TAMING TECHNOLOGY FOR PRESERVATION

Americans have always been quick to seize upon the advances of science to benefit their daily lives. In 1750, Benjamin Franklin, in the same letter in which he reported his discoveries on electricity to the Royal Society of London, described how a system of pointed iron rods and grounding wires could be mounted on buildings to afford protection against lightning. Undoubtedly, the lightning rod is the earliest instance of American technology applied to building preservation.

More than two centuries later the preservation of buildings, as well as historic districts, has become the goal of numerous government programs and citizens groups throughout the nation. However, preservation is a complex task. Once preliminary considerations (i.e., public relations, legal, planning and financial arrangements) are resolved, preservationists must next contend with the whole range of physical problems that beset old buildings. These may include deteriorated materials and finishes, structural failures, obsolete installations, insensitive alterations and perhaps even a lack of skilled craftsworkers to execute the restoration work.

To remedy these problems and reduce subsequent maintenance, we look to our technological prowess for assistance. Unfortunately, our attempts to apply the technological developments in other fields to the needs of historic preservation rarely have been so spontaneous or beneficial as Franklin's example. A survey of the use of modern technology in the American preservation movement reveals a wide gulf between potential and practice.

PROBLEMS IN THE USE OF TECHNOLOGY

For the most part, the preservation movement has been slow to use the vast array of technological innovations that have had such profound effects on most American enterprises. The traditional nature of preservation work, the limitations of professionals in the field, and the frequent incompatibility of modern techniques with historic fabric have all tended to pose impediments to the ready use of technological advances made in the physical sciences. Further examination of these three impediments may help to explain the current dilemma.

In the first instance, the aim of most preservationists in this century has been to recapture historical ambience, or at least create a modern approximation of historic reality. Very often, when materials have deteriorated or features have not conformed to the desired image, these elements have been replaced with new building fabric to better facilitate "painting the picture," as restorationists used to say.[1] Authentic elements of many structures were consumed by this exercise of restoration zeal. Until recently, both the public and many professionals often failed to realize that such features as authentic materials and craftsmanship or subsequent modifications are more valuable than a modern approximation of the original appearance.

Secondly, the architect and historian are handicapped in their understanding of the properties and behavior of historic building materials, as well as in the effective use of modern technology. Without adequate background in science, they find it difficult to communicate, let alone collaborate, with research technologists, who presumably could bring their expertise to bear on preservation problems.

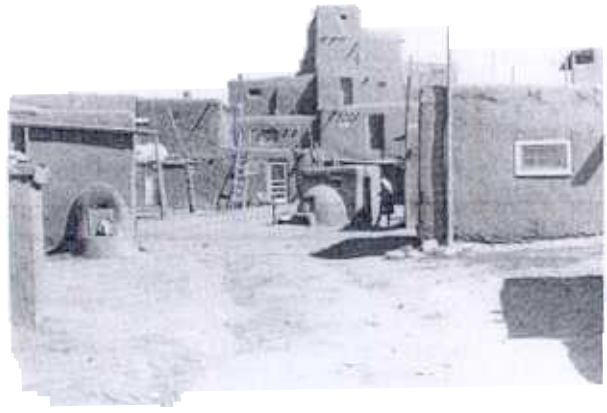
Finally, it should be recognized that contemporary technology is limited in its application to building preservation. Most of the technological advances of recent decades have been produced by industrial research laboratories in response to a specific problem. The new product developed usually meets the carefully defined needs of the problem at hand. If a new advance finds wider application, it is generally a fortuitous circumstance, as in the case of the material Teflon, first developed for rocket nose cones and now used to coat cooking utensils. Because no research laboratory in this country is devoted exclusively to the needs of building preservation, we are dependent on happenstance for techniques and products from private industry that will benefit our endeavors. Even when a technological innovation may be of value to historic preservation, many problems often bar its ready use. For example, there are obvious time lags that result from poor communications. Since architects rarely read research abstracts and most industrial researchers are not concerned with old buildings, years may pass before the proper connection is made between those groups. A further problem is that once adopted, an innovation may prove to be costly, too difficult to be applied in the uncontrolled conditions of a building site, or simply incompatible with historic building materials.

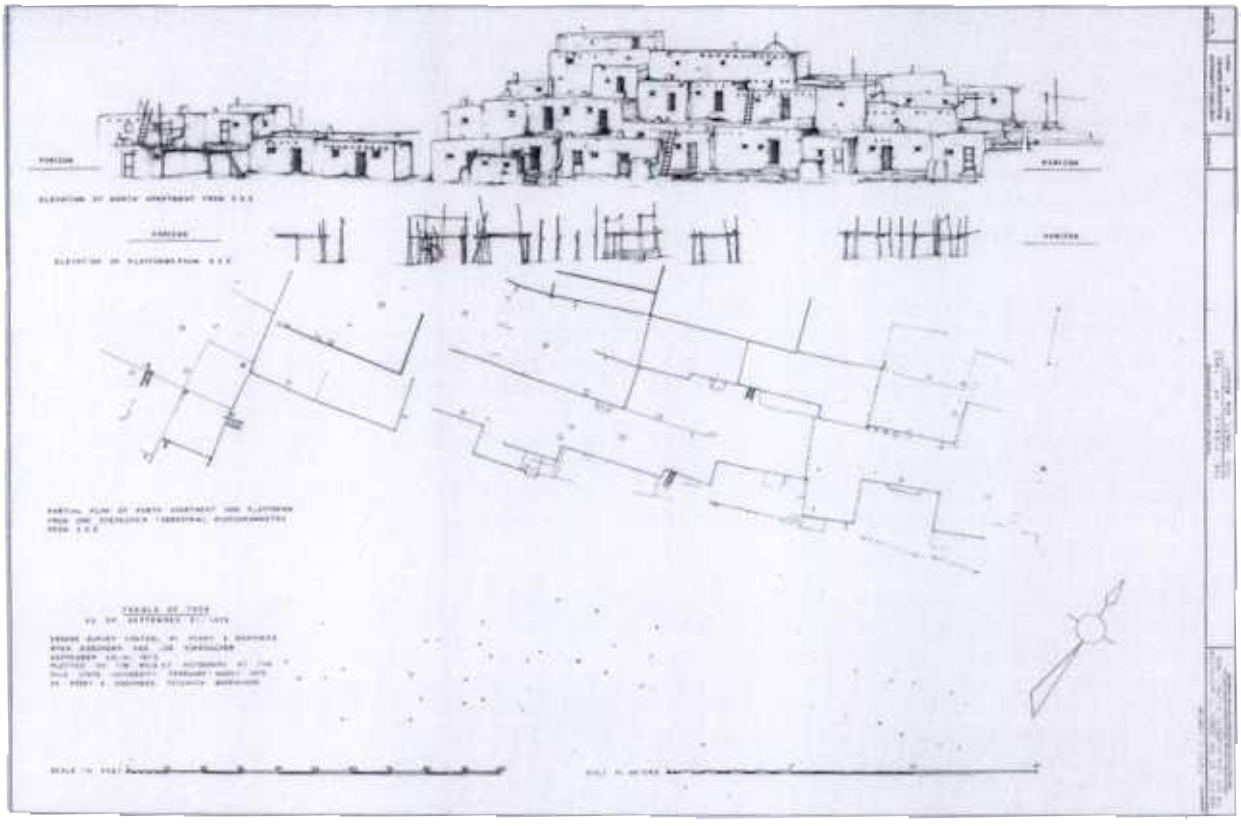
The problems that may arise with technological intervention in historic preservation are illustrated in the use and abuse of synthetic materials developed by the chemical industry over the past several decades: coatings, adhesives and composites. The preservationist now has an opportunity, for the first time, to use these and other new materials in the conservation of our cultural heritage. These materials have frequently been seen as a panacea that would arrest deterioration of historic building elements, as well as a means of reducing building maintenance. However, the improper application of these

materials has sometimes hastened the deterioration of the resource that they were intended to preserve.
This misfortune has been demonstrated by numerous attempts at adobe preservation in the Southwest. Adobe, or sun-dried earth brick, is the softest, most porous form of masonry; therefore, it is very susceptible to erosion by weathering. Traditionally, adobe was maintained by periodic replastering with a new coat of mud. To avoid this maintenance, several synthetic treatments have been used, with unfortunate results. For example, the application of clear waterproof coatings has tended to trap moisture within the walls by reducing the natural per-

Since 1971 the Historic American Buildings Survey (HABS) has conducted photogrammetric projects in New Mexico and Arizona to record Indian pueblos, early Spanish-American villages and mission churches, prehistoric cliff dwellings and the Anglo-American architecture of mining towns and ranches. A full range of aerial and terrestrial photogrammetric techniques, as well as reverse perspective analyses of 19th-century photographs, has been used to record whole settlements of adobe structures with sculptured walls and irregular openings such as the pueblo of Taos, New Mexico, shown here. (Myra Borchers)

Depuis 1971, le Historical American Buildings Survey (HABS) dirige des projets photogrammétriques au Nouveau Mexique et en Arizona pour enregistrer les villages indiens, les premiers villages hispano-américains et les églises missionnaires, les habitations troglodytes préhistoriques et l'architecture anglo-américaine des villes minières et des ranches. Une serie complète de techniques aériennes et terrestres, ainsi qu l'analyse photogrammétique de vues renversées de photographies du XIX^{e} siècle, a été utilisée pour enregistrer des ensembles complets de structures d'habitats aux murs sculptés et aux ouvertures irrégulières comme le village indien de Taos, au Nouveau Mexique, presénté ici.





meability (breathing characteristics) of the porous material, causing surface spalling. Similarly, fiberglass coatings, which can be made to duplicate the color and texture of adobe, have been used to cover large sections of walls. When natural movements occur in the adobe, the fiberglass is stressed and cracks. This allows rain to penetrate behind the coating, where it cannot evaporate easily, and great mischief ensues.

