing portion; Plastogen G was carefully laid on the wax from the outside. This was accomplished by waiting until the Plastogen was nearly ready to jell. After the resin had cured, the wax removed, and Araldite had been run into the joints between the glass and resin, this section was complete.

In restoring the larger missing part on the other side of the beaker, two problems arose: 1. After a wax impression was made from the already restored area including two of the sharp relief-cut circles, the wax became very thin because of its proximity to the sharp edges of the relief-cutting. Another layer of wax was added to give more strength to hold the shape. 2. When the shape and design were transferred to the missing part, the cut circles did not line up properly. Instead of making an impression of both circles at once, the impression of one circle was placed over the missing area, the location of the other circle was marked, and an impression made at that point. The final impression had to be shaped more by free hand than would normally have been done.

In cutting the wax mold to its final shape so it could be filled from the top, which was completely open, the wax was extended well above the top lip. This extra extension allowed overfilling the mold, which collected the air bubbles and also acted as a resin reserve to allow for shrinkage. The inside mold, having a smooth surface, could be completed and sealed in place with only one layer of wax.

The mold was then filled with Plastogen G and allowed to cure. The wax was removed, the extra extension on the lip cut off and polished. The Plastogen was tinted with oil paint thinned with xylene.

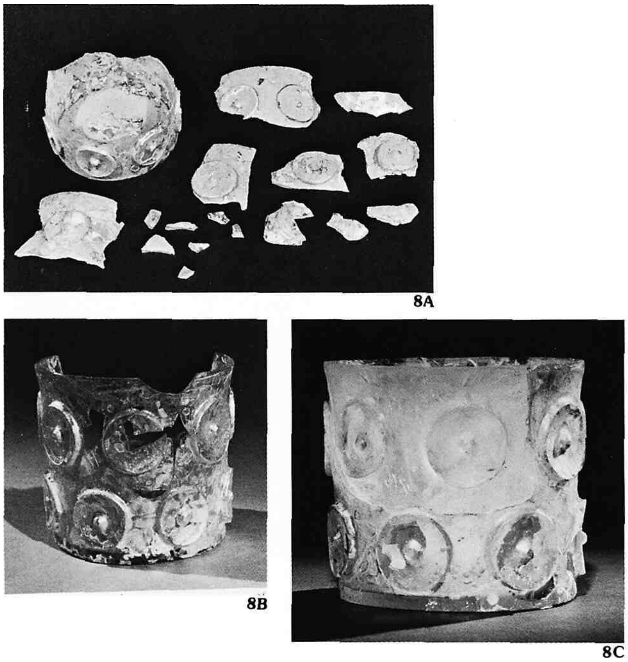


Fig. 8. (a) Cut beaker with a series of bosses, before cleaning and during restoration, (b) Beaker before restoration, (c) Beaker after restoration,

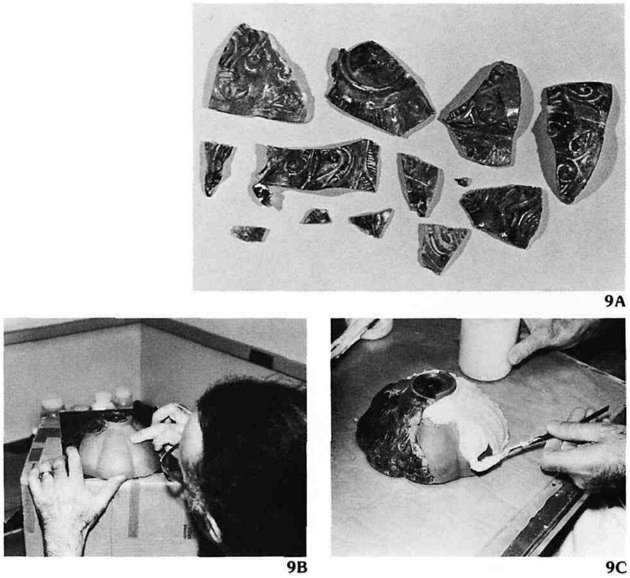


Fig. 9. (a) Islamic cut bowl before restoration, (b) Shaping the exterior of the bowl in clay. (c) Applying silicone rubber to the clay model.