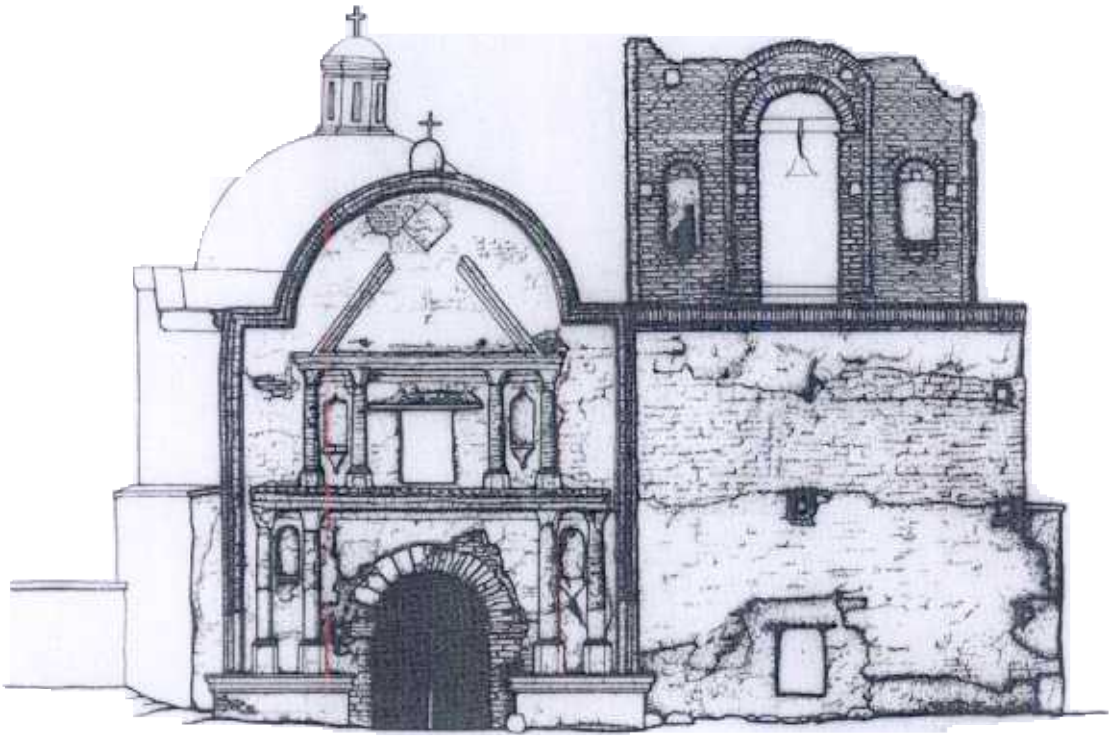
If architects and archaeologists are to act as "para-technologists," the above experiences demonstrate that they must adopt proper research techniques before prescribing restoration treatments. Furthermore, these professionals should be prudent enough to refrain from using irreversible treatments, since unsatisfactory results may occur or more effective techniques may be developed in the future.

PRESERVATIONISTS AS CONSERVATORS

Clearly, we now need a generation of competent professionals who can deal with historic structures in the light of contemporary technology. For example, museum conservators, who share the aims and principles of preservationists, have developed considerable knowledge on the composition, deterioration and treatment of historic materials. Because these conservators are thoroughly skilled in both art history and scientific technique, they have bridged the gap between preservation and technology. Their activities have not been entirely confined to small-scale artifacts, since their work occasionally involves large architectural sculpture and paintings on the walls and ceilings of great monuments.

The church at Tumacácori, Arizona, was drawn photogrammetrically to distinguish between some 20 partial restorations that have been carried out on this adobe structure since it was declared a national monument in 1906. (Historic American Buildings Survey, Perry Borchers)

L'église de Tumacacori, Arizona, a été dessinée photogrammétiquement pour distinguer les quelques vingt restaurations partielles qui ont été réalisées sur cette structure depuis qu'elle a été reconnue comme monument national en 1906.



Realizing the parallel nature of their concerns, preservationists and conservators have recently established closer contact, which has resulted in a broad range of endeavors involving mutual interests: conducting symposia to discuss technical problems, establishing training workshops to deal with conservation techniques, and undertaking technical information publications.

The formation eight years ago of the Association for Preservation Technology (APT), a joint Canadian-American venture, gave architects and preservationists an effective forum for exploring the application of science and technology to architectural preservation. Through its quarterly *Bulletin,* the bimonthly *Communique,* annual meetings and periodic technical courses, APT has been of inestimable value in improving the quality of professional practice in the field of building conservation.[2]

Several governmental and private organizations across the nation are paralleling the endeavors of APT by placing greater emphasis on preservation technology in their operations. In the National Park Service, which for decades has been the national leader in the development of preservation standards and techniques, the recent reorganization of the Office of Archeology and Historic Preservation includes the creation of a Division of Technical Preservation Services. Drawing on years of practical experience obtained by National Park Service personnel, the new division will furnish technical advice and consulting services to other agencies of the federal government and to state and private preservation groups.

In addition, the National Trust for Historic Preservation is presently expanding its technical assistance staff in Washington and its regional offices, in order to respond to the increasing demand for expertise on building conservation problems throughout the nation. The Society for the Preservation of New England Antiquities (SPNEA) in 1973 formed a new department of technical consulting services to accommodate a similar need in the New England region.

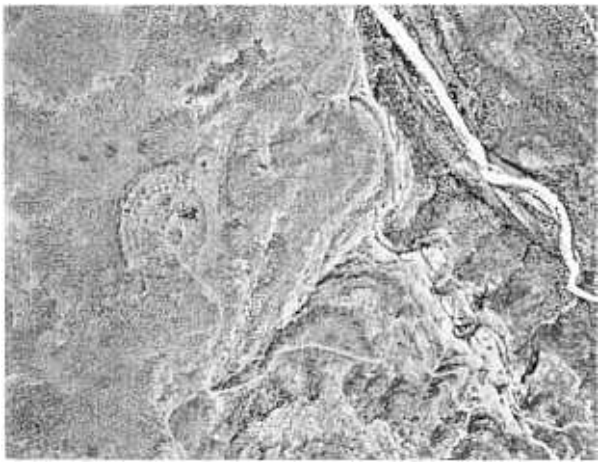
In 1970, New York State's Division for Historic Preservation organized a Bureau of Preservation and Restoration with regional restoration crews. This program, in addition to accomplishing the restoration of state historic sites, provided opportunities for training craftsmen, developing new restoration procedures, and educating the public on preservation techniques through day-long seminars.

Some of the most fruitful collaboration between conservators and preservationists has occurred in the several symposia conducted in recent years. The most ambitious of these ventures took place in September 1972, when the International Centre for Conservation sponsored a conference in both Williamsburg, Virginia, and Philadelphia, Pennsylvania. The subject was "Preservation and Conservation: Principles and Practices." For five days, 140 practitioners in the fields of conservation and preservation exchanged experiences and explored mutual problems. The proceedings of this conference were published this year by the National Trust; the volume constitutes a compendium on architectural conservation.[3]

Another symposium, entitled "Building Early America,"

Over the past several years archaeologists engaged in a joint research project of the National Park Service and the University of New Mexico at Chaco Canyon in northwestern New Mexico have experimented with remote sensing techniques as aids in data gathering. The mapping and identification of surface features of prehistoric roadways in Chaco Canyon have been accomplished through extensive use of aerial imagery. By careful laboratory examination of aerial photographs, ground features, heretofore unknown, can be predicted and subsequently located in the field, such as the remains of this prehistoric causeway near Penasco. (*Manual of Remote Sensing* by permission, American Society of Photogrammetry)

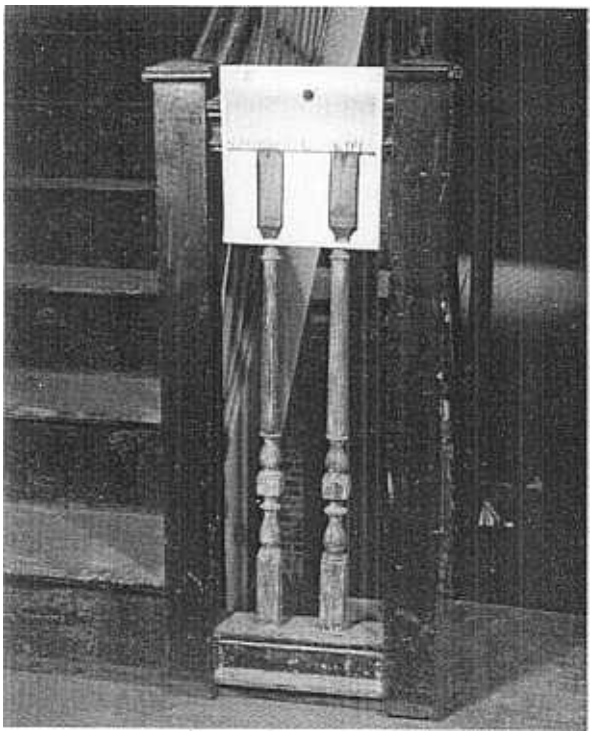
Ces dernières années, les archéologues se sont sont engagés dans un projet en commun du Service des Parcs Nationaux et de l'Université du Nouveau Mexique à Chaco Canyon, au Nouveau Mexique de l'Ouest, et ont expérimenté les techniques télésensorielles pour rassembler les données. La cartographie et l'identification des particularités de surface des chaussées préhistoriques à Chaco Canyon ont été accomplies par une vaste utilisation de figures aériennes. L'étude détaillés en laboratoire de ces photographies aériennes permet de prédire et de localiser les particularités de paysage, inconnues jusqu'ici, telles les ruines de cette chaussée préhistorique près de Penasco.



was organized by the Carpenters' Company of the City and County of Philadelphia in 1974 to commemorate the 250th anniversary of the group's founding. The agenda was divided in two parts: the first dealt with the history of American building, with emphasis on materials and construction techniques; the second was concerned with contemporary preservation efforts. The proceedings of this conference have also been published.[4]

While the content of these two symposia was wide-ranging, other meetings have been conducted on selected topics to allow more in depth treatment. In March 1973, SPNEA and APT jointly sponsored a conference on the performance of old and new mortars in old masonry walls.[5] The Geological Society of America presented a series of lectures on stone conservation during its 1974 annual meeting. The annual meeting of the American Concrete Institute in 1975 involved a one-day symposium on the restoration of historic concrete structures.

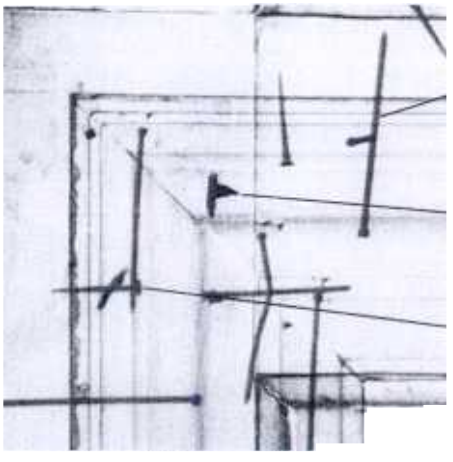
Training courses have also proven to be effective vehicles for dispensing newly developed technical know-how. In May of 1975, the National Park Service and the National Trust sponsored a one-week course designed to provide administrators of historic sites with a background on historic preservation maintenance.[6] This year APT is conducting a course on the deterioration and preservation of wood.[7] A similar session on the use of polymer adhesives in the repair and restoration of buildings was sponsored last year by APT at Colonial Williamsburg. These training sessions on the application of newly developed specialized techniques have been carried on largely by preservationists and conservators as continuing education programs for professionals.

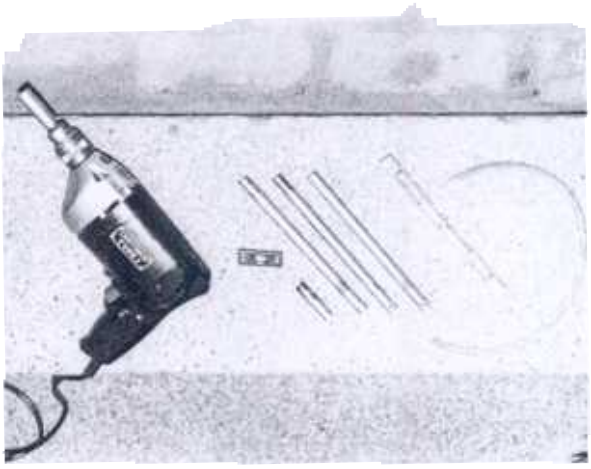


Since 1964 the School of Architecture at Columbia University in New York City has conducted a two-year graduate program in restoration and preservation of historic buildings to train professional preservationists. Under the direction of Professor James Marston Fitch, the curriculum has stressed an interdisciplinary approach to preservation in which each year several dozen professional experts serve as guest lecturers. The course exposes students to a wide range of specialists' knowledge, ranging from the techniques of archival research and architectural recording to knowledge of historical materials and modern conservation techniques.

X-ray examination of wood structures provides a nondestructive technique for dating building elements. Analysis of the various types of nails—hand wrought, cut, and wire—revealed in X-ray photographs together with data concerning probable construction and renovation dates helps establish construction sequence. In a house built in 1763, X-ray photographs showed that turned balusters in an old stair, fastened with wire nails, dated from an early 1900s renovation. Other portions of the stair balustrade had wrought nails that indicated a pre-1795 construction date for some elements. Similar interpretation of nails found in an X-ray photograph of a section of wall paneling in a house built in the 1790s, remodeled in the 1860s and again in the 1950s, showed that wrought nails were used in the original construction, cut nails in the 1860s and wire nails in the 1950s. (David Hart, National Park Service Handbook for Historic Preservation)

L'étude radiologique de structures boisees est une technique inoffensive de dater les éléments de construction. L'analyse de variétés de clous -façonnés à la main, taillés, trefilés -révélés ici dans les photos radiologiques de pair avec les données concernant les procédés problables de construction et de date de rénovation, aide à etablir la série des constructions. Dans une maison bâtie en 1763, les photographies radiologiques ont montré que les balustres tournées d'un viel escalier, fixées par des clous préfilés, dataient d'une rénovation du début du XIX^{e} siècle. A d'autres endroits de la balustrade, des clous façonnés indiquaient une construction antérieure à 1795 pour certains des éléments. Une interprétation semblable de clous trouvés dans la photo d'une section de panneau mural dans une maison construite dans les années 1790, remodelée dans les années 1860 puis en 1950, montrait que des clous façonnés avaient été employés dans la première construction, des clous taillés en 1860 et des clous tréfilés en 1950.





The tools necessary for field dendrochronology: A variable-speed drill, starting plate and starting bit, coring bits, and a wire to break loose the core once finished. The key to the feasibility of this technique lies in the nonbinding bits, which are made of a metal alloy that expands little or not at all under the extreme heat produced in the coring process. (Society for the Preservation of New England Antiquities)

Les outils nécessaires pour les ouvrages de dendrochronologie: une perforeuse à plusieurs vitesses, une plaque et une mèche de mise en marche, des mèches de perforage et un fil pour détacher le noyau une fois le processus terminé. Le secret de la faisabilité de cette technique repose dans les mèches non agglomérantes faites d'un alliage de métaux qui se dilate peu ou pas du tout sous l'action de la chaleur extrême dégagée par le perforage.

Core-boring a 17th-century girt. In order not to trap sawdust, the hollow bit is frequently made to slide in and out of the core-hole while in motion. (SPNEA)

Perforage d'une poutre du XVII^{e} siècle. Pour éviter que la sciure ne pénètre à l'intérieur, on fait souvent glisser la mèche creuse en mouvement de l'interieur à l'extérieur du trou de perforage.

The preservationist/conservator dialogue is further augmented by a growing body of technical publications. For example, the introduction earlier this year of a new magazine, *Technology and Conservation,* indicates the converging interests of these two groups.[8] This magazine will concentrate on the application of science and technology to building preservation and art conservation.