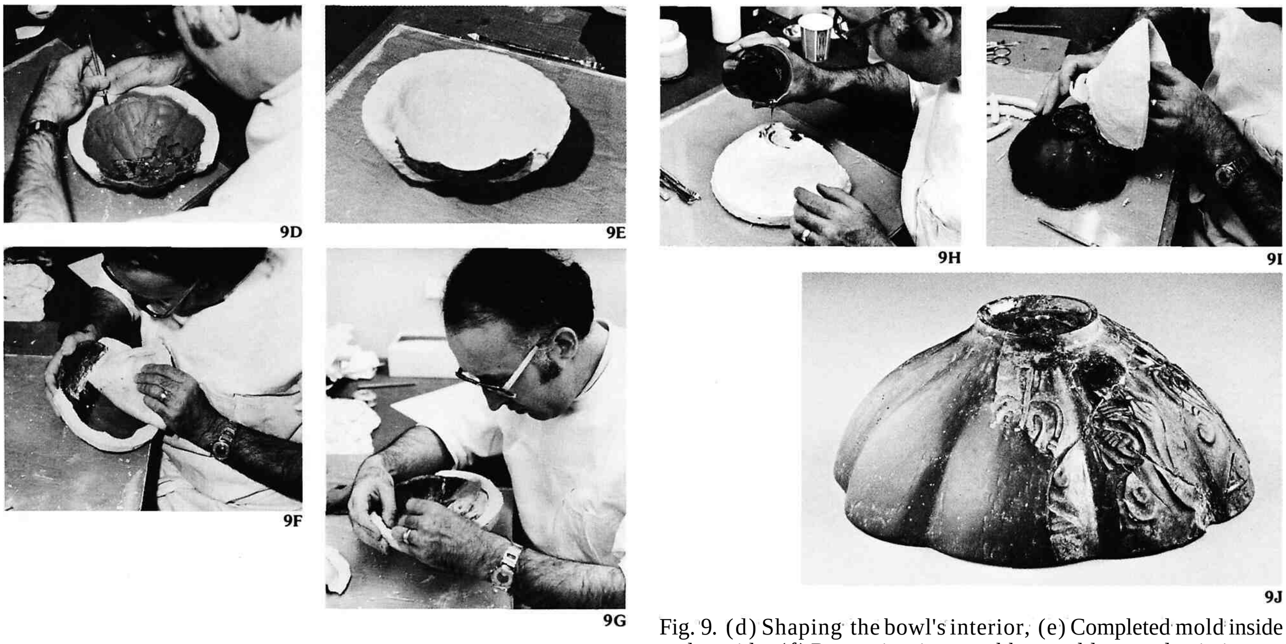
9) Islamic cut bowl (No. 55.1.136). (Fig. 9a, b, c, d, e, f, g, h, i, j)

An Islamic cut bowl previously restored with plaster had come apart. There were thirteen fragments which comprised approximately fifty per cent of the object. The old restoration and adhesive were cleaned from the object. Surfaces to be glued were cleaned with ammonia and acetone. The fragments were then fitted and taped together. Araldite was run into the joints. The bowl was placed on a flat surface, upside down, and clay was used to form the outside contour, eliminating the cut design because shape was most important; the design was still visible on the other side (Fig. 9b).

Because the outside shape and size were of chief concern, the clay on the inside was left in a very large lump. When the desired shape was produced, the clay was covered with a layer of silicone rubber which had been thickened with Cab-O-Sil so it would not run. This rubber mixture was placed very carefully to prevent air between the clay and rubber (Fig. 9c). Note the excess clay around the edge of the base, later used as a spout for pouring the resin. After curing, the silicone was covered with a layer of plaster firm enough to hold the shape of the rubber and to support the weight of the object.

The bowl, with clay, rubber, and plaster was then turned over to shape the inside (Fig. 9d). The thickness of the clay was measured by inserting wooden pegs through the clay to the silicone rubber. A layer of silicone rubber with Cab-O-Sil added was put on the inside and covered with plaster to permit easy removal of the plaster in one piece. The plaster and rubber were removed from the inside (Fig. 9f). All the clay was carefully removed from the mold (Fig. 9g), without breaking the seal between the glass and rubber which covered the outside of the mold. This procedure could be reversed if necessary, depending on the shape of the object. Experience indicated which side would be the easier to remove. In this case the inside came off more easily because the scallops and cutting tended to lock the outside in place.