In addition to publication of the conference proceedings already mentioned, various government agencies have been issuing other technical publications and restoration reports. For instance, the National Park Service has commenced a multivolume technical handbook on the state-of-the-art in preservation.[9] This project of the Office of Archeology and Historic Preservation is assembling preservation expertise gained over the past several decades. The first volume of the series, *Cyclical Maintenance for Historic Buildings,* by J. Henry Chambers, was published earlier this year. To insure that the handbook will reflect current developments and widespread experience, the Park Service is distributing preliminary drafts of each section for comment and discussion by professionals in the field.[10]

Since the demand for technical information is so pressing, the Park Service is also preparing concise leaflets called *Preservation Briefs,* on various handbook topics. These materials are for broad distribution to local groups and individuals with limited technical preservation experience. The first two leaflets in the series have dealt with cleaning and repointing masonry.[11]

To supplement these publications and provide a vehicle for an even wider exchange of ideas and experiences, the Park Service initiated in June of 1976 a news bulletin entitled *11593.* Also, the National Trust and Columbia University have begun a series of publications on the technology of early American buildings, beginning with a volume on masonry construction.[12] Finally, the Division for Historic Preservation in New York State has published reports on its research in 19th-century tin roofing and its experience in stabilizing an 18th-century ornamental plaster ceiling.[13]

Considered together, the foregoing recital of efforts may appear impressive; however, all this is merely preliminary to the actual work of preservation. To gauge properly our accomplishments to date, we must take stock of the

projects executed. By reviewing the present record of achievements in the various areas of building conservation, we gain a better understanding of our weaknesses and strengths.

DOCUMENTING AND RECORDING

The need to record and document our historic resources accompanies nearly all preservation activities. This process ranges from preparing archival records for posterity to recording a building prior to restoration work, or surveying an entire historic district for environmental planning purposes.

The Historic American Buildings Survey (HABS) of the National Park Service is the federal vehicle for this extensive activity.[14] Established in 1933 by the U.S. Congress, HABS is the Park Service's oldest existing preservation program. Its summer field teams have provided nearly two generations of architectural students with valuable experience in historic preservation. Both the scope of its undertakings and a description of its disciplined techniques have been set forth in the HABS manual, *Recording Historic Buildings*.[15]

The Historic American Engineering Record (HAER) grew out of HABS involvement with engineering works. Founded in 1969, HAER is responsible for documenting and recording our civil engineering heritage, including bridges, canals, tunnels waterworks and industrial complexes.[16]

Given the tremendous scope of the tasks confronting HABS and HAER, they have used architectural photogrammetry to provide an efficient, accurate and quick method of recording historic structures. The techniques of photogrammetry and equipment used in this country were extensively developed in Europe. Once photographic stereopairs of a subject have been taken and oriented within a plotting instrument, orthographic views of the subject can be drawn directly by the instrument operator, who moves a measuring mark over the stereoscopic optical model. Or the digital readout of the coordinates of innumerable points on the optical model can be translated by a computer into graphic form. This recording technique is well suited to structures of complex, irregular form, or those with difficult access. The plotting instrument establishes a coordinate system for measurement that would be difficult to establish on the site. The use of photogrammetry in the United States has been much less organized and intensive than in several European countries, but the technique has been applied selectively during the past 20 years on a wide variety of projects. Most of these were sponsored by the Historic American Buildings Survey and executed by Professor Perry Borchers of Ohio State University. Photogrammetry projects have been undertaken to provide drawings for restoration work, to record a structure before its imminent demolition, or to arouse public awareness of the architectural quality of a building threatened with destruction.[17]

Another photo-documentation technique recently used by architects consists of incorporating photographs of existing building conditions with the working drawings prepared for a restoration project. This procedure, which exploits the use of photographic emulsions applied to mylar drafting sheets, does not require the sophisticated efforts of the methods described above. It saves considerable time in making field notations and preparing contract documents; furthermore, the documents are more readily comprehensible to both craftsworkers and laypeople.[18]

Efforts in surveying and recording historic sites have been greatly augmented by the use of aerial and terrestrial photo-documentation. Archaeologists in the Southwest concerned with surveying prehistoric Indian settlement sites are experimenting with various remote sensing techniques developed by the military for photo-reconnaissance and by geologists for oil exploration. As a result, airborne archaeologists now have at their disposal several new data-gathering systems.

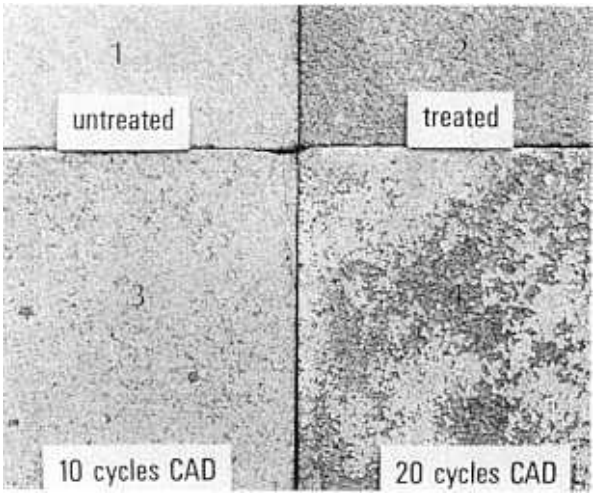
In addition to conventional aerial black and white photography, these remote sensing techniques include infrared scanning imagery, multispectral photography and radar. Application of these innovations has been limited; however, combined with traditional ground-based techniques, they have the potential to greatly enlarge an archaeologist's abilities to predict site locations, record sites, and even assist in maintenance through periodic surveying of conditions.[19]

NONDESTRUCTIVE INVESTIGATION

Before detailing the restoration of a building, an architect must become familiar with its evolution and present physical condition. In the past, many buildings were torn apart to obtain this information. This is no longer necessary; now we have begun to rely on some of the nondestructive testing instruments developed by manufacturing industries to monitor the quality of their goods. Some of these are laboratory instruments that can generate data from very small samples of building materials. With other portable instruments, it is possible to perform nonsampling analysis within the historic structure.

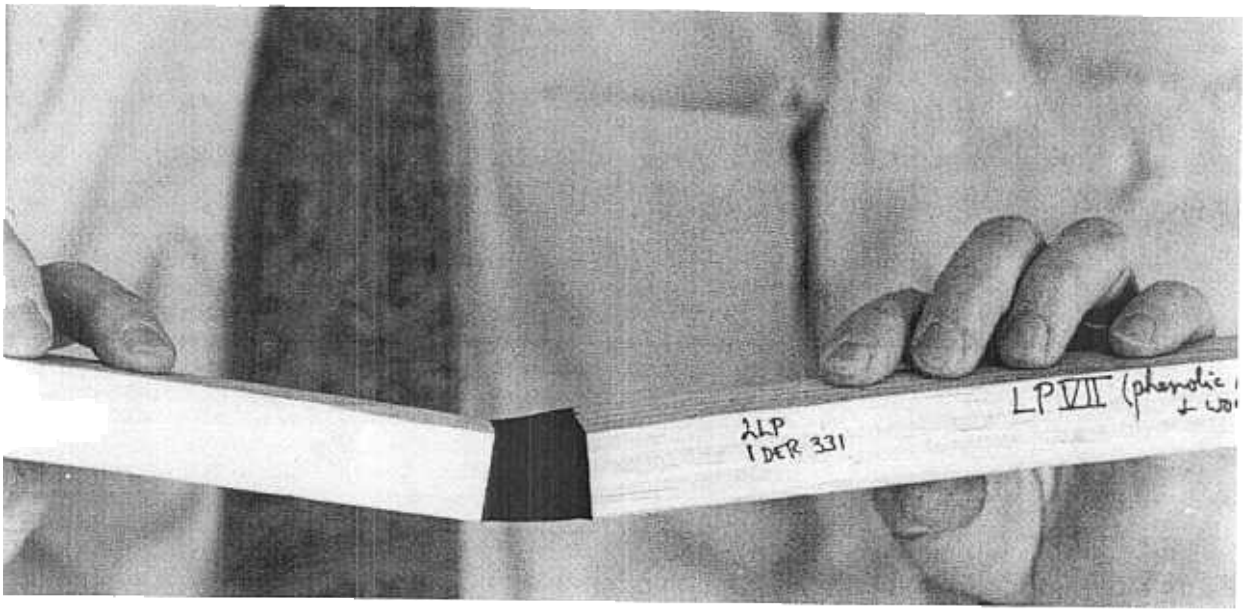
Museum conservators have used X-ray units extensively to investigate the internal structure of artifacts.[20] In the past few years, the National Park Service and SPNEA have experimented with the use of portable X-ray equipment to determine the condition, configuration and construction history of hidden elements in wood structures.[21] Since a large portion of America's historic buildings are of wood construction (in which the structural members are obscured under layers of paint, plaster and wood cladding) a nondestructive technique, as quickly and simply performed as an X-ray examination, should find wide application.

X-ray fluorescence and X-ray diffraction are two other investigative techniques used by museum conservators because they require only small samples. While they hold promise for the architectural conservator, these techniques have found only slight application in that field. In X-ray fluorescence, the material to be analyzed is subjected to intense radiation, producing fluorescent energy. Identifying the various wavelengths in this



Using the Chamber for Accelerated Decay (CAD), scientists at the National Bureau of Standards, Gaithersburg, Md., determine stone preservative performance. In the CAD, stone specimens are subjected to daily test cycles under conditions that can degrade materials and their coatings, such as ultraviolet light, simulated air pollution, freeze-thaw, moisture and salt action. This Indiana gray limestone is shown (1) untreated; (2) treated with stone preservative before testing; (3) with preservative treatment after 10 CAD test cycles, showing preservative treatment beginning to flake; (4) after 20 CAD test cycles, showing increased loss of stone preservative treatment. (National Bureau of Standards)

En utilisant la Chambre de détérioration accélérée, (Chamber for Accelerated Decay)-(CAD), les savants du Bureau National des Normes, determinent la qualité des pierres préservatives. Dans cette chambre, les échantillons de pierre sont soumis à des examens cycliques dans des conditions capables de détériorer les matériaux et leur enduit, telles les rayons ultra-violets, la pollution stimulée de l'atmosphère, gel/dégel, humidité et activité saline. Ce calcaire gris d'Indiana est présenté: (1) non-traité, (2) avant l'expérience, traité avec des pierres préservatives, (3) après dix cycles dans la chambre, le traitement commence à s'émietter, (4) après vingt cycles, témoignant d'une perte croissante du traitement preservatif.



Recently developed synthetic materials, such as epoxies, offer new possibilities to retain deteriorated historic building materials rather than replacing them with new materials. It is a common misconception that all epoxy materials are rigid. A polysulfide-modified epoxy filler, one of several developed by the Society for the Preservation of New England Antiquities, was used to attach these two pieces of wood, thus displaying the flexibility that can be attained with special formulations of these materials. (Norman Weiss)

Des matériaux récemment développés comme les époses offrent de nouvelles possibilités de maintenir les matériaux premiers des bâtiments historiques détériorés, plutôt que de les remplacer par de nouveaux matériaux. C'est une conception ordinairement erronée que de coire à la rigidité de ces matériaux époxiques. Un mastic époxique de polysulfide modifié—l'un des nombreux mastics développés par la Société pour la Conservation des Antiquités de la Nouvelle Angleterre, utilisé pour attacher ces deux blocs de bois, démontre la flexibilité quqe l'on peut obtenir par les différentes formules de ces matériaux.

fluorescence allows the diverse constituent chemical elements in the material to be detected and measured. By recording distinctive patterns of diffracted X-rays that vary according to the spacing and arrangement of the atoms in a crystal, X-ray diffraction aids in the identification of chemical compounds in a material. These analyses can be extremely helpful in understanding the composition and behavior of historic building materials.[22]

A very different form of nondestructive analysis is dendrochronology, the study of the chronological sequence of annual growth rings in trees. It is hoped that this technique will soon provide fairly accurate dating of wood structural members in buildings within a particular climatic zone. The Laboratory of Tree-Ring Research at the University of Arizona in Tucson has been the main center for this activity in the United States. In the past year, this laboratory's staff has assisted SPNEA in undertaking the necessary research to begin tree ring dating of structures in New England.[23]

It is becoming increasingly common for architectural offices specializing in preservation work to undertake simple forms of material analysis, such as gravimetric (weight measurement) mortar analysis and microscopic analysis of paint. No doubt this practice has largely come about as the result of specialists publishing their experience with these analytical techniques in technical journals and leaflets.[24]

PRESERVATION OF MATERIALS

The field of materials preservation is probably the most difficult specialty of architectural conservation. Unlike the processes of recording and investigation, most of the techniques used in treating materials involve serious intervention—usually chemical—in the fabric of a historic building. The current concern to preserve materials in situ has led preservationists to seek processes that will restore finishes, arrest deterioration, strengthen materials and in general reduce maintenance.

These are worthy ambitions, but unfortunately many attempts have produced irreversible damage. The best results have occurred when a particular problem is carefully diagnosed, alternative procedures are tested, and long-range effects are observed before treatment is attempted in the field. Hence, many of the most promising techniques for conserving building materials remain in their infancy; these include impregnations, adhesive repair and composite patching.[25] Some of these techniques are still in an experimental phase, with limited use and little solid accomplishment.

The past two decades have seen the widespread use of polymer coatings for exterior masonry. The application of such finishes is often suggested in the belief that these treatments will prevent water intrusion and thereby eliminate weathering, staining and efflorescence. Recent studies by the National Bureau of Standards' Center for Building Technology have confirmed the practical observation of many building conservators that most commercially available coatings do not provide an easy answer to preservation problems.[26] We have already noted, in the case of adobe, the problems that can develop when the surface of a porous material is made totally impermeable to water.

Such coatings as silicone that are merely water repellent, without eliminating vapor transmission, generally seem safe, especially when the preliminary analysis of the overall structure indicates few problems with condensation and rising ground water. Nevertheless, some well-publicized failures (probably in instances where the masonry units themselves contain water soluble salts prior to treatment) have made most preservationists wary of silicone coatings until more systematic field data can be gathered.[27]

The use of adhesives has been expanding slowly in the past few years with the encouragement of APT and other professional societies. Last year's APT training course on polymer materials paved the way for more enthusiastic cooperation between preservationists and a number of corporations currently making structural repairs with high-strength adhesives.[28] Patching damaged masonry has been greatly simplified by the use of new resins in the formulation of polymer-mineral composites that look like natural stone. However, a persistent problem appears to be the tendency of some of these materials to discolor upon prolonged exposure. This result has been attributed to the photochemical degradation of many of the new synthetics, especially epoxies. A number of laboratories trying to resolve this issue are also looking at the use of epoxies, urethanes and organosilicates for impregnation of stone, brick and plaster.[29] A closely related investigation into the use of soil consolidants in the stabilization of archaeological sites has recently been carried out by the Franklin Institute in Philadelphia as part of a larger program of preservation-related research.[30]

The preservation of architectural wood and metal has advanced steadily as the result of a few important projects. SPNEA recently completed a study of material for wood conservation that included the formulation of a semiflexible filler based on polysulfide-modified epoxy resins. Practical experimentation with this product is now underway.[31]

An interdisciplinary team of scientists and conservators at Washington University in St. Louis, Missouri, is responsible for a number of major breakthroughs in the treatment of outdoor bronze sculpture. The size of these monuments prompted the search for a rapid but safe method of cleaning. After extensive comparative testing, glass bead peening proved to be the most suitable approach. This technique, a modification of an older industrial procedure, has found parallel use in the cleaning of buildings in Venice.[32] The application of corrosion-inhibiting protective coatings has also been an interest of these researchers, who have already treated several monuments in St. Louis with dramatic results.[33]

PHYSICAL INTERVENTIONS

Technological intervention in a historic building is not limited to chemical treatments. Every preservation project involves the conflict between the demands of modern

usage and the fragility of historic construction. The installation of various internal systems, such as mechanical equipment, sanitary facilities, electrical installations and fire detection/suppression systems often constitute serious threats to the historic integrity of a building. The problems presented by building, fire safety and seismic codes are different, but frequently cause fundamental alterations in an old structure.[34]

Internal systems usually have a life span that is but a fraction of the total life of the buildings in which they are installed. It is not uncommon to find old buildings riddled by the various heating systems installed over the years. Original fireplaces were superseded by stoves; these in turn were followed by a variety of central heating systems using pipes and ducts. We now realize that heating and air-conditioning systems become obsolete in 20 to 30 years; plumbing and illumination systems have a similar history. If old buildings are not to be mutilated continually by these installations, we must develop small, compact systems that can be inserted in a structure with a minimum of cutting and patching. Industry has yet to produce a system that can fill this need. Perhaps the ubiquitous window-mounted air-conditioner units, which do not require pipes and ducts, are a reasonable interim solution.

In historic buildings that contain valuable artifacts, another problem is encountered with environmental control systems. Because buildings and artifacts required different optimum temperature and humidity levels, administrators of historic properties must often decide whether the structure or its contents receives preference. A decision to favor contents can have disastrous effects on historic buildings in cold climates. When humidity is raised to the level best for artifacts, condensation within walls of an uninsulated structure can result in wood decay and lime mortar decomposition.

Since the technology of intrusion and fire detection/suppression systems is rapidly changing and developing, most installations today run the risk of rapid obsolescense. Several effective intrusion systems, using ultrasonic motion detection or pressure sensitive devices, are now available. Their installation requires only minimal intervention in the historic fabric of a structure.