The rubber mold was then sealed to the object with a thin coat of uncured rubber all along the edges. This acted as a gasket to keep the resin from leaking, and it was similar to the wax seal used on Fig. 6 to repair the Roman beaker (Fig. 6f). The plaster was pressed back into the rubber to give it support before the seal began to cure. The mold was then turned over and filled with Araldite dyed green (Fig. 9h) through the opening left by the excess clay on the base. This filling procedure was done in the morning to prevent any leak in the mold. After curing, the mold was removed (Fig. 9i) and the object cleaned.



9D 9E 9F 9G 9H 9I 9J

Fig. 9. (d) Shaping the bowl's interior, (e) Completed mold inside and outside, (f) Removing inner rubber mold; note plastic insert at left with metal handle, (g) Rolf Wihr removing clay and cleaning mold. (h) Pouring Araldite into rubber mold. (i) Removal of outer mold. (j) Completed restored object.

Appendix V

Materials and Suppliers

ADHESIVES:		
(a) AralditeAY103 (b) Hardener HY956	Ciba Company GmbH Wehr, Baden, Germany	Not available in the United States.
(a) RP-103 (Resin) (b) H-956 (Hardener) 17%P.B.W	Ren Plastics 5656 South Cedar Lansing, Mich. 48909	Substitute for Araldite AY103
Duco Cement	Hardware stores	An easy to obtain, no mixing adhesive for temporary repairs.
CASTING RESINS:		
Technovit 4004a	Kulzer & Co. Frolingstr. 29, POB 261 Bad Homburg v.d. Hoohe, Germany	A hard, glassy, room temperature curing polymethacrylate resin. Cloudy in color.
Plastogen G	Alfons Schmidt St. Germanstr. 14 Speyer, Bavaria, Germany	A room temperature curing polymethacrylate resin. Yellowish in color.
Polyester- GIEBHARZ GTS	Vosschemie 2082 Uetersen bei Hamburg Esinger Steinweg 50 Germany	A room temperature curing polyester resin. Clear in color.
MOLDING MATERIALS:		
Silastic RTV (A Silicone Rubber)	Dow Corning Corp. Midland, Mich.	A durable, fast-setting silicone rubber.
Jeltrate	L.D. Caulk Co. Milford, Delaware	A fast, pliable, water setting mold material. Must be used immediately.
Plaster of Paris	Hardware stores	A durable, easy to use, dense mold-making material.
Baseplate Wax	Dentsply International, Inc. York, Pa.	Dental wax.
CLEANING MATERIALS:		
Lymoff	The Lymoff Co. 6728-4th Street St. Paul, Minn. 55119	Lymoff should be used mainly on glassware, as it tends to corrode metals. It works most effectively on recent deposits of lime.
TOOLS:		
Flexible Shaft	Paul H. Gesswein & Co., Inc. 235 Park Ave. South New York, N.Y. 10003	Used for cutting, buffing and polishing. Complete descriptive catalog available.
Potter's Wheel		
MISCELLANEOUS:		
Acryloid B-72	Rohm & Haas Philadelphia, Pa. 19105	Protective coating for wherever it is necessary.
Cab-O-Sil (Fumedsilica) Grade # EH-5	Cabat Corp. 125 High Street Boston, Mass. 02110	Filler or thickening agent. Very good in silicone rubber to keep it from running.
Spectrum 100	Abbey Materials Corp. 116 W 29th St. New York, N.Y. 10001	A cold setting enamel paint used to restore missing decoration.
Ultrasonic cleaner		Used to clean mud and dirt from unreachable areas of *broken objects only*, due to its tendency to cause fractures.
Sodium Pyrophosphate solution 10 grams/liter of HzO		Cleans mud from cracks.

Appendix VI

Acknowledgements, References, Chapter IV

The author is indebted to Dr. R. H. Brill, Director, and Dr. J. H. Martin, Administrative Officer, The Corning Museum of Glass for their encouragement of these investigations, conducted with the assistance of Robert G. Kephart. Special thanks are given to Mr. Thomas W. Duncan, paper conservator, and his assistant, Mr. Merle A. Peck, for their help in conducting these experiments. Appreciation is due Mr. Robert M. Organ, Chief of Conservation, Analytical Laboratory at the Smithsonian Institution, for his information on uses of ethylene oxide. Valuable contributions during the initial stages of this study were made by Mr. Dale Johnson, a summer assistant. The gracious cooperation of The Corning Community College Administration in allowing use of their laboratory facilities for conducting microbiological tests and analyses was apreciated.

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Appendix VII

Acknowledgements, Chapter V

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