For example, an ionization detection system, which is extremely sensitive to combustion in the incipient stage (before smoke and flames are produced), can be inserted inconspicuously in an existing building as an entirely surface-mounted installation. This system continuously draws samples of air from each space in the building through a series of small plastic tubes connected to a central monitor; there the percentage of combustion particles (ions) is measured. When the percentage exceeds a predetermined level, an alarm is sounded.

In the past, internal fire suppression systems were largely limited to sprinklers; this often caused more damage to a structure and its contents from water than from the fire. It is now possible to provide systems that deluge a space with an inert, liquified gas such as "Halon" (CF_3Br). When triggered, this gas vaporizes into the fire zone, extinguishes the fire by chemically interfering with the combustion process, and leaves no residue or damage to furnishings.[35]

Finally, all forms of technology, both historic and contemporary, are applied at the building site by craftsworkers and specialists. The ultimate success of our interventions largely depends upon their skills. Realizing this, the National Park Service established in 1956 its Building Restoration Specialists Program, which aimed to develop craftsmen's skills and build up a core of trained mechanics for employment on Park Service restoration projects. The National Trust and several state preservation agencies have subsequently adopted similar programs.

COMPUTERS IN HISTORIC PRESERVATION

America is the land of the computer in the eyes of the rest of the world; yet, the historic preservation movement here has barely begun to use the computer as an information manager. An examination of computers in historic preservation therefore must deal largely with potentialities. By and large, preservationists have been intimidated by computers, which they view as costly and alien ventures. Thus, the required investment in planning and programming has not been forthcoming.

As the need for coordination in the preservation field becomes more urgent, computers will play a larger role. The most likely sources of computer activity are state and federal agencies, which may in turn make computer services available to local agencies. The directions for the growth of the computer as an information manager for historic preservation parallel those in other fields, such as the physical and social sciences. These directions include: information storage and retrieval, business and communications management, computer-assisted publications, and design graphics.

Information storage and retrieval is one of the most urgent needs in the management of such preservation records as site inventories and case studies. Computer retrieval is useful in two important ways: in isolating a particular record from a large collection, and in drawing summary conclusions from the body of stored information. For example, a governmental agency might want to reassess the impact of its grant programs on a number of related buildings. Summary reporting from manual files is generally difficult and expensive because of the labor involved in manually retrieving each record from a file cabinet. Computer-assisted retrieval significantly minimizes clerical labor, renders the operation both faster and more economical, and eliminates much of the human error of manual work.

The most critical need for automated information retrieval in preservation is in the area of inventory management; central, authoritative historic property lists, which could serve as a basis for future planning, are lacking. The National Register of Historic Places is itself an attempt to compile a single, central list at the federal level. Because of financial limitations and the lack of a nationwide standard for recording, only a few state inventories have been automated. In most cases these inventories have not used the recently developed class of programming systems known as DBMS (data base man-

agement systems), which allow the nontechnical user great flexibility in such areas as data design and retrieval. In the near future, the National Park Service's Register of Historic Places, as well as the other surveys of the Office of Archeology and Historic Preservation, are expected to be installed on such a system.

The wealth of accumulated experience in preservation is not systematically collected, coordinated and made available to those who could benefit from the knowledge. The lack of sharing through a highly developed communications network leads to the squandering of precious time and resources. Although numerous organizations publish information, hold meetings and otherwise disseminate ideas, there is no single clearinghouse for all phases of preservation information. The United States lacks a comprehensive pooling of experience as to legal aspects, public policy and technical innovations. The scientific, legal and medical fields all have developed clearinghouses, often maintained under government auspices, which rely heavily upon computer support. In Canada, the Department of Indian and Northern Affairs has developed within its Restoration Services Division a computerized preservation data storage and retrieval system. This system, known as Infotech, demonstrates the efficiencies that computer technology can bring to the field of historic preservation.

Design graphics has been one of the most exciting applications of the computer. For example, programs and equipment developed by aircraft and engineering corporations and further refined at two universities have made it possible to display perspective views of design alternatives from continuously moving points of view. Also, a system being developed by Professor Donald Greenberg and his students at Cornell University displays scenes in full color, adding another design factor that can be presented by computer. Using these systems, it is possible to present streetscapes, individual building exteriors and even interiors to those who might be reviewing a variety of possible preservation alternatives in an old neighborhood. Applied to the aims of historic preservation, the impact of losing a building in a community could thus become graphically clear. Alternate proposals could also be tested without the deceits inherent in architectural renderings.

The above uses of computers in preservation must all be developed, but only in the sense of applying existing technology to the field. Within the next five years, it is expected that the sharing of facilities will reduce unit costs and result in far wider acceptance of computers. Moreover, mutually exclusive, redundant, and nonconforming independent systems should be avoided if the computer is to become an effective tool in managing historic resources.[36]

NEEDS AND GOALS

Since the time of Daedalus, the myth of the architect as a master of technology has persisted. Despite Americans' inclination to equate "know-how" with technological expertise, our architects are ill-equipped to exploit the advances of technology and assume the conservator's role for the benefit of historic preservation. To improve the competency of all professionals involved in the conservation of our cultural resources, there must be nationwide recognition of the problems confronting their endeavors.

The establishment in 1973 of the National Conservation Advisory Council (NCAC) was an initial step in this direction. Comprised of a membership representing the leading institutions concerned with the conservation of our cultural resources, the Council has undertaken the study of conservation problems and the formulation of recommendations to meet the nation's needs in this field.[37] Last spring the Council issued a preliminary report, *Conservation of Cultural Property in the United States*.[38] That report urges creation of a national institute for conservation, and several regional conservation centers to deal more closely with various geographic areas of the nation. The national institute, as envisioned by the Council, would serve the major areas of need: information exchange, education and training, and maintenance of a research laboratory.

A central information exchange, functioning as a clearinghouse, is badly needed for collecting and disseminating experience gained in the laboratory on the one hand, and in field applications on the other. This exchange would act as a liaison linking professionals, students and researchers in private industry.

In conjunction with an information exchange, a national preservation education center could be active in conducting a wide range of continuing education courses and seminars. Some programs could be directed to professionals, others might allow students and craftsmen on-the-job training, and still others could be designed to increase public awareness of preservation issues.

A national research laboratory, devoted exclusively to preservation problems, is a logical extension of these informational and educational activities. At present, there are no government laboratories systematically concerned with the problems of deterioration in historic structures.[39] If extended tests and analysis of materials and techniques were undertaken, this laboratory could act as a catalyst in the proper use of technology in conservation procedures. The laboratory could also establish uniform standards for testing methods and for composition of materials used in conservation.

Another encouraging indication that the technical needs of historic building preservation are gaining wider recognition is seen in the proposal of the Committee for the National Museum of the Building Arts.[40] This group advocates the establishment of a national museum in Washington, one that will focus public and professional interest on America's building heritage. At present, not a single museum in this country is devoted to the building arts. Very often preservationists find themselves trying to apply modern technology to building elements whose origin, fabrication, or material characteristics they do not fully understand. A collection of architectural components could form the basis of study of historic construction materials and techniques. Surely, creation of such a museum, which has been proposed on several previous occasions,[41] is vitally needed in view of the growing activity in historic preservation.

In 1966, after extensively surveying conditions in this country, the Special Committee on Historic Preservation (formed by the U.S. Conference of Mayors) outlined its recommendations for a comprehensive national plan of action "to encourage, improve and reinforce public and private leadership" in the nation's historic preservation movement. These recommendations were set forth in the final chapter of the Committee's report, entitled *With Heritage So Rich.*[42]

Nearly all of the Committee's recommendations have since been acted upon, and preservation laws have been promulgated. We have experienced a profound shift in our national goals. The desire of the people to preserve their architectural patrimony as an enduring part of their daily lives has been manifested in the Congress, state legislatures and city councils. Conservation, restoration and recycling have now been accepted as rational undertakings.

In realizing these aims, we have throttled many of our impulses to waste and destroy. But beyond this achievement, a further task remains. Our nation must now allocate the resources and train the personnel who will ultimately tame our technology to accomplish the purposes of historic preservation in America.

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RÉSUMÉ

Malgré l'inclination américaine à la technologie, la nation a toujours été lente à utiliser les innovations technologiques modernes dans le domaine de la conservation historique. Plusieurs facteurs ont empêché un plus vaste succés de l'emploi de la technologie de conservation. Ce n'est que depuis ces dernières années que de nombreux conservateurs (preservationists) *commencent à se préoccuper de la conservation* in situ *des structures d'édifices historiques. La plupart des projets de restauration ont été confiés à des architectes et à des historiens qui, à cause de leur formation et de leur expérience, ne sont familiers ni avec les sciences ni avec la recherche technologique ni avec la nature et le comportement des matériaux. Le développement de matériaux et de techniques convenables est retardé par le manque de facilités de recherches consacrées aux problèmes de la conservation d'édifices. Enfin, l'intervention de la technologie dans la restauration de structures historiques présente souvent des problèmes d'incompabilité de matériaux qui peuvent causer la détérioration involontaire de ressources historiques.*

Les conservateurs (preservationists) *de bâtiments ont beaucoup bénéficié de leurs contacts accrûs avec les conservateurs de musées qui possédent une vaste expérience de l'utilisation de techniques technologiques avancées pour la conservation d'objets façonnés. Une conférence de cinq jours intitulée "Protection et Conservation: Principes et Pratique," parrainée par le Centre de la Conservation à Philadelphie et à Williamsburg en Septembre 1972, a fourni un forum incomparable aux conservateurs et aux "preservationists" pour examiner leurs problèmes mutuels. Une autre conférence, tenue en 1974, "La Reconstruction de l'Amérique des Premiers Temps", organisée par la Compagnie des Charpentiers de Philadelphie, s'est occupée de l'histoire de la construction américaine, mettant l'accent sur les matériaux et procédés de construction et sur les nombreux efforts contemporains de conservation.*

Le souci croissant du progrès d'une technologie de conservation historique a conduit à la formation de l'Association Américo-Canadienne "Pour l'Avancement des Méthodes de Préservation (APT)" en 1968. Récemment, les opuscules disponibles sur l'histoire de la technologie de construction et de techniques de conservation d'édifices se sont multipliés, de manière significative, (voir les notes de renvoi) à mesure que plusieurs bureaux de conservation privés et gouvernementaux plaçaient davantage l'accent sur les problèmes technologiques. Le Service des Parcs Nationaux, qui depuis des décennies est le chef de file national pour le développement de normes et de techniques de conservation, s'est embarqué dans la préparation d'un manuel technique en plusieurs volumes qui s'occupe de l'état de l'art dans la conservation. De plus, le Service des Parcs, le Trust National pour la Conservation Historique et la Société pour la Conservation des Antiquités de la Nouvelle Angleterre offrent au public et aux groupes privés des conseils techniques et des consultations sur les problèmes de conservation.

Les conservateurs américains (preservationists) *ont obtenu un succès variable dans l'application des récentes innovations technologiques aux divers aspects de la conservation d'édifices: documentation et enregistrement*

des sites historiques, investigation sans dommages des structures, traitement des matériaux historiques, installation de systèmes internes dans les édifices et utilisation d'ordinateurs. La plupart de ces innovations ont été développées pour être employées dans d'autres domaines et actuellement commencent à servir de manière tentative dans le domaine de la conservation. Par exemple, les archéologues qui s'occupent de l'expertise des vestiges indiens du Sud-Ouest des Etats-Unis mettent en pratique les techniques télésensorielles développées par l'Armée, telles que les figures de scrutation infra-rouges, la photographie multi-spectrale et le radar. L'application de ces techniques télésensorielles s'est avérée limitée; cependant, une fois combinées aux techniques archéologiques de base, elles offrent la possibilité d'élargir grandement l'abilité d'un archéologue de prédire et d'enregistrer un site historique. Dans d'autres domaines, le fossé entre les possibilités technologiques et leur application pratique demeure grand. Le défaut de ne pas employer les ordinateurs de manières variées est un exemple flagrant des difficultés auxquelles se confrontent les conservateurs américains dans l'exploitation des abondants moyens technologiques à l'avantage de leurs entreprises.

Peu à peu, à mesure qu'une plus juste appréciation des problèmes et des possibilités de l'emploi de la technologie pour la protection des constructions gagne davantage d'élan de par la nation, des fonds sont alloués pour la réalisation des projets de conservation historique. Des progrès se sont accomplis en vue de l'établissement d'organisations qui faciliteraient la formation de conservateurs d'édifices (preservationists), *le développement de laboratoires de recherche et la dissémination de renseignements techniques.*

FOOTNOTES

1. In recent years the history of the historic preservation movement in the United States has become the subject of scholarly research. See Stephen W. Jacobs, "Government Experience in the United States," and Charles B. Hosmer, Jr., "Private Philanthropy and Preservation," both in *Historic Preservation Today* (Charlottesville: The University Press of Virginia, 1966), pp. 100-131, and 150-176. Also see *Presence of the Past* by Mr. Hosmer (New York: G. P. Putnam's Sons, 1965), and "The Early Restorationists of Colonial Williamsburg," *Preservation and Conservation: Principles and Practices* (Washington: The Preservation Press, 1967) pp. 511-521.
2. Information concerning APT may be obtained from Ann Falkner, Secretary, Box 2487, Station D, Ottawa, Ontario K1P 5W6, Canada.
3. *Preservation and Conservation: Principles and Practices,* Proceedings of the North American International Regional Conference, Williamsburg, Virginia, and Philadelphia, Pennsylvania, September 10-16, 1972, ed. Sharon Timmons (Washington: The Preservation Press, 1976).
4. *Building Early America: Contributions Toward the History of a Great Industry,* ed. Charles E. Peterson (Radnor, Pennsylvania: Chilton Book Company, 1976).
5. An extensive summary of the subjects discussed was prepared by Morgan Phillips. See "SPNEA-APT Conference on Mortar, Boston, March 15-16, 1973," *Bulletin of the Association for Preservation Technology,* Vol. VI, No. 1, 1974, pp. 9-39.
6. The National Park Service continues to conduct short courses in historic preservation maintenance for administrators and managers of historic properties. This year, in California, the National Park Service Training Institute co-sponsored with the National Trust for Historic Preservation a course that included studies in preservation of wood, concrete, brick, adobe and other earth materials, ruins and unroofed structures.
7. This course, to be conducted by Morgan Phillips and Norman Weiss, will cover field identification of wood species in structures, fungi and insect pests, fungicides and pesticides, preventive measures and rehabilitation of deteriorated wood.
8. *Technology and Conservation* is published by the Technology Organization, One Emerson Place, Boston, Massachusetts 02114.
9. Information on the handbook series of technical preservation subjects for historic preservation may be obtained from the Technical Preservation Services Division, Office of Archeology and Historic Preservation, National Park Service, U.S. Department of the Interior, Washington, D. C. 20240, attention Lee H. Nelson, AIA, Editor, Preservation Handbook.
10. Portions of the Handbook circulated include: J. Henry Chambers, "Rectified Photography and Photo Drawings for Historic Preservation"; Norman R. Weiss, "Exterior Cleaning of Historic Masonry Buildings"; David M. Hart, "X-Ray Non-Destructive Examination of Historic Structures"; and "Guidelines for Rehabilitating and Preserving Old Buildings, Neighborhoods, and Commercial Areas."
11. Robert C. Mack, AIA, "The Cleaning and Waterproof Coating of Masonry Buildings," *Preservation Briefs 1,* 1975; Mack, "Repointing Mortar Joints in Historic Brick Buildings," *Preservation Briefs 2,* 1976. Available from the Office of Archeology and Historic Preservation, National Park Service, U. S. Department of the Interior, Washington, D.C. 20240.
12. Harley J. McKee, FAIA, *Introduction to Early American Masonry: Stone, Brick, Mortar and Plaster* (Washington: National Trust for Historic Preservation, 1973).
13. Diana S. Waite, *Nineteenth Century Tin Roofing and Its Use at Hyde Hall* (Albany: New York State Historic Trust, 1972); John G. Waite, *The Stabilization of an Eighteenth Century Plaster Ceiling at Philipse Manor* (Albany: New York State Historic Trust, 1972).
14. For a more complete account of HABS activity, see *Documenting a Legacy: 40 Years of the Historic American Buildings Survey,* reprint from the *Quarterly Journal* of the Library of Congress, October 1973.
15. Harley J. McKee, FAIA, *Recording Historic Buildings* (Washington: National Park Service, U.S. Department of the Interior, 1970). Order from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Publication No. I.29.2H62/12. $6.50.
16. HAER summer projects during 1974 and 1975 were described in *Society for Industrial Archeology Newsletter,* Supplementary Issues: No. 7, December 1974, and No. 8, April 1976, editor, Robert M. Vogel, National Museum of History and Technology, Smithsonian Institution, Washington, D.C. 20560.
17. These remarks on architectural photogrammetry have been abstracted from a statement prepared for this article by Perry E. Borchers of Ohio State University, who introduced architectural photogrammetry to this country. Also see Borchers, "Architectural Photogrammetry in Restoration," *Building Research,* Vol. 1, No. 5, September-October 1964, pp. 18-19; and "Architectural Photogrammetry for Historic Preservation" (working title), to be published by the Office of Archeology and Historic Preservation, National Park Service, U.S. Department of the Interior.
18. Cynthia J. Phifer, "Using Photographs in Contract Documents on Restoration Work," *AIA Journal,* February 1976, pp. 44-47. Also, Richard Bergmann, in a paper read to the 1975 annual meeting of APT, described his use of this technique in the preparation of bidding documents for restoration of the Winder Building in Washington, D.C.
19. For a more complete description of remote sensing in archaeology, see George J. Gumerman and Thomas R. Lyons, "Archeological Methodology and Remote Sensing," *Science,* Vol. 172, 1971, pp. 126-132; Thomas R. Lyons, Basil G. Pouls and Robert K. Hitchcock, "The Kin Beneola Irrigation

Study: An Experiment in the Use of Aerial Remote Sensing Techniques in Archeology," *Proceedings of the Third Annual Conference on Remote Sensing in Arid Lands* (Tucson: University of Arizona, 1972); H. Homer Aschmann, *et. al.*, "People: Past and Present," *Manual of Remote Sensing* Vol. II (Falls Church, Virginia: American Society of Photogrammetry, 1975), Chapter 26, pp. 1999-2060.

20. An early use of X-rays to examine artifacts was described in Stewart Culin, "An Archaeological Application of the Röntgen Ray," *Bulletin of the Free Museum of Science and Art*, Vol. I, No. 4, 1897, Philadelphia.

21. See David M. Hart, "X-Ray Investigations of Buildings," *Bulletin of the Association for Preservation Technology*, Vol. V, No. 1, 1973, pp. 9-21; Hart, "X-Ray Analysis of the Narbonne House," *Ibid.*, Vol. VI, No. 1, 1974, pp 78-98; Hart, "X-Ray Non-Destructive Examination of Historic Structures," December, 1975, draft prepared for the National Park Service *Technical Handbook for Historic Preservation.*

22. For a more complete treatment of these and other scientific techniques used in archaeology, see Bernard Keisch, *Secrets of the Past: Nuclear Energy Applications in Art and Archeology* (Oak Ridge, Tennessee: U.S. Atomic Energy Commission, 1972); *Scientific Methods in Medieval Archaeology*, ed. Rainer Berger (Berkeley: University of California Press, 1970).

23. For a general description of dendrochronology, see C. W. Ferguson, "Concepts and Techniques of Dendrochronology," *Scientific Methods in Medieval Archaeology*, pp. 183-200; Marvin A. Stokes and Terah L. Smiley, *An Introduction to Tree Ring Dating* (Chicago: The University of Chicago Press, 1968).

24. A procedure for mortar analysis was described in: E. Blaine Cliver, "Tests for the Analysis of Mortar Samples," *Bulletin of the Association for Preservation Technology*, Vol. VI, No. 1, 1974, pp. 68-73. Paint color analysis techniques have been described by Penelope Hartshorne Batcheler in *Paint Color Research and Restoration*, Technical Leaflet 15 (Nashville, Tennessee: American Association for State and Local History, 1968); Morgan W. Philips, "Discoloration of Old House Paints: Restoration of Paint Colors at the Harrison Gray Otis House, Boston," *Bulletin of the Association for Preservation Technology*, Vol. III, No. 4, 1971, pp. 40-47; and Morgan W. Phillips and Norman R. Weiss, "Some Notes on Paint Research and Reproduction," *Bulletin of the Association for Preservation Technology*, Vol. VII, No. 4, 1975, pp. 14-16.

25. The work of the Forest Products Laboratory at Madison, Wisconsin, founded in 1910 as a research unit of the Forest Service, U.S. Department of Agriculture (USDA), provides a notable exception to this statement. While not directly concerned with the problems of historic preservation, this laboratory has conducted extensive research on the characteristics, use and preservation of wood.

The Forest Service has issued many publications reporting research by the laboratory. Recent titles of interest to building preservationists include: *Wood Handbook: Wood as an Engineering Material*, Agriculture Handbook No. 72, revised 1974; *Condensation Problems in Your House: Prevention and Solution*, Agricultural Information Bulletin No. 373, 1974; *Principle for Protecting Wood Buildings from Decay*, USDA Forest Service Res. Pap. FPL 190, 1973.

Also, a trade association, the American Wood Preservers Institute, 1651 Old Meadow Road, McLean, Virginia, 22101, issues a bimonthly magazine and numerous technical publications dealing with wood preservation.

26. The Center for Building Technology currently has in progress a study of stone preservatives commissioned by the National Park Service. See Gerald A. Sleater, *A Review of the Subject of Natural Stone Preservation* (Washington: National Bureau of Standards, 1973), available from National Technical Information Service, Springfield, Virginia 22151.

27. Mack, "The Cleaning and Waterproof Coating of Masonry Building," *Preservation Briefs 1*, (Washington: National Park Service, U.S. Department of the Interior, 1975) p. 4.

28. The Adhesive Engineering Company, San Carlos, California, is among the companies pioneering in the use of permanent structural adhesives in pressure grouting cracks in dams, highways and other large concrete structures.

29. Among the better known American investigators who have carried out important research in this very specialized field are: K. Lal Gauri, Department of Geology, University of Louisville, Louisville, Kentucky; Seymour Z. Lewin, Professor of Chemistry, New York University, 4 Washington Place, New York, New York 10003; Edward V. Sayre, Conservation Center of the Institute of Fine Arts, New York University, 1 East 78th Street, New York, New York 10021; Norman R. Weiss, Science Consultant, Haverhill, Massachusetts 01830.

30. This project involved the conservation of basement remains at the site of the Benjamin Franklin house in Philadelphia. The site was excavated by the National Park Service and is part of Franklin Court in Independence National Historical Park.

31. This project was supported by the National Park Service. A report on the project will be published as one of the Handbook series by the Office of Archeology and Historic Preservation, National Park Service, U.S. Department of the Interior, Washington, D.C. 20240.

32. Phoebe Dent Weil, "The Use of Glass Bead Peening to Clean Large Scale Outdoor Bronze Sculpture," *AIC Bulletin*, Vol. 15, No. 1, pp. 51-58, 1974; Weil, "Problems of Preservation of Outdoor Bronze Sculpture: Examination and Treatment of *The Meeting of the Waters*, in St. Louis, Missouri," *AIC Bulletin* 1974, Vol. 14, No. 2, pp. 84-92.

33. This review of materials preservation, as outlined in the last five paragraphs, was prepared by Norman R. Weiss for inclusion in this article. Mr. Weiss is a consulting scientist specializing in conservation problems.

34. The problems presented by building codes in preserving older biuldings was the subject of a conference sponsored by the National Trust for Historic Preservation in Washington in May 1974. See *Preservation and Building Codes* (Washington: The National Trust for Historic Preservation, 1975).

35. The foregoing remarks on various internal systems have been prepared in collaboration with my associate in the Preservation/Design Group, John G. Waite, and in large measure reflect his experience in supervising the restoration of Olana (the 1870 home of Frederic Church near Hudson, New York) for the New York State Division for Historic Preservation.

36. These remarks on computers in historic preservation have been abstracted from a statement prepared for this article by Wilford Cole of the Office of Archeology and Historic Preservation, National Park Service, Washington.

37. The needs of architectural conservation were considered by a special study committee chaired by Elliott Carroll, Executive Assistant to the Architect of the Capitol. This committee included in its membership representatives from organizations concerned with building preservation: The National Park Service, The American Institute of Architects, the National Trust for Historic Preservation, the Advisory Council for Historic Preservation and the Association for Preservation Technology.

38. *Conservation of Cultural Property in the United States* (Washington: National Conservation Advisory Council, 1976). Copies of this report are available from Gretchen Gayle, Executive Secretary, NCAC, c/o SI-356, Smithsonian Institution, Washington, D.C. 20560.

39. As noted above, the Center for Building Technology in the National Bureau of Standards has occasionally been commissioned by the National Park Service to undertake research projects.

40. Inquiries concerning this endeavor may be directed to Cynthia R. Field, President, Committee for the National Museum of the Building Arts, 1800 M Street, N.W., Suite 400 S, Washington, D.C. 20036.

41. Charles E. Peterson, over the past four decades, has made several proposals for a national architectural museum. See "A Museum of American Architecture," *The Octagon* (Washington: The American Institute of Architects, November, 1936), "The Museum of American Architecture: A Progress Report," *Journal of the Society of Architectural Historians*, Vol. 1, No. 3-4 (July-October 1941), and "The Role of the Architect in Historical Restoration," *Preservation and Conservation: Principles and Practices*, p. 6.

42. *With Heritage So Rich*, ed. Albert Rains and Laurance G. Henderson, (New York: Random House, 1966).